Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)

1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普適氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)

1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)

1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)

1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)

1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

The following list of formulae may be found useful :

Energy transfer during heating or cooling $E = mc\Delta T$

Part A : HKCE examination questions

1. **< HKCE 1980 Paper II - 15 >**

When a mercury thermometer is immersed in melting ice and then in steam, the lengths of the mercury thread in the stem are respectively 2 cm and 22 cm. When the thermometer is put in a water bath, the length of the thread is 11 cm. What is the temperature of the water bath ?

A. 40°C
B. 45°C
C. 50°C
D. 55°C

2. **< HKCE 1984 Paper II - 13 >**

An equal quantity of heat is supplied to each of the following substances and the corresponding rises in temperature are recorded. Which of the following substances has the smallest specific heat capacity ?

	Substance	Mass (kg)	Rise in temperature (°C)
A.	*P*	2.5	5
B.	*Q*	3.0	4
C.	*R*	4.5	3
D.	*S*	5.0	3

3. **< HKCE 1986 Paper II - 16 >**

The heat capacity of an object depends on its
(1) material
(2) mass
(3) shape

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

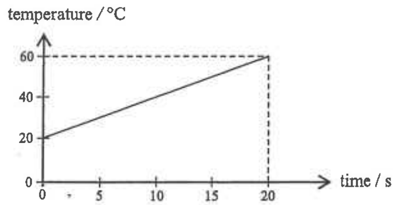
4. **< HKCE 1987 Paper II - 25 >**

Which of the following pairs of objects have different specific heat capacities ?

A. 1 kg of water and 2 kg of water
B. 1 kg of liquid naphthalene and 1 kg of solid naphthalene
C. 1 kg of oil in a glass container and 1 kg of oil in a metal container
D. 1 kg of water at 15°C and 1 kg of water at 30°C

5. **< HKCE 1988 Paper II - 12 >**

The graph shows the relationship between temperature and time when 1 kg of a liquid is heated by a 500 W immersion heater. Assuming no loss of heat, what is the specific heat capacity of the liquid ?



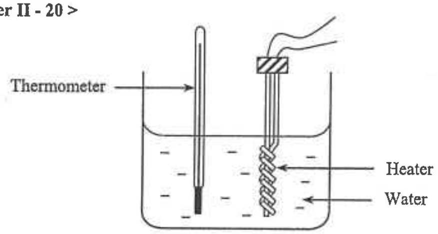
A. 0.01 J kg^{-1} °C^{-1}
B. 250 J kg^{-1} °C^{-1}
C. 420 J kg^{-1} °C^{-1}
D. 2500 J kg^{-1} °C^{-1}

6. **< HKCE 1989 Paper II - 20 >**

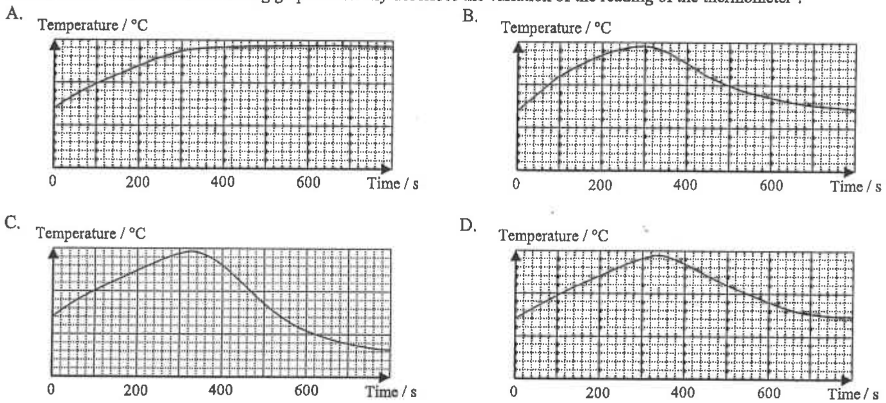
A heater supplies energy to a liquid of mass 0.5 kg and specific heat capacity 4000 J kg^{-1} °C^{-1} contained in a vessel of negligible heat capacity. Assume that the heat exchange with the surroundings can be neglected. If the temperature of the liquid rises from 10°C to 70°C in 100 s, the power of the heater is

A. 200 W
B. 1200 W
C. 1400 W
D. 12000 W

7. **< HKCE 1992 Paper II - 20 >**



In the diagram shown, the water is initially at room temperature. The electric heater is switched on for 300 s and then switched off. Which of the following graphs correctly describes the variation of the reading of the thermometer ?



8. **< HKCE 1993 Paper II - 18 >**

An energy of 16500 J is supplied to a metal block of mass 0.5 kg and its rise in temperature is 64°C. The specific heat capacity of the metal is

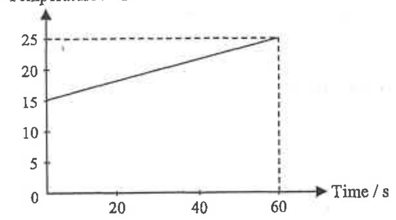
A. $\dfrac{16500 \times 0.5}{64 + 273}$ J kg^{-1} °C^{-1}
B. $\dfrac{16500 \times 64}{0.5}$ J kg^{-1} °C^{-1}
C. $\dfrac{16500}{64 \times 0.5}$ J kg^{-1} °C^{-1}
D. $\dfrac{16500}{(64 + 273) \times 0.5}$ J kg^{-1} °C^{-1}

9. **< HKCE 1993 Paper II - 16 >**

Water is used as a coolant in motor car engines because

A. water has a low specific heat capacity.
B. water has a high specific heat capacity.
C. water has a low specific latent heat of vaporization.
D. water has a high specific latent heat of vaporization.

15. **< HKCE 1998 Paper II - 21 >**



The graph shows the variation of the temperature of liquid with time when the liquid is heated by a 400 W heater. The mass of the liquid is 2 kg. Find the specific heat capacity of the liquid. Assume all the energy given out by the heater is absorbed by the liquid.

A. 83 J kg^{-1} °C^{-1}
B. 480 J kg^{-1} °C^{-1}
C. 1200 J kg^{-1} °C^{-1}
D. 2400 J kg^{-1} °C^{-1}

16. **< HKCE 1998 Paper II - 19 >**

Which of the following statements about internal energy, heat and temperature is/are true ?

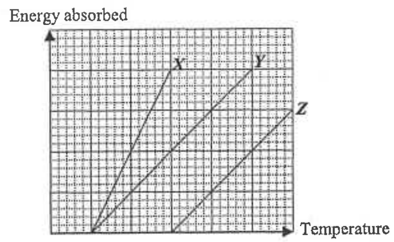
(1) The internal energy of a body is a measure of the total kinetic energy and potential energy of the molecules in the body.

(2) Two bodies of the same temperature always have the same amount of internal energy.

(3) Heat is a measure of the energy transferred from one body to another as a result of temperature difference between the two bodies.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

17. **< HKCE 1999 Paper II - 16 >**



Equal masses of liquids *X*, *Y* and *Z* are separately heated. The graph shows the variation of the energies absorbed by the liquids with their temperatures. Let c_X, c_Y and c_Z be the specific heat capacities of *X*, *Y* and *Z* respectively. Which of the following relations is correct ?

A. $c_X = c_Y > c_Z$

B. $c_X = c_Y < c_Z$

C. $c_X < c_Y = c_Z$

D. $c_X > c_Y = c_Z$

10. **< HKCE 1994 Paper II - 16 >**

An equal amount of energy is supplied to each of the following substance. Which one of them has the smallest rise in temperature ?

	Substance	Mass / kg	Specific heat capacity / J kg^{-1} °C^{-1}
A.	*P*	1	4200
B.	*Q*	2	2300
C.	*R*	3	2200
D.	*S*	4	900

11. **< HKCE 1995 Paper II - 18 >**

Which of the following statements about heat is/are true ?

(1) Heat is used to describe the total energy stored in a body.
(2) Heat is used to describe the energy transferred from one body to another as a result of a temperature difference between them.
(3) A body's internal energy is increased when it is heated.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

12. **< HKCE 1996 Paper II - 18 >**

Which of the following phenomena concerning water can be explained by its high specific heat capacity ?

(1) Water is used as a coolant in car engines.
(2) Inland areas generally have hotter summers and colder winters than coastal areas of similar latitude and altitude.
(3) The body temperature of human beings changes slowly even when the surrounding temperature changes sharply.

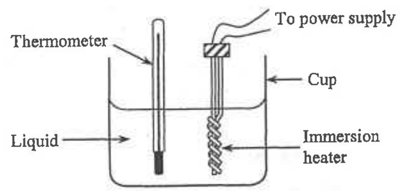
A. (2) only
B. (1) & (2) only
C. (1) & (3) only
D. (1), (2) & (3)

13. **< HKCE 1997 Paper II - 19 >**

The apparatus is used to find the specific heat capacity of a liquid. Which of the following can improve the accuracy of the experiment ?

(1) Take the final temperature of the liquid immediately after switching off the power supply.
(2) Cover the cup with a lid.
(3) Stir the liquid throughout the experiment.

A. (1) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)



14. **< HKCE 1997 Paper II - 20 >**

An heater with a power of 100 W is used to heat 0.3 kg of a liquid which has a specific heat capacity of 2000 J kg^{-1} °C^{-1}. If the initial temperature of the liquid is 23°C, find its temperature after 2 minutes. Assume all the energy given out by the heater is absorbed by the liquid.

A. $(\frac{100 \times 120}{0.3 \times 2000} + 23)$ °C

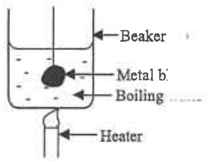
B. $(\frac{0.3 \times 2000 \times 23 \times 2}{100})$ °C

C. $(\frac{100 \times 120 \times 0.3}{2000} + 23)$ °C

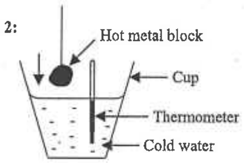
D. $(\frac{0.3 \times 2000}{100 \times 120} + 23)$ °C

Questions 21 and 22 : The specific heat capacity of a metal is measured using the following method :

Step 1:



Step 2:



A metal block is first immersed in boiling water for some time. The block is then transferred to a cup of cold water. After a while, the temperature of the water is measured.

21. **< HKCE 2002 Paper II - 20 >**

The result of the experiment is as follows :

Mass of metal block = 0.8 kg

Mass of water in the cup = 0.3 kg

Initial temperature of water in the cup = 23°C

Final temperature of water in the cup = 38°C

Find the specific heat capacity of the metal (in J kg^{-1} °C^{-1}).

(Given : Specific heat capacity of water = 4200 J kg^{-1} °C^{-1}.)

A. 236
B. 381
C. 622
D. 953

22. **< HKCE 2002 Paper II - 21 >**

The result obtained in the last question is found to be higher than the true value of the specific heat capacity of the metal. Which of the following is a probable reason ?

A. Some hot water is still adhered to the metal block when the block is transferred to the cold water.
B. Some energy is lost to the surroundings when the metal block is transferred to the cold water.
C. Some energy is absorbed by the cup.
D. The temperature of the metal block is still higher than 38°C when the final temperature of the water in the cup is measured.

23. **< HKCE 2003 Paper II - 19 >**

If there is no heat flow between two bodes when they are in contact, then the two bodies must have the same

A. temperature.
B. internal energy.
C. specific heat capacity.
D. specific latent heat of vaporization.

24. **< HKCE 2003 Paper II - 22 >**

A student uses an electric kettle to heat 0.5 kg of water at 20°C. The water boils in 4 minutes. Estimate the output power of the kettle. The specific heat capacity of water is 4200 J kg^{-1} °C^{-1}.

A. 175 W
B. 700 W
C. 875 W
D. 1400 W

18. **< HKCE 2000 Paper II - 22 >**

An object *P* has a higher temperature than another object *Q*. Which of the following statements is/are correct ?

(1) The internal energy of *P* must be higher than that of *Q*.
(2) The specific heat capacity of *P* must be higher than that of *Q*.
(3) There will be a heat flow from *P* to *Q* when they are in contact.

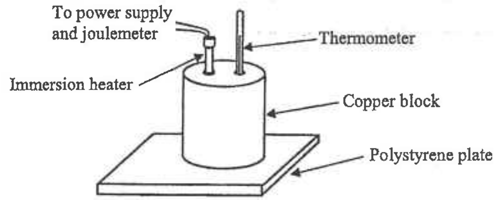
A. (3) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

19. **< HKCE 2000 Paper II - 20 >**

Equal amount of four different liquids are separately heated at the same rate. The initial temperatures of the liquids are all 20°C. The boiling points and specific heat capacities of the liquids are shown below. Which one of the following liquids will boil first ?

	Liquid	Boiling point / °C	Specific heat capacity / J kg^{-1} °C^{-1}
A.	*P*	50	1000
B.	*Q*	60	530
C.	*R*	80	850
D.	*S*	360	140

20. **< HKCE 2001 Paper II - 17 >**



The apparatus shown is used to measure the specific heat capacity of a cylindrical copper block. The result of the experiment is as follows :

Mass of copper block	=	m kg
Initial temperature	=	21°C
Final temperature	=	47°C
Initial joulemeter reading	=	R_1 J
Final joulemeter reading	=	R_2 J

Which of the following expressions gives the specific heat capacity of copper in J kg^{-1} °C^{-1} ?

A. $\dfrac{m(R_2 - R_1)}{26}$

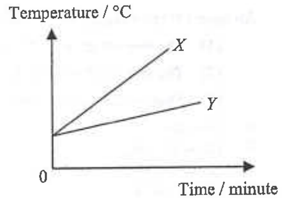
B. $\dfrac{R_1 - R_2}{26m}$

C. $\dfrac{R_2 - R_1}{26m}$

D. $\dfrac{m(R_1 - R_2)}{26}$

30. **< HKCE 2010 Paper II - 33 >**

The figure shows the temperature-time graph of two objects *X* and *Y* when they are heated at the same power. Which of the following deductions are correct ?



(1) The heat capacity of *X* is smaller.
(2) If *X* and *Y* are made of the same material, the mass of *X* is smaller.
(3) The specific heat capacity of *X* is smaller.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

31. **< HKCE 2011 Paper II - 8 >**

Two liquids *X* and *Y* are heated by two different heaters. The energy supplied, the mass of the liquid and the temperature rises are recorded as follows.

	Liquid *X*	Liquid *Y*
Energy supplied / J	24000	18000
Mass / kg	0.3	0.2
Temperature rise / °C	20	25

Which of the following statements are correct ?

(1) The heat capacity of *X* is larger than that of *Y*.
(2) The specific heat capacity of *X* is larger than that of *Y*.
(3) The heat capacity of *X* determined remains the same if the experiment is repeated by doubling the mass of *X*.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

Part B : Supplemental exercise

32. What is the advantages of using mercury in a liquid-in-glass thermometer ?

(1) It expands evenly with rise in temperature.
(2) It is liquid over a convenient range.
(3) It is transparent.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

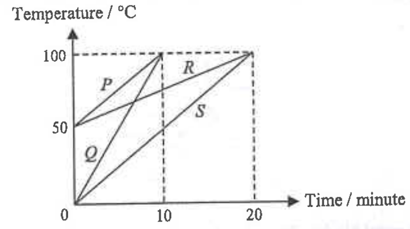
33. Which of the following can increase the heat capacity of a cup of water ?

(1) Increase the mass of the water
(2) Increase the temperature of the water
(3) Change the water to another cup

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

25. **< HKCE 2007 Paper II - 10 >**

Four liquids *P*, *Q*, *R* and *S* with the same mass are heated at the same rate. The graph below shows the variation of their temperatures with time.



Which liquid has the highest specific heat capacity ?

A. *P*
B. *Q*
C. *R*
D. *S*

26. **< HKCE 2008 Paper II - 35 >**

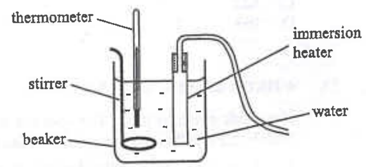
What physical properties does the temperature of an object represent ?

(1) A measure of the degree of hotness of the object.
(2) A measure of the internal energy of the object.
(3) A measure of the average kinetic energy of the molecules of the object.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

27. **< HKCE 2008 Paper II - 10 >**

A 100 W immersion heater is used to heat 0.5 kg of water, which is being stirred by a stirrer. After 3 minutes, the water temperature increases from 25°C to 30°C. What is the estimated energy loss in this period ? Given : specific heat capacity of water = 4200 J kg^{-1} °C^{-1}



A. 7500 J
B. 10500 J
C. 18000 J
D. 28500 J

28. **< HKCE 2009 Paper II - 9 >**

Which of the following descriptions about internal energy are correct ?

(1) Different masses of water at the same temperature have the same amount of internal energy.
(2) A copper block has greater internal energy when it is hot than when it is cold.
(3) Water at 0°C has greater internal energy than a block of ice of the same mass at 0°C.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

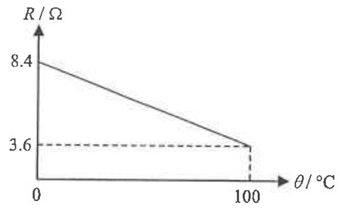
29. **< HKCE 2009 Paper II - 33 >**

A bottle of 0.5 kg water and a bottle of 0.75 kg water have been stored in a refrigerator for a few days. Which of the following statements are correct ?

(1) The temperatures of the two bottles of water are equal.
(2) The average kinetic energy of the water molecules in the two bottles is equal.
(3) The total potential energy of the water molecules in the two bottles is equal.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

41.



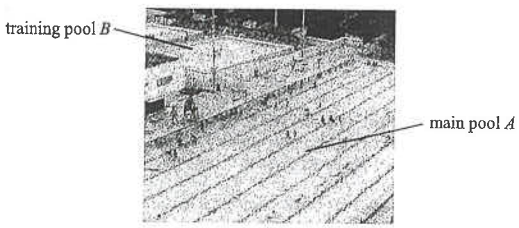
The variation of electrical resistance can be used to determine temperature. Suppose a thermistor has resistances of 8.4 Ω and 3.6 Ω at ice point and steam point respectively. Assume that the change of resistance with temperature is uniform as shown in the figure. What would be the temperature if the resistance of the of the metal wire is 5.8 Ω ?

A. 42°C
B. 46°C
C. 54°C
D. 58°C

Part C : HKDSE examination questions

42. **< HKDSE Practice Paper IA - 2 >**

In the figure below, a training pool B is located next to the main pool A. The training pool B has a smaller area and is shallower. If the pools are under the sunlight at the same time, which of the following statements about the rise in the water temperature of the two pools is correct ? Assume that the initial water temperatures of the pools are the same.



A. The water temperature of training pool B rises faster because it is shallower.
B. The water temperature of training pool B rises faster because it has a smaller surface area.
C. The water temperature of main pool A rises faster because it is deeper.
D. The water temperature of main pool A rises faster because it has a larger surface area.

43. **< HKDSE Practice Paper IA - 3 >**

Peter adds 50 g of milk at 20°C to 350 g of tea at 80°C, what is the final temperature of the mixture ?

Given : Specific heat capacity of milk = 3800 J kg^{-1} °C^{-1}
Specific heat capacity of tea = 4200 J kg^{-1} °C^{-1}

A. 50.0°C
B. 72.5°C
C. 73.1°C
D. 77.4°C

34. What happens when a cup of water at room temperature is heated ?

(1) An increase in the total number of water molecules
(2) An increase in molecular size
(3) An increase in the average kinetic energy of the molecules

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

35. Which of the following physical properties cannot be used to measure temperature ?

A. Liquid volume
B. Resistance of metal
C. Mass
D. Gas pressure

36. The length between the 0°C mark and the 100°C mark is 20 cm. When the mercury level is 5 cm below the 100°C mark, the temperature is

A. 25°C
B. 50°C
C. 60°C
D. 75°C

37. When a mercury thermometer is immersed in melting ice, the length of the mercury thread is 2 cm. When it is put into the steam above boiling water, the length of the thread is found to be 24 cm. What is the difference between each 1°C mark on the thermometer ?

A. 0.22 cm
B. 0.24 cm
C. 2.20 cm
D. 22.0 cm

38. Heat is supplied at the same rate to equal amount of water and oil placed in similar containers. The temperature of the oil rises faster. Which of the following is the possible reason ?

A. Oil has a lower density than water.
B. Oil has a higher boiling point than water.
C. Oil has a smaller specific heat capacity than water.
D. Oil evaporates less readily than water.

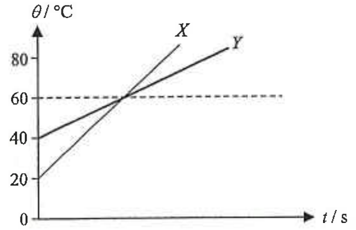
39. It takes 8 minutes to raise the temperature of 2 kg of a liquid by 40°C using a 2.5 kW heater. How long would it take to raise the temperature of 4 kg of the liquid by 20°C using a 5.0 kW heater ? (Assume no heat loss to the surroundings.)

A. 2 minutes
B. 4 minutes
C. 16 minutes
D. 32 minutes

40. A beaker contains 0.5 kg of water at 60°C. A cup containing 0.3 kg of water at 18°C is poured into the beaker. When the mixture reaches the final common temperature, 200 J of heat is lost to the surroundings. Calculate the final temperature of the mixture. Given : specific heat capacity of water is 4200 J kg^{-1} °C^{-1}.

A. 35.6°C
B. 44.2°C
C. 48.5°C
D. 54.2°C

47. **< HKDSE 2015 Paper IA - 2 >**



Two objects X and Y are heated separately by heaters of the same power. They are made of the same material. The graph shows the variation of temperature θ of X and Y with time t. What is the ratio of mass of X to that of Y ?

A. 3 : 1
B. 2 : 1
C. 1 : 2
D. 2 : 3

48. <HKDSE 2020 Paper IA-2>

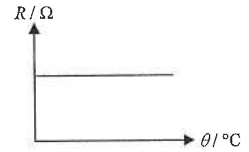
An electric kettle which contains 1 kg of water at room temperature takes 168 s to heat up the water to boiling point. The kettle's rated value is '220 V, 2000 W'. Assume that all the electrical energy consumed by the kettle is transferred to the water. Which of the following statements is/are correct ?
Given: specific heat capacity of water = 4200 J kg^{-1} °C^{-1}

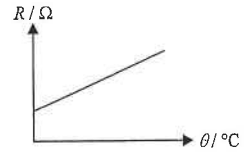
(1) The initial temperature of the water is 20 °C.
(2) The resistance of the kettle's heating element is about 24 Ω.
(3) If the electric kettle is operated with 110 V, the time taken to heat up the water to boiling point will be doubled.

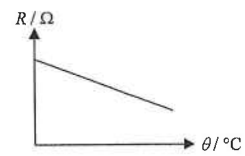
A. (1) only
B. (3) only
C. (1) and (2) only
D. (1), (2) and (3)

44. **< HKDSE Practice Paper IA - 1 >**

The graph below show how the electrical resistance R of three different circuit elements change with temperature θ. Which of the circuit elements can be used to measure temperature ?

(1)


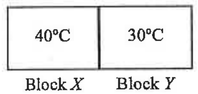
(2)


(3)


A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

45. **< HKDSE 2012 Paper IA - 1 >**

Two metal blocks X and Y of the same mass and of initial temperatures 40°C and 30°C respectively are in good thermal contact as shown. The specific heat capacity of X is greater than that of Y. Which statements is correct when a steady state is reached ? Assume no heat loss to the surroundings.



A. The temperature of block X is higher than that of block Y.
B. Their temperature becomes the same and is lower than 35°C.
C. Their temperature becomes the same and is higher than 35°C.
D. Their temperature becomes the same is equal to 35°C.

46. **< HKDSE 2015 Paper IA - 3 >**

When two objects P and Q are in contact, heat flows from P to Q. P must have a higher

(1) temperature.
(2) internal energy.
(3) specific heat capacity.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. B	11. D	21. B	31. A	41. C
2. D	12. D	22. A	32. A	42. A
3. C	13. C	23. A	33. A	43. C
4. B	14. A	24. B	34. B	44. D
5. B	15. C	25. C	35. C	45. C
6. B	16. C	26. B	36. D	46. A
7. D	17. D	27. A	37. A	47. C
8. C	18. A	28. C	38. C	48. C
9. B	19. B	29. A	39. B	
10. C	20. C	30. A	40. B	

M.C. Solution

1. B

By $\dfrac{\theta}{100} = \dfrac{\ell - \ell_0}{\ell_{100} - \ell_0}$ $\quad\therefore\ \dfrac{\theta}{100} = \dfrac{11-2}{22-2}$ $\quad\therefore\ \theta = 45°C$

2. D

By $c = \dfrac{E}{m \cdot \Delta T} \propto \dfrac{1}{m \cdot \Delta T}$

$\therefore$ The smallest specific heat capacity corresponds to the largest product of mass and rise in temperature.

$\therefore$ S would be the substance with the smallest specific heat capacity.

3. C

As heat capacity = mass × specific heat capacity ($C = m\,c$)

$\therefore$ Heat capacity depends on mass m and the material c but does not depend on shape.

4. B

× A. Same type of material (water) has the same specific heat capacity.

✓ B. Different states of the same substance have different specific heat capacities.

× C. Specific heat capacity is independent of the container

× D. Specific heat capacity is independent of the temperature

5. B

By $E = P\,t = m\,c\,\Delta T$ $\quad\therefore\ (500)(20) = (1)\,c\,(60-20)$ $\quad\therefore\ c = 250\ \text{J kg}^{-1}\ °\text{C}^{-1}$

6. B

By $E = P\,t = m\,c\,\Delta T$

$\therefore\ P(100) = (0.5)(4000)(70-10)$

$\therefore\ P = 1200$ W

7. D

At time = 300 s, the heater is still hot and still transfers heat to the water

$\therefore$ water temperature rises for a short while as shown in C and D

A short while after the heater switched off, water starts to cool down,

$\therefore$ the temperature of water drops and finally equals the initial room temperature as shown in D.

8. C

By $E = m\,c\,\Delta T$

$\therefore\ c = \dfrac{E}{m \cdot \Delta T} = \dfrac{16500}{0.5 \times 64}\ \text{J kg}^{-1}\ °\text{C}^{-1}$

9. B

Water, with high specific heat capacity, can absorb large amount of the heat in the engine.

$\therefore$ Water is used as coolant.

10. C

By $E = m\,c\,\Delta T$

$\therefore\ \Delta T = \dfrac{E}{m \cdot c} \propto \dfrac{1}{m \cdot c}$

$\therefore$ The smallest rise in temperature corresponds to the largest product of mass and specific heat capacity.

$\therefore$ R would be the substance with the smallest rise in temperature.

11. D

× (1) Internal energy is the total energy stored in a body, heat is a process to transfer energy.

✓ (2) It is the definition of heat.

✓ (3) When a body is heated, energy is transferred to the body and its internal energy must increase.

12. D

✓ (1) Water has a high specific heat capacity to absorb heat in car engines.

✓ (2) Since water has a high specific heat capacity, its temperature change is smaller and thus coastal areas have less change of temperature while inland areas have larger change of temperature between summer and winter.

✓ (3) Since human beings contain large amount of water and water has a high specific heat capacity, therefore, body temperature changes more slowly than the surroundings.

20. C

Since $E = m\,c\,\Delta T$

$\therefore$ $(R_2 - R_1) = m\,c\,(47 - 21)$ $\therefore$ $c = \dfrac{R_2 - R_1}{26\,m}$

21. B

Heat lost by the metal block = heat gained by water

$\therefore$ $m_b\,c_b\,\Delta T_b = m_w\,c_w\,\Delta T_w$

$\therefore$ $(0.8)\,c_b\,(100 - 38) = (0.3)\,(4200)\,(38 - 23)$

$\therefore$ $c_b = 381\ \text{J kg}^{-1}\ {}^\circ\text{C}^{-1}$

22. A

By $c_b = \dfrac{m_w\,c_w\,\Delta T_w}{m_b\,\Delta T_b}$

✓ A. If some hot water is adhered to the metal block, ΔT_w is greater and thus c_b is higher than the true value.

× B. If some energy is lost to the surroundings, ΔT_w is smaller and thus c_b should be lower than the true value.

× C. If some energy is absorbed by the cup, ΔT_w is smaller and thus c_b should be lower than the true value.

× D. If the temperature of the metal block is still higher than 38°C when the water reaches 38°C,
heat gained by the water is smaller and thus ΔT_w is smaller $\therefore$ c_b should be lower than the true value.

23. A

Heat must flow from a body of higher temperature to a body of lower temperature until they are at the same temperature.

If there is no heat flow, the two bodies must be at the same temperature.

24. B

$E = m\,c\,\Delta T = (0.5)\,(4200)\,(100 - 20) = 168\,000\ \text{J}$

$P = \dfrac{E}{t} = \dfrac{168000}{4 \times 60} = 700\ \text{W}$

25. C

By $E = P\,t = m\,c\,\Delta T$

Slope $= \dfrac{\Delta T}{t} = \dfrac{P}{m\,c} \propto \dfrac{1}{c}$

Since R has the smallest slope, R has the highest specific heat capacity c.

26. B

✓ (1) Temperature is a measure of the degree of hotness of an object.

× (2) Internal energy depends on temperature, but also depends on mass, material and state.

✓ (3) Temperature and average kinetic energy of the molecules are inter-related.

13. C

× (1) Heater is still hot and still transfers heat to the liquid after switched off
Thus the temperature should not be taken immediately
but should wait for a short while until the liquid reaches the final temperature.

✓ (2) Covering the cup with a lid can reduce energy loss to surroundings and improve the accuracy

✓ (3) Stirring can ensure uniform temperature of the liquid

14. A

By $E = P\,t = m\,c\,\Delta T$

$\therefore$ $(100)\,(2 \times 60) = (0.3)\,(2000)\,(T - 23)$

$\therefore$ $T = \left(\dfrac{100 \times 120}{0.3 \times 2000} + 23\right){}^\circ\text{C}$

15. C

By $E = P\,t = m\,c\,\Delta T$

$\therefore$ $(400)\,(60) = (2)\,c\,(25 - 15)$

$\therefore$ $c = 1200\ \text{J kg}^{-1}\ {}^\circ\text{C}^{-1}$

16. C

✓ (1) It is the definition of internal energy.

× (2) Two bodies of different masses have different internal energy even if they are at the same temperature.

✓ (3) It is the definition of heat.

17. D

As $E = m\,c\,\Delta T$

$\therefore$ slope $= \dfrac{E}{\Delta T} = m\,c \propto c$

As slope of X > slope of Y = slope of Z

$\therefore$ $c_X > c_Y = c_Z$.

18. A

× (1) Internal energy also depends on mass of the body and the type of material.

× (2) Since P and Q are two different objects, they should have different specific heat capacity.

✓ (3) Heat would always flow from a body of high temperature to another body of lower temperature.

19. B

By $E = P\,t = m\,c\,\Delta T$

$\therefore$ $t = \dfrac{m \cdot c \cdot \Delta T}{P} \propto c \cdot \Delta T$

where ΔT is the difference of temperatures between the boiling point and 20°C

Among the four liquids, Q has the smallest $c\,\Delta T$, thus Q boils first.

33. A

✓ (1) Heat capacity = mass × specific heat capacity

✗ (2) Heat capacity is independent of the temperature of the object

✗ (3) Heat capacity is independent of the container

34. B

✗ (1) Total number of water molecules should remain unchanged.

✗ (2) Molecular size would not increase when temperature is increased.

✓ (3) When water is heated, its temperature increases ; thus the average K.E. of water molecules increases.

35. C

✓ A. The expansion of liquid causes the liquid volume to increase with temperature

✓ B. Resistance of metal increases with temperature.

✗ C. Mass remains constant when temperature increases.

✓ D. Gas pressure in a fixed container increases with temperature.

36. D

If the mercury level is 5 cm below 100°C mark, then it is 15 cm above 0°C mark.

By $\dfrac{\theta}{100} = \dfrac{\ell - \ell_0}{\ell_{100} - \ell_0}$ $\quad \therefore \dfrac{\theta}{100} = \dfrac{15}{20}$ $\quad \therefore \theta = 75°C$

37. A

Length of mercury thread between 0°C mark and 100°C mark = 24 – 2 = 22 cm

Length of mercury thread between each 1°C mark = $\dfrac{22}{100}$ = 0.22 cm

38. C

By $E = m c \Delta T$

a smaller value of specific heat capacity c causes a greater rise of temperature ΔT.

39. B

By $E = P t = m c \Delta T$

$t = \dfrac{m c \Delta T}{P} \propto \dfrac{m \Delta T}{P}$ $\quad \therefore \dfrac{t_1}{t_2} = \dfrac{m_1}{m_2} \cdot \dfrac{\Delta T_1}{\Delta T_2} \cdot \dfrac{P_2}{P_1}$

$\therefore \dfrac{(8)}{t_2} = \dfrac{(2)}{(4)} \cdot \dfrac{(40)}{(20)} \cdot \dfrac{(5.0)}{(2.5)}$ $\quad \therefore t_2 = 4$ minutes

40. B

Heat lost by the hot water = heat gained by the cold water + heat lost to surroundings

$\therefore (0.5)(4200)(60 - \theta) = (0.3)(4200)(\theta - 18) + (200)$ $\quad \therefore \theta = 44.2°C$

27. A

① $E = P t = (100)(3 \times 60) = 18000$ J

② $E = m c \Delta T = (0.5)(4200)(30 - 25) = 10500$ J

③ Energy loss = 18000 – 10500 = 7500 J

28. C

✗ (1) Internal energy depends on the mass of water,
water of greater mass contains more internal energy.

✓ (2) Internal energy depends on temperature,
water of higher temperature contains more internal energy.

✓ (3) Internal energy depends on the state,
water at liquid state contains more internal energy than that in solid state.

29. A

✓ (1) After a long time, the temperature of the water should be same as the environmental temperature,
i.e. temperature inside the refrigerator, thus their temperatures should be equal.

✓ (2) Average kinetic energy depends on the temperature, thus their average *KE* is equal.

✗ (3) Total *PE* depends on the state, and also depends on the number of molecules,
the bottle containing greater mass of water has more molecules, thus it has more total *PE*.

30. A

✓ (1) By $E = P t = C \Delta T$ $\quad \therefore$ slope = $\dfrac{\Delta T}{t} = \dfrac{P}{C} \propto \dfrac{1}{C}$
Object X has greater slope, thus X has smaller heat capacity C.

✓ (2) If they are made of the same material, they have the same specific heat capacity c.
By $C = m c \propto m$ As X has the smaller C, X has the smaller mass m.

✗ (3) As the two objects may have different masses, their relation of specific heat capacity c cannot be known.

31. A

✓ (1) $C = \dfrac{E}{\Delta T}$ $\quad \therefore C_X = \dfrac{24000}{20} = 1200$ J °C^{-1} and $C_Y = \dfrac{18000}{25} = 720$ J °C^{-1} $\quad \therefore C_X > C_Y$

✓ (2) $c = \dfrac{E}{m \cdot \Delta T}$ $\quad \therefore c_X = \dfrac{24000}{0.3 \times 20} = 4000$ J kg^{-1} °C^{-1} and $c_Y = \dfrac{18000}{0.2 \times 25} = 3600$ J kg^{-1} °C^{-1} $\therefore c_X > c_Y$

✗ (3) Heat capacity depends on the mass. If the mass is doubled, the heat capacity will also be doubled.

32. A

✓ (1) Mercury expands uniformly when temperature rises.

✓ (2) Mercury remains as liquid at least from 0°C to 100°C which is suitable for our daily application.

✗ (3) Mercury is opaque.

47. C

By $P\,t = m\,c\,\Delta\theta$

Since the two objects are made of the same material, they have the same specific heat capacity c.

For the same time t and same power P,

$m_X : m_Y = \Delta\theta_Y : \Delta\theta_X = (60-40) : (60-20) = 20 : 40 = 1 : 2$

41. C

$\theta = \dfrac{5.8-8.4}{3.6-8.4} \times 100 = 54°C$

42. A

✓ A. Since pool B is shallower, the mass of water is less, by $E = m\,c\,\Delta T$, the rise of temperature is faster.

× B. Pool B absorbs less solar energy due to the smaller surface area, it is not the reason for the faster rise of temperature.

× C. Since pool A is deeper, the mass of water is more, thus the rise of temperature should not be faster.

× D. Although pool A absorbs more solar energy due to larger surface area, larger surface area also implies more mass, thus the rise of temperature cannot be faster.

43. C

By conservation of energy and assume no heat lost to the container and surrounding air.

Heat gained by the milk = heat lost by the tea

$(0.050)(3800)(\theta - 20) = (0.350)(4200)(80 - \theta)$

$\therefore\ \theta = 73.1°C$

44. D

× (1) Since the resistance is constant and does not change with the temperature, it is not suitable.

✓ (2) As the resistance increases with the temperature, it is suitable to be used to measure temperature.

✓ (3) As the resistance decreases with the temperature, it is suitable to be used to measure temperature.

45. C

At steady state, the temperature must be the same.

By conservation of energy and assume no heat lost to the surroundings.

Heat lost by block X = heat gained by block Y

$m\,c_X\,\Delta T_X = m\,c_Y\,\Delta T_Y$

$\therefore\ c_X > c_Y \qquad \therefore\ \Delta T_X < \Delta T_Y$

Thus, the final temperature should be closer to 40°C, that is, higher than 35°C.

46. A

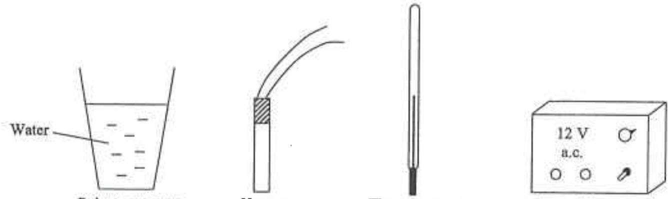
✓ (1) Heat must flow from object of higher temperature to that of lower temperature. Thus, temperature of P must be higher than that of Q.

× (2) A body may have less internal energy than another body but higher temperature. Thus, no conclusion can be drawn about the internal energy of P and Q.

× (3) The specific heat capacity depends on the material. Different specific heat capacity would not affect the direction of flow of heat.

2. **< HKCE 1986 Paper I - 4 >**

The below figure shows the apparatus which may be used to measure the specific heat capacity of water.



(a) Draw a simple diagram to show how the apparatus can be set up for the experiment. (3 marks)

(b) The following are readings taken in the experiment : (7 marks)

The rating of the heater	=	12 V 40 W
Mass of water used	=	200 g
Initial temperature of the water	=	25.1°C
Final temperature of the water	=	53.2°C
Time taken to heat up the water	=	10 minutes

(i) Calculate the specific heat capacity of water as measured from the experiment, given that the water is well-stirred throughout the experiment.

(ii) Give two reasons why a polystyrene cup should be used in the experiment.

(iii) Why should the water be stirred throughout the experiment ?

(c) Describe, with the aid of a diagram, a method to check whether the power output of the heater is 40 W. Show how the actual power output of the heater can be calculated. (5 marks)

Diagram

The following list of formulae may be found useful :

Energy transfer during heating or cooling $E = m c \Delta T$

Part A : HKCE examination questions

1. **< HKCE 1984 Paper I - 4 >**

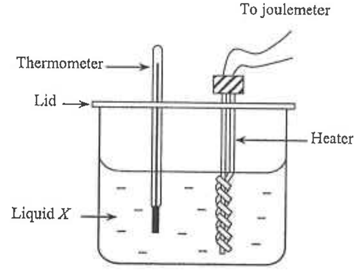


Figure 1

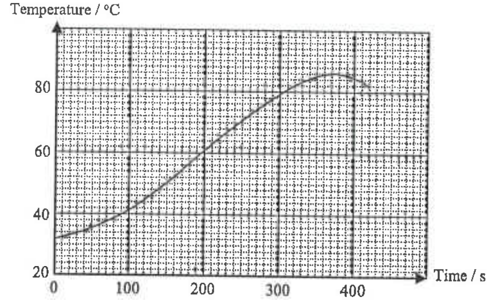


Figure 2

The figure 1 above shows an experimental set-up to find the specific heat capacity of a liquid. The liquid X, contained in the plastic cup, is heated from room temperature by an immersion heater. The energy transferred through the heater is measured by a joulemeter. The heater is switched on for 330 s and then switched off. The variation of the temperature of the liquid X with time is plotted in a graph shown in figure 2.

(a) After the heater is switched off, the temperature of the liquid rises for a while and then falls. Explain why. (3 marks)

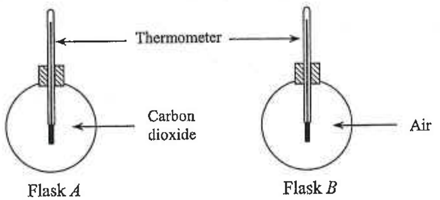
(b) What is the maximum increase in the temperature of liquid X in this experiment ? (2 marks)

(c) The initial and final readings of the joulemeter are 74050 J and 83770 J respectively. The mass of the liquid X is 0.2 kg. What is the specific heat capacity of the liquid, as found from this experiment ? Assume the heat capacity of the apparatus and the heat lost to the surroundings are negligible. (4 marks)

(d) Although the plastic cup is made of poor conducting material, some energy is still lost to the surroundings. Should the result obtained in (c) be higher or lower than the true value of the specific heat capacity of the liquid X ? Explain briefly. (3 marks)

(e) If a student forgets to cover the plastic cup with the lid, would he expect the maximum increase in temperature to be higher than, equal to or lower than the value obtained in (b) ? Explain briefly. (3 marks)

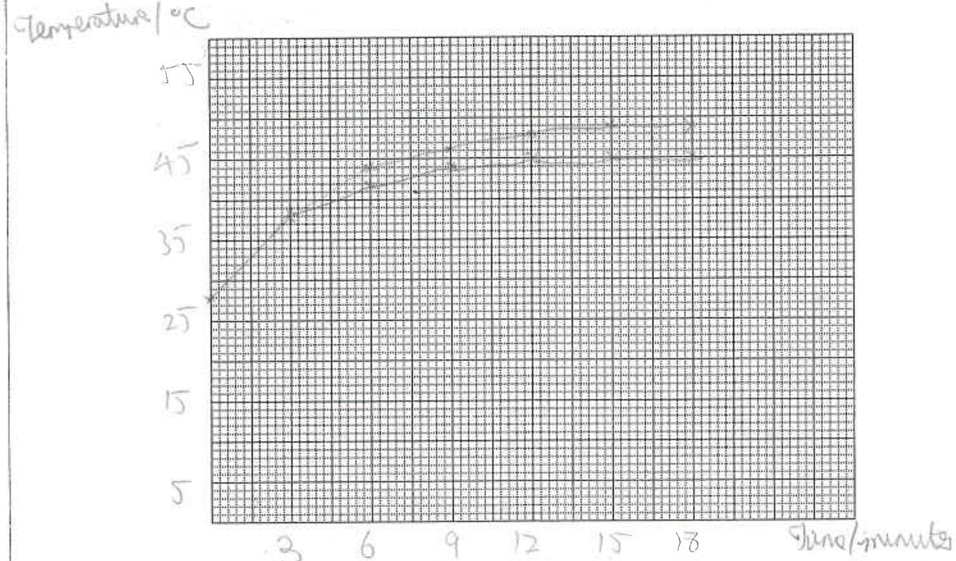
4. **< HKCE 1991 Paper I - 5 >**



The figure above shows the apparatus of an experiment to study the absorption of solar energy by gases. Identical flasks *A* and *B* are filled with carbon dioxide and air respectively. They are placed under sunlight and their temperatures are taken at 3-minute intervals. The results are as follows :

Time / minutes	0	3	6	9	12	15	18
Temperature in *A* / °C	28.0	38.4	44.0	46.2	47.8	48.8	48.8
Temperature in *B* / °C	28.0	37.7	41.8	43.7	45.2	46.0	46.0

(a) Using a scale that 2 cm represents 5°C and 2 cm represents 3 minutes, plot the temperature-time graphs for carbon dioxide and air on the same graph paper. (5 marks)



(b) Why does each of the gases reach a steady temperature ? (2 marks)

(c) The mass of carbon dioxide in flask *A* is 0.00196 kg and the mass of air in flask *B* is 0.00125 kg. The specific heat capacities of carbon dioxide and air are 640 J kg^{-1} °C^{-1} and 740 J kg^{-1} °C^{-1} respectively. Which flask of gas gains more energy to reach its steady temperature ? Show your calculations. (5 marks)

3. **< HKCE 1987 Paper I - 6 >**

The specific heat capacity of water is 4200 J kg^{-1} °C^{-1}.

(a) What does this statement mean ? (2 marks)

(b) Describe briefly, with the aid of a diagram, an experiment to measure the specific heat capacity of water. (5 marks)

Diagram

(c) A kettle with 1.6 kg of water is placed on top of an electric heater at 1000 W. It takes 14 minutes for the temperature of the water to increase from 20°C to 100°C.

(i) Find

(I) the energy released by the heater, and

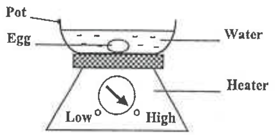
(II) the energy absorbed by the water

during that time. (4 marks)

(ii) Give TWO reasons to account for the difference of the values you obtained in (i) and (ii). (2 marks)

(d) The specific heat capacity of water is higher than most of the other liquids. Name TWO practical importance of this in daily life. (2 marks)

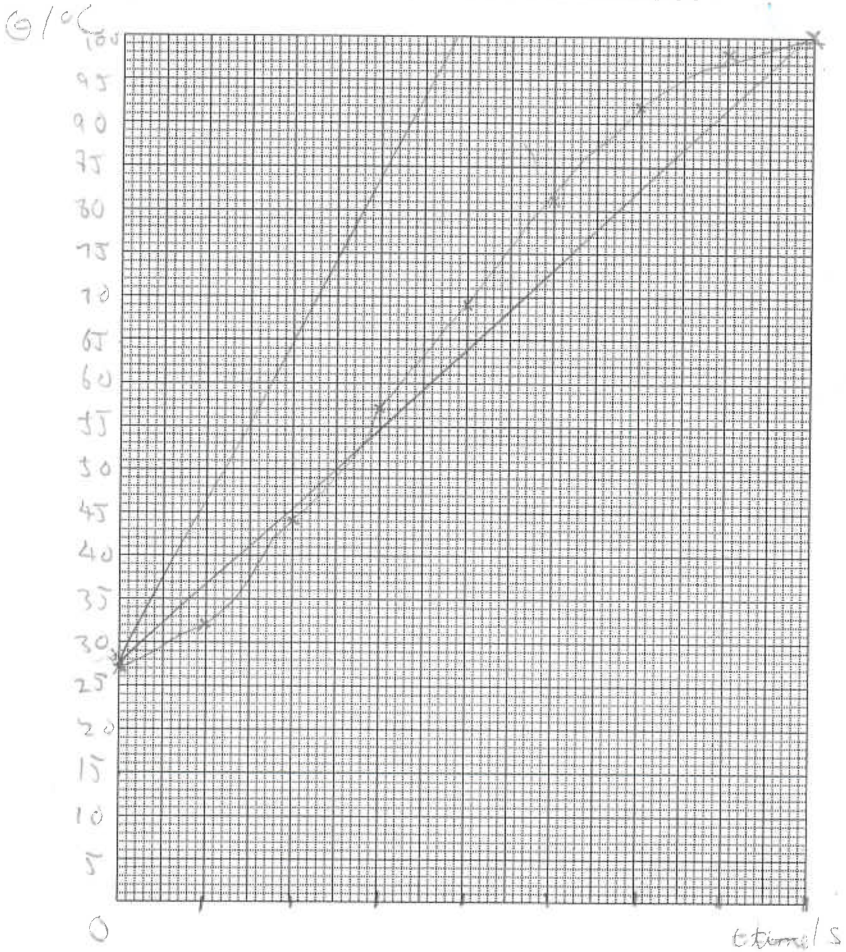
6. < HKCE 2000 Paper I - 8 >



An electric heater has two settings : 'Low' and 'High'. The power output of the heater is 1400 W at the 'Low' setting and 2200 W at the 'High' setting. The heater is used to cook an egg. The egg is first put into a pot containing 1 kg of water and the heater is operated at the 'High' setting. (See the above figure.) The temperature of the water is recorded every 30 s and the following results are obtained :

Time t / s	0	30	60	90	120	150	180	210	240
Temperature θ / °C	27	32	44	57	69	81	92	98	100

(a) Using a scale of 1 cm to 5°C and 1 cm to 15 s, plot a graph of θ against t on graph paper. (4 marks)



4. (d) Each year the amount of carbon dioxide in the atmosphere is increased by billions of tons.

(i) Suggest a possible effect on the mean temperature of the Earth. (1 mark)

____

(ii) Suggest two methods to reduce the amount of carbon dioxide in the atmosphere. (2 marks)

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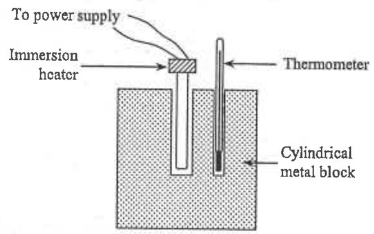
5. < HKCE 1992 Paper I - 4 >

A student uses the experimental set-up shown in the below figure to find the specific heat capacity of a metal. The cylindrical metal block is heated by an immersion heater of unknown power.



The following results are obtained:

Mass of metal block	=	1 kg
Initial temperature of metal block	=	29°C
Final temperature of metal block	=	41°C
Energy supplied by the heater	=	12300 J

(a) Describe, with the help of a diagram, a method to measure the energy supplied by the heater. (4 marks)

Diagram

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(b) Calculate the specific heat capacity of the metal. (2 marks)

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(c) The value obtained in (b) is found to be higher than the actual specific heat capacity of the metal. Suggest a reason for this and explain your answer briefly. (3 marks)

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(d) Suggest TWO improvements on the set-up to increase the accuracy of the experiment. (2 marks)

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(e) Is the above method suitable for finding the specific heat capacity of wood ? Explain briefly. (3 marks)

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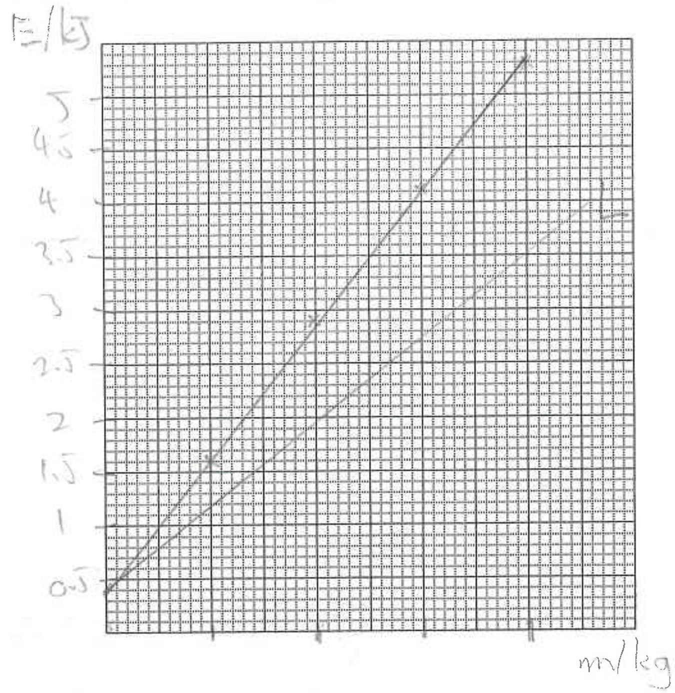
7. (b) (i) Plot a graph of E against m in the following figure. A scale of 1 cm to 0.5 kJ and 0.025 kg is used. (4 marks)



(ii) Using the graph plotted in (b)(i), find the specific heat capacity of liquid X. (3 marks)

(iii) Estimate the heat absorbed by the apparatus. (1 mark)

(iv) If the experiment is repeated with liquid Y with a smaller specific heat capacity than liquid X and the increase in temperature is also 10°C, sketch a graph of E against m you would expect to obtain in the above figure, and label it as L. (2 marks)

6. (b) (i) Find the energy supplied by the heater from $t = 0$ to $t = 240$ s. (2 marks)

(ii) Find the energy absorbed by the water from $t = 0$ to $t = 240$ s.
(Note : Specific heat capacity of water = 4200 J kg^{-1} °C^{-1}.) (2 marks)

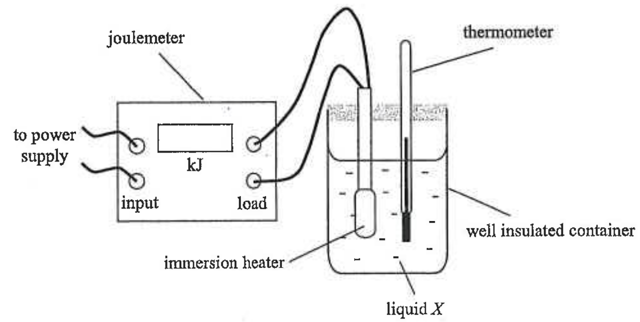
(iii) State **two** reasons to account for the difference between your answers in (i) and (ii). (2 marks)

(c) After the water boils, the heater is turned to the 'Low' setting and the water still boils afterwards. A student argues that this will lengthen the time required to cook the egg. Do you agree ? Explain your answer. (3 marks)

(d) If less water is used in the above cooking process, on the graph in (a), draw the graph of θ against t you expect to obtain. (2 marks)

7. **< HKCE 2008 Paper I - 4 >**

A student performs an experiment with the setup in the below Figure to measure the specific heat capacity of a liquid X. The joulemeter in the figure is used to measure energy consumed by the immersion heater.



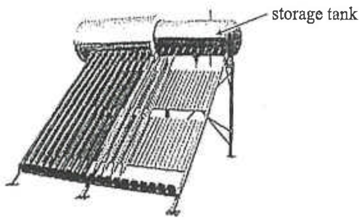
The increase in the reading of the joulemeter (E) for an increase of temperature of 10°C for different mass (m) of liquid X is recorded in the Table below.

E / kJ	1.6	2.9	4.1	5.3
m / kg	0.05	0.10	0.15	0.20

(a) State the importance of using a "well insulated" container in the experiment. (1 mark)

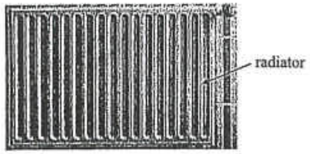
9. **< HKDSE 2013 Paper IB - 1 >**

Figure 1



A solar water heater shown in Figure 1 is installed on the rooftop of a house. During the day, the heater heats up 1.5 m^3 of water to 80°C. At night, the hot water in the storage tank is circulated to the radiators (see Figure 2) in different rooms of the house to keep the rooms warm.

Figure 2



Given : density of water = 1000 kg m^{-3}

specific heat capacity of water = 4200 J kg^{-1} °C^{-1}

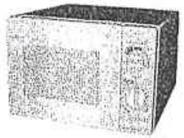
(a) Given that 15% of the energy is lost during the transfer of water, how much heat can be released from the system to the rooms when the water temperature drops to 60°C ? (3 marks)

(b) Given that during night time the radiators maintain an average output power of 4.5 kW, how long can the radiators maintain this average power until the water temperature in the system drops to 60°C ? Give your answer in hours. (2 marks)

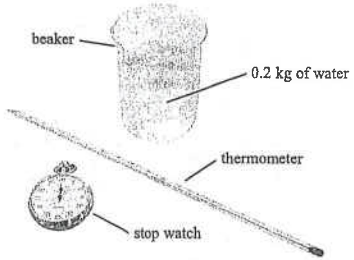
(c) The rate of heat released by the solar water heating system during the time period calculated in (b) is in fact not constant and gradually drops. Explain why this is so. (1 mark)

Part B : HKDSE examination questions

8. **< HKDSE Sample Paper IB - 9 >**



The Figure above shows a microwave oven. Mary wants to conduct an experiment to estimate the useful output power of the oven. She is provided with the apparatus and material shown in the Figure below.



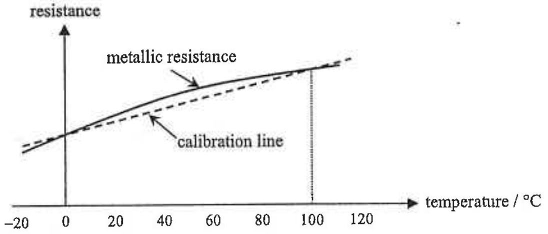
(a) Describe how Mary should conduct the experiment. Specify all measurements that Mary has to take. State **EITHER** one precaution taken **OR** one assumption made when conducting this experiment. Write down an equation for calculating the useful output power. (5 marks)

(b) The value obtained by Mary is found to be smaller than the specified power of the oven. Suggest one possible reason to account for this difference. (1 mark)

(c) Explain whether increasing the mass of water used in the experiment would improve the accuracy of the experiment. (1 mark)

11. **< HKDSE 2015 Paper IB - 1 >**

A metallic resistance thermometer is calibrated at standard atmospheric pressure for the melting point of ice and the steam point of boiling water. The dotted calibration line in the figure below represents how the resistance of the thermometer varies with temperature if a linear resistance-temperature relationship is assumed. The solid curve shows how the resistance of the thermometer actually varies with temperature. The deviation of the curve from linearity has been exaggerated in the figure.



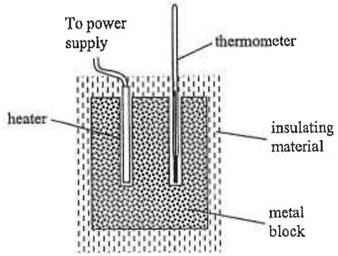
(a) (i) Using the resistances at the calibration points tabulated below, calculate the expected resistance at 60°C if the resistance varies linearly with temperature. (2 marks)

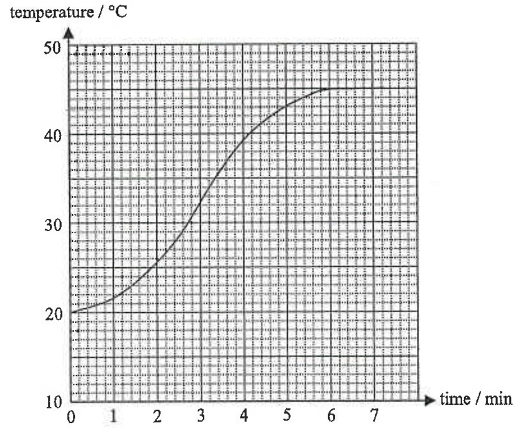
temperature / °C	resistance / Ω
0	102.00
100	140.51

(ii) Now if the resistance of the resistance thermometer is the value found in (a) (i), is the actual temperature higher than, lower than or equal to 60°C ? (1 mark)

(b) In an experiment to determine the specific heat capacity of water c_w, Peter used this calibrated resistance thermometer to measure the temperature of water being heated from 0°C to 60°C. Heating was stopped when this thermometer's resistance reached the value found in (a) (i). Assuming negligible heat exchange with the surroundings, no error in measuring the energy supplied and the mass of water, explain whether the experimental value of c_w found is higher than, lower than or the same as the actual value. (2 marks)

10. **< HKDSE 2014 Paper IB - 1 >**





The above figure shows an experimental set-up to find the specific heat capacity of a metal. The metal block is wrapped by insulating material. A heater is connected to a power supply. It is switched on when the temperature of the metal block is 20°C and then switched off when the temperature reaches 43°C. The graph shows the variation of the temperature of the metal block with time.

(a) Use the graph to find the duration time that the heater is switched on. (1 mark)

(b) After the heater is switched off, the temperature of the metal block continues to rise for a while. Explain why. (1 mark)

(c) Given : mass of the metal block = 0.80 kg ; heater voltage = 12 V ; heater current = 4.0 A.

(i) By considering the maximum temperature rise of the metal block, calculate the specific heat capacity of the metal as found from the experiment. (2 marks)

(ii) Would your result be the same, higher, or lower than the actual value of the specific heat capacity of the metal ? Explain. (2 marks)

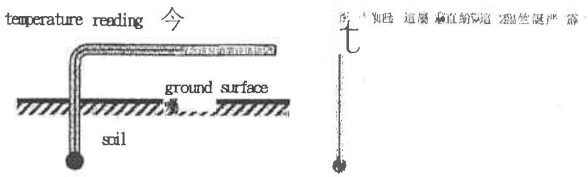
(d) This method is not suitable for measuring the specific heat capacity of a glass block. Explain. (1 mark)

13. <HKDSE 2017 Paper 1B - 1>

Read the following passage about soil thermometer and answer the questions that follow.

The temperature of soil changes with depth, and this information is important to farmers and scientists. To measure soil temperatures at depths close to the ground surface, the bulb of a thermometer is buried in the soil. The stem of the thermometer is bent 90° for easy reading. Figure 1a is a schematic diagram and Figure 1b shows a photo of a soil thermometer.

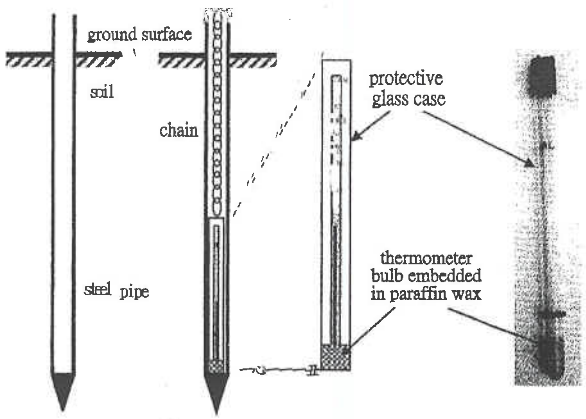
Figure 1



(a) (b)

For depths greater than 30 cm, a steel pipe is driven into the soil (Figure 2a); and a liquid-in-glass thermometer with a protective glass case is lowered into the steel pipe (Figure 2b). The bulb of the thermometer is embedded in paraffin wax (Figure 2c). To read the temperature, the thermometer is lifted out of the steel pipe by pulling the chain.

Figure 2



(a) (b) (c)

(a) As shown in Figure 1b, the bulb of the soil thermometer is very large compared to those of common thermometers. Suggest a reason for this design. (1 mark)

12. <HKDSE 2016 Paper 1B - 1>

The following experimental items are provided for estimating the specific heat capacity of bronze c_b.

a bronze sphere of mass 0.80 kg hung with a thread at room temperature T_o

a polystyrene cup containing 0.50 kg of water at room temperature T_o

a water bath maintained at 80 °C

a thermometer

a stirrer

a towel

(a) Describe the procedures of the experiment and state TWO experimental precautions to be taken. Write down an equation for finding c_b.

Given: specific heat capacity of water = 4200 J kg^{-1} °C^{-1} (6 marks)

(b) The value of c_b found in the experiment in (a) is lower than the actual value. Explain. (2 marks)

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

Question Solution

1. (a) After switching off, the heater is still hot. [1]

Energy continues to transfer to the liquid. [1]

After a while, heat is lost to the surroundings, thus temperature drops. [1]

(b) Maximum increase in temperature $= 86 - 32$ [1]

$= 54°C$ [1]

(c) $E = m\,c\,\Delta T$ [1]

$(83770 - 74050) = (0.2)\,c\,(54)$ [2]

$\therefore\ c = 900\ J\ kg^{-1}\ °C^{-1}$ [1]

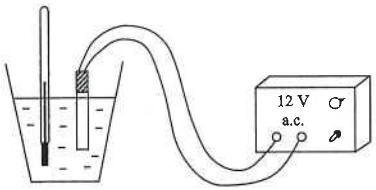
(d) Higher [1]

More energy is required to raise the same temperature of the liquid. [2]

(e) Smaller [1]

More energy is lost to surroundings [2]

2. (a)



< heater immersed in water > [1]

< heater connected to power supply > [1]

< thermometer immersed in water > [1]

(b) (i) Heat transferred to water :

$E = 40 \times 60 \times 10 = 24000\ J$ [1]

Increase in temperature :

$\Delta T = 53.2 - 25.1 = 28.1°C$ [1]

By $E = m\,c\,\Delta T$ [1]

$\therefore\ (24000) = (0.2)\,c\,(28.1)$

$\therefore\ c = 4270\ J\ kg^{-1}\ °C^{-1}$ [1]

13. (b) On a certain morning, the air temperature is 15°C. An observer takes a measurement of the soil temperature at 1 m deep. The thermometer reading is 20°C. It is given that the mass of the paraffin wax enclosing the thermometer bulb is 0.015 kg, and the specific heat capacity of paraffin wax is $2.9 \times 103\ J\ kg^{-1}\ °C^{-1}$.

(i) Calculate the energy loss of the paraffin wax as it cools down to the air temperature. (2 marks)

____

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(ii) It is known that the paraffin wax enclosing the bulb of the thermometer gains or loses energy at a constant rate of $0.5\ J\ s^{-1}$, estimate the time taken for the paraffin wax to reach the air temperature after the thermometer is lifted out of the soil. (2 marks)

____

____

____

(iii) If there is no paraffin wax enclosing the bulb of the thermometer, explain how the thermometer reading as recorded by the observer is affected. (2 marks)

____

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14 < HKDSE 2019 Paper 1B -1 >

(a) An insulated container of negligible heat capacity contains 1.5 kg of tea at a temperature of 60 °C.

(i) What mass of ice at 0 °C should be added to the tea so that the final temperature of the mixture is lowered to 10 °C ? Assume that the specific heat capacity of tea is the same as that of water. (3 marks)
Given: specific latent heat of fusion of ice = 3.34×10^5 J kg^{-1}
specific heat capacity of water = 4200 J kg^{-1} °C^{-1}

(ii) Suggest **ONE** modification to this bag that would enhance its ability to keep things stored inside at a low temperature. (1 mark)

15. < HKDSE 2020 Paper 1B -1 >

In a restaurant, 'wontons in soup' is prepared by putting 5 pieces of cooked wonton at 4 °C into a bowl with 0.60 kg of soup at temperature 96 °C.
Given: average mass of each piece of wonton = 0.02 kg
specific heat capacity of wonton = 3300 J kg^{-1} °C^{-1}
specific heat capacity of soup = 4200 J kg^{-1} °C^{-1}

(a) Find the final temperature of the mixture. Assume that the heat capacity of the bowl and the heat loss to the surroundings are negligible. (2 marks)

(b) The soup in (a) is taken from a metallic container of heat capacity 2000 J °C^{-1} containing 16 kg of soup maintained at 96 °C by an immersion heater.

(i) Why does that energy have to be supplied by the heater to keep the soup at 96 °C ? (1 mark)

(ii) A student used the following method to find the heater's operating power P: remove the heater from the container and record the temperature of the 16 kg of soup after 10 minutes. It is found that the temperature has dropped 9 °C. Estimate P. (3 marks)

(iii) If the student repeats the measurement after another 10 minutes, would the corresponding temperature drop be larger than, equal to or smaller than 9 °C ? Explain. (2 marks)

3. (c) (i) (II) $E = m\,c\,\Delta T$

$= (1.6) \times (4200) \times (100 - 20)$ [1]

$= 537\ 600$ J [1]

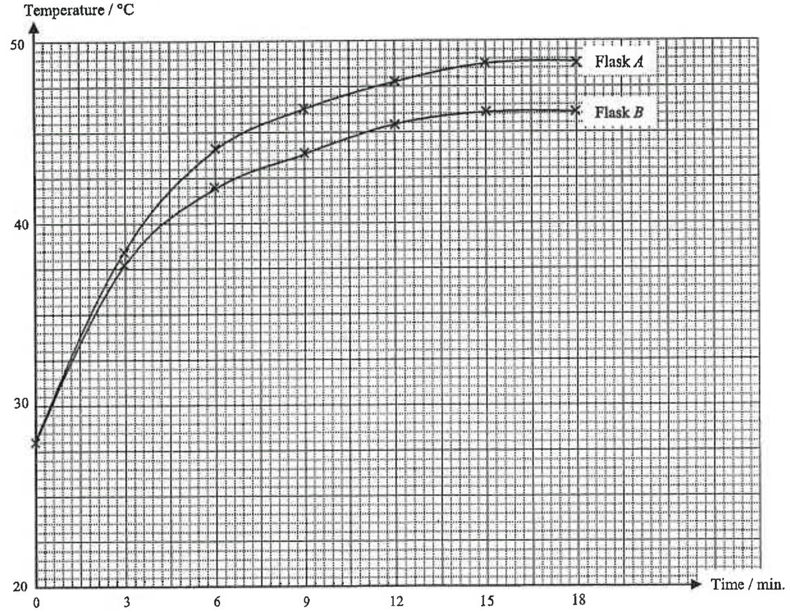
(ii) ① There is heat lost to surrounding air. [1]

② Some heat is used to heat up the kettle. [1]

(d) ① Water can be used as coolant in motor car. [1]

② Water causes the temperature of the sea to change much more slowly than that of the land.
Thus the coastal areas have relatively cooler summer and warmer winters than inland areas. [1]

4. (a)



< Correct scales > [1]

< Correct labelled axes with units > [1]

< Correct points for the curve of flask *A* > [1]

< Correct points for the curve of flask *B* > [1]

< 2 smooth curves fitted to the points > [1]

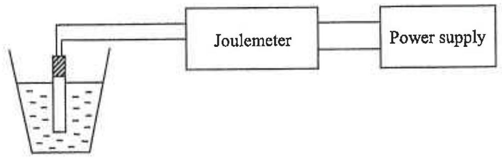
(b) The rate of heat lost by the gas to the surroundings [1]
is just equal to the rate of heat absorption from the sun. [1]

2. (b) (ii) Energy absorbed by the polystyrene cup is small since its heat capacity is small. [1]

Energy lost to the surroundings is small since polystyrene is a poor conductor of heat. [1]

(iii) To ensure that the temperature of water is uniform. [1]

(c)



[1]

The heater is connected to the power supply through a joulemeter. [1]

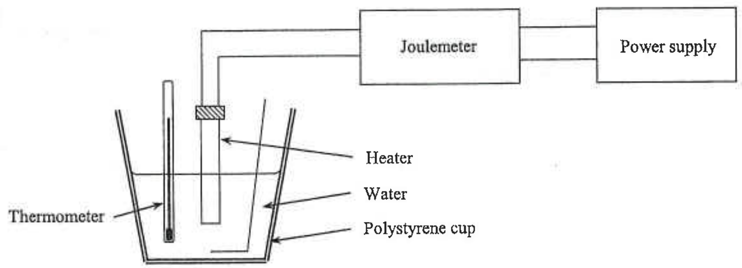
The energy given to the heater E is found by recording the initial and final readings of the joulemeter. [1]

The time taken t is found by a stop-watch. [1]

The power output of the heater is found by $P = \dfrac{E}{t}$ [1]

3. (a) It means that the energy needed to increase the temperature of 1 kg of water [1]
through 1°C is 4200 J. [1]

(b)



[1]

(b) Put known mass of water, m, into a polystyrene cup and then put the heater and thermometer into the water. [1]

The heater is then connected to the power supply through a joulemeter
and the energy E given out from the heater is recorded. [1]

The increase of temperature ΔT is recorded by using the thermometer. [1]

The specific heat capacity of water is then found by $c = \dfrac{E}{m \cdot \Delta T}$ [1]

(c) (i) (I) $E = P\,t$

$= (1000) \times (14 \times 60)$ [1]

$= 840\ 000$ J [1]

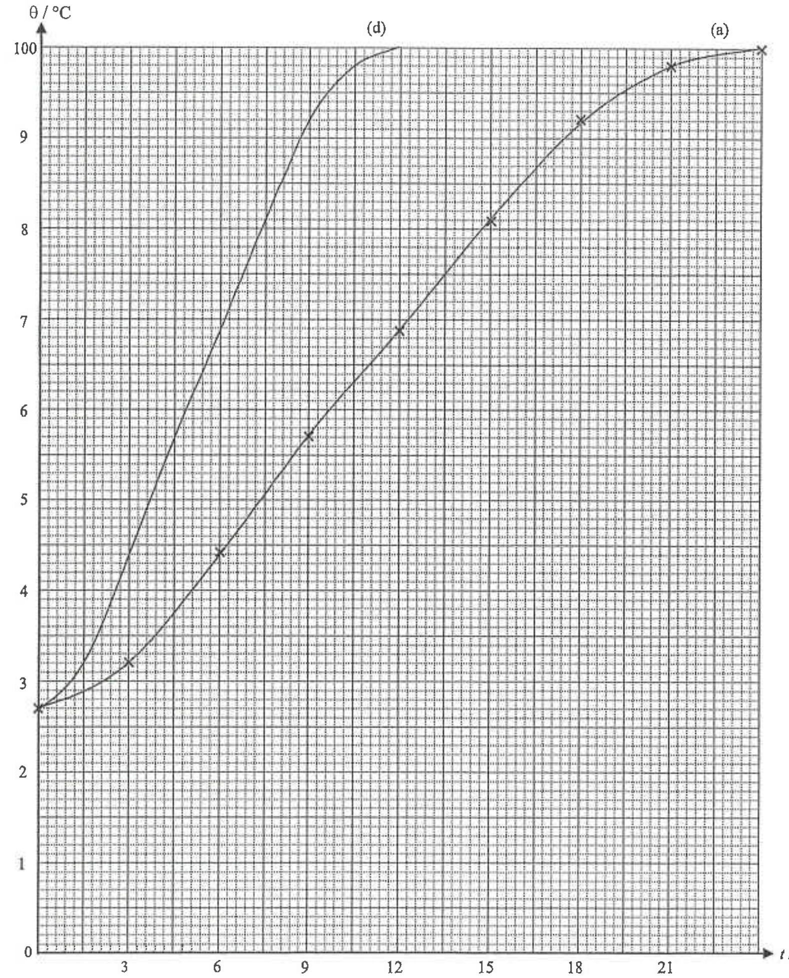
5. (e) No. [1]

Wood is a poor conductor of heat. (**OR** Wood is not a good conductor of heat.) [1]

The wood cannot have uniform temperature throughout the wood. [1]

(**OR** Different parts of the wood would have different temperatures. [1]

6. (a)



< Labelled axes with units > [1]

< Correct scales > [1]

< Correct points plotted > [1]

< Correct curve > [1]

4. (c) Temperature rise of flask A = 48.8 – 28.0 = 20.8°C [1]

Energy absorbed by carbon dioxide in flask A = $m\,c\,\Delta T$

= (0.00196) × (640) × (20.8) [1]

= 26.1 J [1]

Energy absorbed by air in flask B = (0.00125) × (740) × (46.0 – 28.0) = 16.7 J [1]

∴ Flask A absorbs more energy [1]

(d) (i) Temperature rises. [1]

(ii) ① Plant more trees. [1]

OR

Stop deforestation. [1]

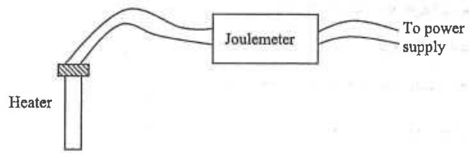
② Any **ONE** of the followings : [1]

- ✱ Use less fossil fuels.
- ✱ Use alternate sources of energy.
- ✱ Save electricity.
- ✱ Use less private cars.

5. (a) Connect a joulemeter to the heater from the power supply. [1]

Measure the initial and final readings of the joulemeter. [1]

The difference of the readings is the energy supplied by the heater. [1]



[1]

(b) By $E = m\,c\,\Delta T$ [1]

∴ (12300) = (1) c (41 – 29)

∴ c = 1025 J kg^{-1} °C^{-1} [1]

(c) There is heat lost to surroundings, [1]

so the energy supplied by the heater is greater than the actual energy absorbed by the metal. [2]

OR

There is heat lost to surroundings, [1]

so the temperature rise of the block is smaller than that if all the energy supplied is absorbed by the metal. [2]

(d) ① Surround the metal block with insulating material. [1]

② Put some oil in the holes to ensure good thermal contact between the heater, thermometer and the metal. [1]

6. (b) (i) $E = P \times t = 2200 \times 240$ [1]

$= 528000\text{ J}$ [1]

(ii) $E = m c \Delta T = (1) \times (4200) \times (100 - 27)$ [1]

$= 306600\text{ J}$ [1]

(iii) Any **TWO** of the following : [2]

* Some energy is lost to the surrounding.
* Some energy is absorbed by the egg.
* Some energy is absorbed by the pot.

(c) No, the time would not be lengthened. [1]

As the temperature of water remains at 100°C, [1]

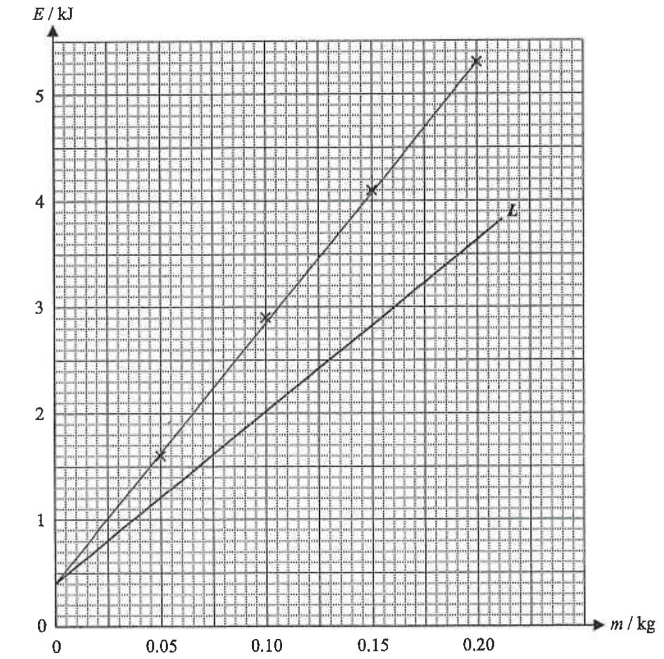
the rate of energy absorbed by the egg remains unchanged. [1]

(d) < The curve has a steeper slope than (a) > [1]

< The curve reaches 100°C eventually > [1]

7. (a) To reduce the heat lost to the surroundings. [1]

(b) (i)



7. (b) (i) < Two axes labelled with correct units > [1]

< Correct scales used > [1]

< Points correctly plotted > [1]

< Best fitted line drawn > [1]

(ii) Slope of the straight line $= \dfrac{(5.3 - 0.4) \times 10^3}{0.20} = 24500$ [1]

By $E = m c \Delta T + E_{app}$ [1]

$\therefore\ E = c\,\Delta T \cdot m + E_{app}$ (compared with $y = m x + c$)

$\therefore$ slope $= c\,\Delta T$

$\therefore$ $(24500) = c\,(10)$

$\therefore$ $c = 2450\text{ J kg}^{-1}\,°\text{C}^{-1}$ < accept 2300 to 2600 $\text{J kg}^{-1}\,°\text{C}^{-1}$ > [1]

(iii) Heat absorbed by the apparatus $=$ y-intercept

$= 0.4\text{ kJ}$ < accept 0.2 to 0.6 kJ > [1]

(iv) < Same y-intercept > [1]

< Straight line with slope smaller as c is smaller, slope $= c\,\Delta T$ > [1]

8. (a) Put the thermometer into the water to measure its initial temperature T_1. [1]

Put the beaker of water into the oven and turn on the oven. [1]

Use the stop watch to record the time of heating t. [1]

Take out the beaker of water from the oven.

Put the thermometer into the water to measure its final temperature T_2.

Precautions / assumptions : (Any **ONE** of the followings) [1]

* Do not use the thermometer to stir the water.
* The heat capacity of the beaker is negligible compared with that of water.
* The heat lost to the surroundings is negligible.
* The energy given out by the microwaves is completely absorbed by the water.

< Use a stirrer to well stir the water is not acceptable, as no stirrer is provided >

Output power $= \dfrac{(0.2) \times c \times (T_2 - T_1)}{t}$ [1]

where c is the specific heat capacity of water

(b) Some energy is absorbed by the beaker. **OR** Some energy is lost to the surrounding air. [1]

(c) The percentage of energy lost would be smaller if larger quantity of water were used. [1]

This measure would improve the accuracy of the experiment.

12. (a) Put the sphere into the water bath for a few minutes. [1]
Transfer the sphere into the polystyrene cup of water. [1]
Measure the final temperature T_f of the water with a thermometer. [1]
By $(0.80) \times c_b \times (80 - T_f) = (0.50) \times (4200) \times (T_f - T_o)$ [1]

$\therefore\ c_b = 2625 \times \dfrac{T_f - T_o}{80 - T_f}$

Precautions :

* Dry the sphere with the towel quickly before putting it into the cup. [1]
* Stir the water to ensure uniform temperature of water. [1]

(b) Any **ONE** of the followings : [1]

* Some heat is lost during the transfer
* Some heat is lost during the drying of the sphere
* Some heat is lost to the apparatus (thermometer, stirrer or cup)
* The temperature of the sphere is still higher than T_f when this final temperature is measured

Thus, the temperature rise of water in the cup is lower than it should be. [1]

13. (a) A large bulb increases the sensitivity of the thermometer. [1]

(b) (i) $E = m\,c\,\Delta T$
$= (0.015) \times (2.9 \times 10^3) \times (20 - 15)$ [1]
$= 217.5$ J <accept 218 J> [1]

(ii) By $E = P\,t$
$\therefore\ (217.5) = (0.5)\,t$ [1]
$\therefore\ t = 435$ s <accept 436 s> [1]

(iii) The thermometer would cool down quickly when it is in direct contact with the cooler air. [1]
The temperature reading would be less than the actual soil temperature. [1]

9. (a) $m = \rho V = 1000 \times 1.5 = 1500$ kg [1]
$E = m\,c\,\Delta T \times (1 - 15\%)$ [1]
$= (1500)(4200)(80 - 60) \times (1 - 15\%)$
$= 1.07 \times 10^8$ J [1]

(b) $E = P\,t$
$(1.07 \times 10^8) = (4.5 \times 10^3)\,t$ [1]
$\therefore\ t = 23778$ s $= 6.60$ hours <accept 6.61 hours> [1]

(c) The rate of heat transfer drops as the water temperature drops. [1]
OR
The rate of heat transfer drops as the temperature difference drops. [1]

10. (a) Time = 5 minutes <accept 300 s> [1]

(b) When the heater is switch off, its temperature is still higher than the metal. [1]

(c) (i) $P = VI = (12)(4.0) = 48$ W [1]
By $P\,t = m\,c\,\Delta T$
$\therefore\ (48)(5 \times 60) = (0.80)\,c\,(45 - 20)$
$\therefore\ c = 720$ J kg^{-1} °C^{-1} [1]

(ii) The calculated value is higher than the actual value. [1]
Since energy is lost to the surroundings. **OR** Some energy is absorbed by the heater and the thermometer. [1]
OR
Not all the energy supplied by the heater goes to the metal. [1]

(d) Glass is not a good conductor of heat. **OR** The heat conductivity of glass is poor. [1]

11. (a) (i) $\dfrac{R - R_0}{R_{100} - R_0} = \dfrac{\theta - 0}{100 - 0}$ [1]

$\therefore\ \dfrac{R - 102.00}{140.51 - 102.00} = \dfrac{60}{100}$

$\therefore\ R = 125.106\ \Omega$ <accepted 125.11 Ω **OR** 125 Ω> [1]

(ii) Actual temperature is lower than 60°C. [1]

(b) Since the actual temperature is lower than 60°C when heating stops, [1]
OR
The energy supplied is actually lower than it should be, [1]
thus, the experimental value of c_w is lower than the actual value. ($c_w = \dfrac{E}{m \cdot \Delta T}$) [1]

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)
1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普通氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)
1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)
1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)
1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)
1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)
1. The universe as seen in different scales (不同空間標度下的宇宙面貌)
2. Astronomy through history (天文學的發展史)
3. Orbital motions under gravity (重力下的軌道運動)
4. Stars and the universe (恒星和宇宙)

Elective 2 – Atomic World (原子世界)
1. Rutherford's atomic model (盧瑟福原子模型)
2. Photoelectric effect (光電效應)
3. Bohr's atomic model of hydrogen (玻爾的氫原子模型)
4. Particles or waves (粒子或波)
5. Probing into nano scale (窺探納米世界)

Elective 3 – Energy and Use of Energy (能量和能源的使用)
1. Electricity at home (家居用電)
2. Energy efficiency in building (建築的能源效率)
3. Energy efficiency in transportation (運輸業的能源效率)
4. Non-renewable energy sources (不可再生能源)
5. Renewable energy sources (可再生能源)

Elective 4 – Medical Physics (醫學物理學)
1. Making sense of the eye (眼的感官)
2. Making sense of the ear (耳的感官)
3. Medical imaging using non-ionizing radiation (非電離輻射醫學影像學)
4. Medical imaging using ionizing radiation (電離輻射醫學影像學)

DSE Physics - Section A : M.C. PA - HG2 - M / 01
HG2 : Transfer Processes

Part A : HKCE examination questions

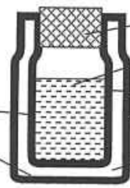
1. **< HKCE 2005 Paper II - 7 >**

The photograph shows a hot potato wrapped by shiny aluminium foil. By what means can the foil help reducing the rate of energy lost from the potato to the surroundings ?

(1) conduction
(2) convection
(3) radiation

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

2. **< HKCE 2006 Paper II - 9 >**

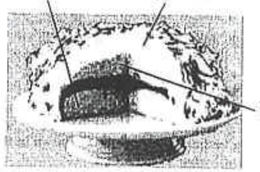


The figure shows a vacuum flask with two glass walls. Which of the following statements are correct ?
(1) The surfaces P and Q are painted silvery to reduce heat loss.
(2) The cork stopper reduces heat loss by conduction and convection.
(3) The vacuum between the double glass walls reduces heat loss by radiation.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

3. **< HKCE 2007 Paper II - 9 >**

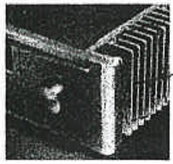
The diagram below shows the structure of a cake.



The ice-cream inside the cake does not melt when it is baked in an oven. Which of the following statements are possible reasons for this phenomenon ?
(1) The whipped egg white is a poor conductor of heat.
(2) The whipped egg white is a good radiator of heat.
(3) The sponge cake is a poor conductor of heat.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

4. **< HKCE 2008 Paper II - 9 >**



The above figure shows the aluminium heat sink of an audio amplifier which is used to transfer heat away from the components inside the amplifier. Which of the following statements about the heat sink is/are correct ?

(1) The heat sink is made of aluminium so that it can transfer heat away faster by conduction.

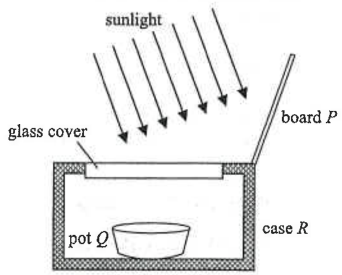
(2) The heat sink is silver in colour so that it can transfer heat away faster by radiation.

(3) The heat sink has a fin-like design to increase the surface area so that it can transfer heat away faster by conduction to air.

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

5. **< HKCE 2011 Paper II - 12 >**

The figure below shows a solar cooker. Which of the following statements about its design is **incorrect** ?



A. Board *P* should be shiny to reflect sunlight into the cooker.

B. Pot *Q* should be painted in black to increase the heat absorption.

C. Case *R* should be made of metal to enhance heat transfer.

D. The glass cover can reduce heat loss by convection.

Part B : Supplemental exercise

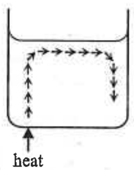
6. The diagram shows an experiment that demonstrates convection taking place in water. What happens to the water to cause the convection ?

A. The water expands and its density decreases.

B. The water expands and its density increases.

C. The water contracts and its density decreases.

D. The water contracts and its density increases.



7. A metal spoon is put into a bowl of hot soup. When it is taken out of the soup, it cools by emitting
A. electrons.
B. infra-red radiation.
C. visible light.
D. ultra-violet radiation.

8. In winter, when we sit on a metal chair, we feel cold continuously. What is the reason behind ?

A. Metal has a small specific heat capacity.

B. Metal is a good reflector of heat.

C. Metal is a good radiator of heat.

D. Metal is a good conductor of heat.

9. Which of the followings are related to the process of convection ?
(1) Some birds use hot air currents to gain height.
(2) At day time, breezes move from sea to land.
(3) At night time, breezes move from land to sea.
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

10. Which of the following processes does not involve the movement of molecules ?
A. conduction
B. convection
C. radiation
D. diffusion

11. Which of the following animals is the best emitter of infra-red radiation from their bodies ?
A. a white cat
B. a black dog
C. a brown horse
D. a red fox

12. Arrange the following materials from the poorest conductor to the best conductor in order.
(1) air
(2) copper
(3) vacuum
(4) water
A. (1), (3), (2), (4)
B. (1), (3), (4), (2)
C. (3), (1), (2), (4)
D. (3), (1), (4), (2)

13. The radiators on motor cars are painted black. What is the reason behind ?

A. It will not get dirty easily.

B. Black surface is a good emitter of heat.

C. Black surface is a good conductor of heat.

D. Black surface is more beautiful.

14. Which of the following is NOT an application of the poor conductor of heat ?
A. wooden handles of frying pans
B. fur of the animals
C. cooling fins of the engine radiators
D. double glazing of windows

15. Which of the following correctly describes shiny surfaces concerning infra-red radiation ?
A. They are good absorbers and good emitters.
B. They are good absorbers but poor emitters.
C. They are poor absorbers and poor emitters.
D. They are poor absorbers but good emitters.

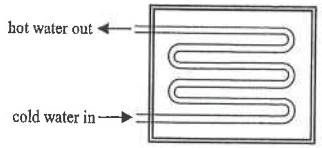
16. A metal rod and a rubber rod are at the same temperature. When they are held in the hand, the metal rod "feels" colder than the rubber rod. The best explanation for this observation should be
A. metal has a higher melting point than rubber.
B. metal has a lower specific heat capacity than rubber.
C. metal is a better conductor of heat than rubber.
D. metal is a better absorber of heat than rubber.

17. Which of the following correctly describes dull surfaces concerning infra-red radiation ?
A. They are good absorbers and good emitters.
B. They are good absorbers but poor emitters.
C. They are poor absorbers and poor emitters.
D. They are poor absorbers but good emitters.

18. A bowl of hot soup is placed in air. Which of the following transfer processes would carry away the energy from the soup to cool it down ?
(1) conduction
(2) convection
(3) radiation
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

19. Which of the following substances is the best conductor of heat ?
A. vacuum
B. air
C. water
D. iron

20. Which of the following process can heat be transferred in a vacuum ?
(1) conduction
(2) convection
(3) radiation
A. (1) only
B. (2) only
C. (3) only
D. (2) & (3) only

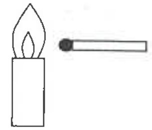
21.


The above figure shows a simple solar heater. What type of material should be used for the pipe to give the hottest water from the heater ?
A. Plastic painted white
B. Plastic painted black
C. Copper painted white
D. Copper painted black

22. Normally, the conduction of heat through a substance depends on its state. Which of the following correctly arranges the three states from the poorest conductor to the best conductor ?

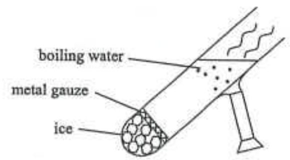
A.	gas	liquid	solid
B.	solid	gas	liquid
C.	gas	solid	liquid
D.	liquid	gas	solid

23. When a match is placed near the flame of a Bunsen burner as shown, it is found that the match does not ignite. Which of the following is the best reason ?
A. The temperature of the flame is not high enough.
B. Air is not a good conductor of heat.
C. There is no convection current near the flame.
D. There is no radiation from the flame.



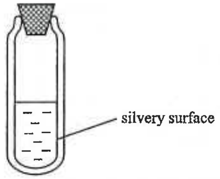
24. In a hot summer day, Peter wears white shirt and black trousers. When he stands under the sun, he feels that his feet are hotter than his back. Which of the following is the possible reason ?
A. The white shirt emits less infra-red radiation than the black trousers.
B. The white shirt emits more infra-red radiation than the black trousers.
C. The white shirt absorbs less infra-red radiation than the black trousers.
D. The white shirt absorbs more infra-red radiation than the black trousers.

25. In the diagram shown, a piece of metal gauze is used to keep the ice at the bottom of the test tube. The upper part of the test tube is then heated until the water boils. However, the ice still exists at the bottom. Which of the followings are the possible reasons ?
(1) Water is not a good conductor of heat.
(2) Convection can hardly be set up between boiling water and ice.
(3) The metal gauze prevents heat from conducting to the ice.
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)



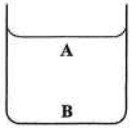
26. A vacuum can prevent heat transfer by
(1) conduction
(2) convection
(3) radiation
A. (1) only
B. (2) only
C. (3) only
D. (1) & (2) only

27.



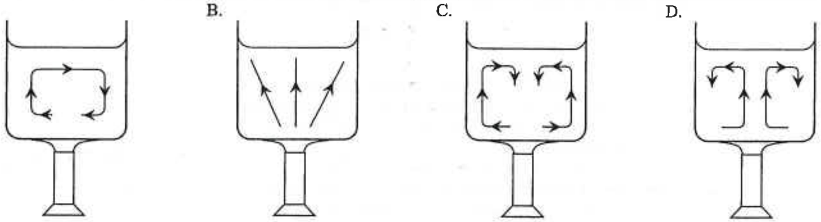
In a vacuum flask, the inside walls have silvery surface. The main purpose of this design is to reduce heat transfer by
A. conduction only.
B. radiation only.
C. conduction and convection only.
D. convection and radiation only.

28.



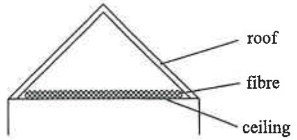
Billy wants to set up a convection current inside the water in a metal tank. Which of the following methods can achieve this ?
(1) Heat the water at *A*.
(2) Cool the water at *A*.
(3) Cool the water at *B*.
A. (1) only
B. (2) only
C. (3) only
D. (1) & (2) only

29. A beaker of water is heated by a flame placed at the bottom. Which diagram below best shows the convection currents ?
A. B. C. D.



30. In a water heating system, the hot water from the heater flows to the tap through water pipes. However, heat is lost during the flowing process. Which of the following statements are correct concerning the flowing process ?
(1) Heat is lost through the walls of the pipes by conduction.
(2) Heat is lost through the surrounding air by convection.
(3) Heat is lost to the surrounding by radiation.
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

Questions 31 and 32 : The following figure shows the design of the top of a house.



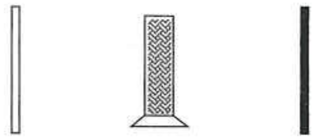
31. What material should be used to cover the roof of the house in order to keep the house cooler in a hot day under the Sun ?
A. a layer of red brick
B. a layer of dark soil
C. a layer of black paint
D. a layer of white paint

32. Fibre is used to separate the roof and the ceiling. How may fibre help to prevent heat from passing through the ceiling ?
A. Fibre allows air to pass through easily.
B. Fibre traps air.
C. Fibre is cold.
D. Fibre is light in colour.

33. Which of the following correctly explains the main reason for the heat to be transferred in the process of convection ?
A. The heat is carried away by infra-red radiation.
B. The process is achieved due to the temperature difference in a solid.
C. The process is achieved due to the density difference in a fluid.
D. The process is achieved due to the vibration of molecules.

34. In the design of a solar heater, the panels are painted black in colour. What is the reason behind ?
A. To make the panel become good conductor.
B. To allow convection to take place.
C. To improve the absorption of infra-red radiation.
D. To improve the emission of infra-red radiation.

35.



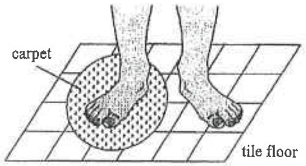
white metal plate electric heater black metal plate

Two identical metal plates, one painted with white colour and the other painted with black colour, are placed at equal distances from a radiant heater as shown. After some time, which metal plate absorbs more energy and which metal plate emits more energy ?

	Metal plate that absorbs more energy	Metal plate that emits more energy
A.	white	white
B.	white	black
C.	black	white
D.	black	black

Part C : HKDSE examination questions

36. < HKDSE Sample Paper IA - 1 >



Cynthia places a carpet on a tile floor. After a while, she stands in bare feet with one foot on the tile floor and the other on the carpet as shown. She feels that the tile floor is colder than the carpet. Which of the following best explains this phenomenon ?

A. The tile is a better insulator of heat than the carpet.

B. The tile is at a lower temperature than the carpet.

C. The specific heat capacity of the tile is smaller than that of the carpet.

D. Energy transfers from Cynthia's foot to the tile at a greater rate than that to the carpet.

37. < HKDSE 2014 Paper IA - 1 >

Two identical scoops of ice-cream are transferred from a refrigerator into paper cup X and vacuum flask Y shown above. Under room temperature, the time required for the ice-cream in the containers to melt completely is t_X and t_Y respectively. What is the expected result and explanation ?

A. $t_X > t_Y$ as the vacuum flask reduces heat loss to the surroundings.

B. $t_X > t_Y$ as the vacuum flask retains the heat.

C. $t_Y > t_X$ as the vacuum flask keeps things cold by releasing heat into the surroundings.

D. $t_Y > t_X$ as the vacuum flask reduces the rate of heat gain from the surroundings.

38. < HKDSE 2015 Paper IA - 1 >

A driver parks his car outdoor under the sun. After parking, he switches off the engine of the car. Two hours later when he gets back into the car, he feels that the inside of the car is far hotter than outside.

The best explanation is

A. the car's engine is still generating heat after the engine has been switched off.

B. the car's metal parts absorb infra-red radiation at a faster rate than the surroundings.

C. the glass windows of the car trap infra-red radiation and a greenhouse effect results.

D. the surrounding air is a good insulator of heat which reduces heat loss by conduction.

39. < HKDSE 2016 Paper IA - 1 >

Some icy cold liquid is kept cold inside a vacuum flask. Which statements are correct ?

(1) The flask's cork stopper reduces heat gain from the surroundings.

(2) The silver coating on the inner surface of the glass wall is a good reflector of infra-red.

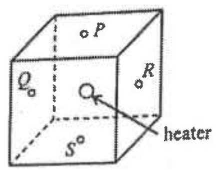
(3) The vacuum between the double glass walls reduces heat gain by radiation.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

40. <HKDSE 2019 Paper IA-1>

41. <HKDSE 2020 Paper IA-1>

A heater is installed at the centre of a fully filled cubic water tank. Temperature sensors P, Q, R and S are fixed at the respective centres of the top, left, right and bottom surfaces of the tank.



After the heater is switched on for a **short duration**, which pair of sensors below would indicate the largest temperature difference ?

A. Q and R
B. R and S
C. Q and S
D. P and R

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care

M.C. Answers

1. B	11. B	21. D	31. D	41. D
2. A	12. D	22. A	32. B	
3. B	13. B	23. B	33. C	
4. D	14. C	24. C	34. C	
5. C	15. C	25. A	35. D	
6. A	16. C	26. D	36. D	
7. B	17. A	27. B	37. D	
8. D	18. D	28. B	38. C	
9. D	19. D	29. D	39. A	
10. C	20. C	30. D	40. D	

M.C. Solution

1. B

× (1) Aluminium is a good conductor ;
heat lost by conduction cannot be reduced.
To reduce heat lost by conduction, the potato should be wrapped with an insulated foil.

× (2) Convection outside the wrapped potato can still take place after wrapping with aluminium foil.
To reduce heat lost by convection, the potato should be placed inside an insulated box.

✓ (3) Shiny surface of the aluminium foil is poor emitter of radiation,
thus heat lost is reduced.

2. A

✓ (1) Silvery can reduce heat loss by radiation since silvery surface is a poor emitter of radiation.

✓ (2) Cork is a poor conductor and reduces heat loss by conduction.
The stopper prevents hot air rises up and reduces heat loss by convection.

× (3) Vacuum can reduce heat loss by conduction and convection but not radiation,
as heat radiation can transfer though vacuum.

3. B

✓ (1) Since the whipped egg white is a poor conductor, heat can hardly transfer from the top to the ice-cream.

× (2) The egg white is white in colour, it should be a poor radiator, and radiation is not a factor here.

✓ (3) Since the cake is a poor conductor, heat can hardly transfer from the bottom to the ice-cream.

4. D

✓ (1) Aluminium is a good conductor, it can conduct heat away faster.

× (2) Silver in colour transfers heat away by radiation slower, not faster.

✓ (3) Fin-like design can increase the surface area for faster conduction of heat.

5. C

✓ A. Board *P* should be shiny to reflect sunlight into the cooker, so that more solar energy can enter the case.

✓ B. Pot *Q* should be painted in black to increase the heat absorption, since black surface is good absorber.

× C. Case *R* should be made of insulator to reduce heat lost to the surroundings.

✓ D. The glass cover can reduce heat loss by convection, as hot air cannot escape from the case.

6. A

When water is heated, it expands and density decreases.
Thus it rises to the top to form the convection current.

7. B

All hot or warm objects would emit heat by radiation which is infra-red radiation.

8. D

Since metal is a good conductor of heat, it conducts heat continuously from our body to make us feel cold.

9. D

✓ (1) Some birds make use of the rise of hot air currents to gain height and reach the upper sky.
The air currents are due to convection in air.

✓ (2) At day time, the land is hotter than the sea.
Air above the land rises and breezes move from the sea to the land to form convection current.

✓ (3) At night time, the sea is hotter than the land.
Air above the sea rises and breezes move from the land to the sea to form convection current.

10. C

Radiation is the transfer of energy by infra-red radiation which can travel in vacuum,
thus it does not involve any molecular motion.

11. B

Black colour surface is the best emitter of radiation.

12. D

Vacuum does not conduct heat, therefore it is the poorest.
Air is a gas which is poor conductor.
Water is a liquid which does not conduct heat well, but the conduction is better than air.
Copper is a solid which is the best conductor.

13. B

Black surface is a good emitter of radiation, thus heat can be emitted quickly.

14. C

✓ A. Wood is a poor conductor.
It is used so that heat cannot conduct well to the handles from the hot pans.

✓ B. The fur of the animals traps air and is poor conductor of heat.
They prevent heat lost from the bodies of animals to the surrounding air.

× C. Cooling fins of the engine radiators are made of good conductors to conduct away heat quickly.

✓ D. Double glazing window contains air between two sheets of glass.
It can reduce heat flow across the window by conduction.

15. C

Shiny surfaces are both poor absorber and poor emitter of infra-red radiation.

16. C

Since metal is a better conductor of heat, it conducts heat quickly away from the hand, thus the hand feels cold.

17. A

Dull surfaces are both good absorber and good emitter of infra-red radiation.

18. D

✓ (1) Heat is conducted away from the bowl to the surrounding air.

✓ (2) Above the soup, convection currents form to carry away the energy from the soup.

✓ (3) The soup emits infra-red radiation to lose energy.

19. D

Iron is metal, all metals are good conductors, thus iron is the best conductor of heat among the given substances.

20. C

× (1) Conduction requires a medium (solid, liquid or gas) to transfer heat.

× (2) Convection requires a fluid (liquid or gas) to form a convection current.

✓ (3) Radiation transfer heat by infra-red radiation which can travel through vacuum.

21. D

Copper is a good conductor.
It should be used so that heat can conduct well from the pipe into the water.

Black surface is a good absorber of radiation.
The surface should be painted black to absorb more heat by radiation.

22. A

Gas is the poorest conductor

Solid is the best conductor among the three states of substances.

23. B

Since air is not a good conductor, heat cannot be conducted well to the match.

Thus the temperature of the match is not high enough to be ignited.

24. C

Since the white shirt is a poor absorber of radiation,

it absorbs less heat than the black trousers which is a good absorber of radiation.

25. A

✓ (1) As water is a not a good conductor of heat, heat is not easy to conduct from the top to bottom of tube.

✓ (2) Since the hot water is at the top and ice at bottom, convection current can hardly be set up between them.

× (3) Metal gauze is a good conductor. It does not prevent heat to be conducted.

26. D

✓ (1) Conduction requires a medium to transfer heat. Thus, there is no conduction in vacuum.

✓ (2) Convection requires a fluid to transfer heat. Thus, there is no convection in vacuum.

× (3) Radiation can take place in vacuum.

27. B

Silvery surfaces are poor emitter of radiation.

28. B

× (1) If the water at A is heated, the hot water has no place to rise to form convection currents.

✓ (2) If the water at A is cooled, the cold water sinks to form convection currents.

× (3) If the water at B is cooled, the cold water has no place to sink to form convection currents.

29. D

The hot water rises to the top and then flows to the sides of the beaker to form convection currents.

30. D

✓ (1) Some heat is lost by conduction through the walls of the pipes.

✓ (2) Since the temperature of the pipe should be higher than the room temperature,
air around the pipe is heated and rises to form convection currents.

✓ (3) All warm objects would emit heat by radiation.

31. D

White colour surfaces are poor absorbers of radiation.

32. B

Fibre traps air to become a poor conductor of heat.

33. C

For convection current to be formed, the fluid must have different densities at different temperatures so that hot fluid rises and cold fluid sinks.

34. C

The panels of a solar heater is painted black since black surface is good absorber, it can absorb more heat by radiation.

35. D

Black surfaces are both good absorber and good emitter of radiation.

36. D

× A. The tile is a better conductor of heat than the carpet, not better insulator.

× B. Both the tile and the carpet are at the same temperature of the surroundings.

× C. For a fixed amount of energy transfer and same mass,
smaller value of specific heat capacity would cause greater rise of temperature.
But in this case, the energy is transferred from the foot continuously with different rate.

✓ D. Since the tile is a better conductor than the carpet,
heat is transferred from the foot to the tile at a greater rate than that to the carpet ;
thus the tile floor is felt colder.

37. D

The vacuum flask *Y* takes longer time for the ice-cream to melt completely
since the vacuum flask can reduce the heat transfer with the surroundings,
thus reduce the rate of heat gain from the surroundings.

38. C

× A. The car's engine would stop giving out heat when the engine has been cooled down
after some time when the engine has been switched off.

× B. The car's metal parts absorb infra-red radiation would only cause the metal body of the car hot,
but not the temperature inside the car.

✓ C. Infra-red radiation from the Sun can pass through the window to heat up the air inside the car,
but the infra-red radiation inside the car cannot pass through the window and is trapped inside.
This is the greenhouse effect.

× D. Heat is trapped inside the car by greenhouse effect.
Heat loss by conduction is not the main reason.

39. A

✓ (1) The cork stopper is a poor conductor, it can reduce heat gain from the surrounding air by conduction.
The stopper can reduce heat gain from the surroundings by convection.

✓ (2) The silver coating is a good reflector of infra-red and thus reduce heat gain by radiation.

× (3) Vacuum cannot reduce heat gain by radiation,
it can only reduce heat gain by conduction and convection.

The following list of formulae may be found useful :

Energy transfer during heating or cooling $E = mc\Delta T$

Part A : HKCE examination questions

1. **< HKCE 2007 Paper I - 3 >**

Read the following passage about thermal flasks and answer the questions that follow.

Working principles of thermal flasks

Thermal flasks are used to store hot liquids and can keep them warm for a period of time. Insulating by foam and insulating by vacuum are two common ways of making thermal flasks.

For a thermal flask applying insulation by foam, a layer of foam is used to wrap the container (see Figure 1). Both the foam and the air trapped inside the foam are poor conductors of heat. Also, the air inside the foam is broken into many tiny bubbles, which reduce convection of air inside the foam. Heat transfer through foam is therefore pretty slow.

For a thermal flask applying insulation by vacuum, there is a vacuum between the double glass walls of the container (see Figure 2). The heat insulation of vacuum is better than that of foam. Furthermore, the inner surface of walls of the glass container is painted silvery to reduce heat transfer. As glass is fragile, the glass container is protected by an outer case with an insulated support.

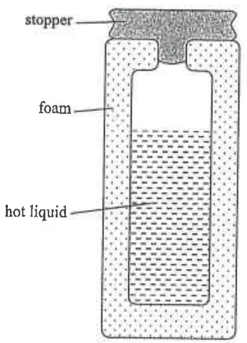


Figure 1

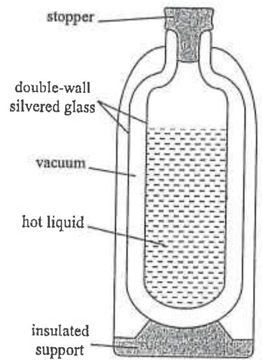


Figure 2

(a) Explain how the foam reduces heat transfer by conduction and convection. (2 marks)

(b) Explain why the heat insulation of vacuum between the double glass walls is better than that of foam. (2 marks)

1. (c) State ONE design in the vacuum flask shown in Figure 2 that helps to reduce heat loss by radiation. (1 mark)

(d) Can a thermal flask also store cold liquids and keep them cold for a period of time ? Explain your answer. (2 marks)

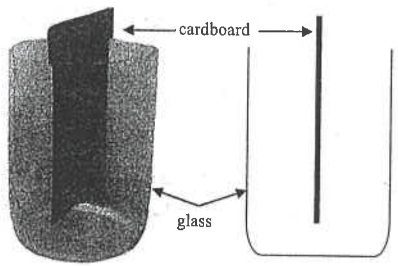
2. **< HKCE 2010 Paper I - 3 >**

Describe how to use the apparatus as shown in the Figure below to conduct an experiment to demonstrate the convection of air current. (4 marks)

a candle

a lighted joss stick (香枝) with smoke

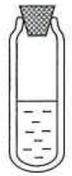
a lighter



a glass with upper part separated by a cardboard (see schematic diagram)

Part B : Supplemental exercise

3.



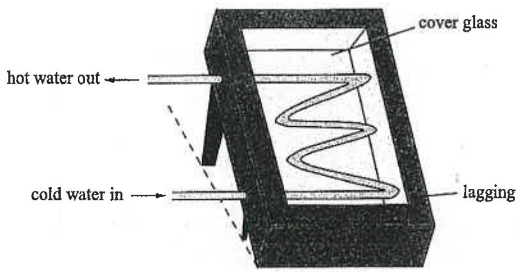
The above figure shows a vacuum flask used for keeping hot liquids warm.

(a) What is the use of the stopper placed at the top of the flask ? (2 marks)

(b) Why do the inside walls of the flask have silvery surfaces ? (2 marks)

(c) Why is the space between the inner wall and outer wall vacuum ? (2 marks)

4.



The figure above shows a simple solar heater.

(a) (i) Why should the inner wall of the heater and surface of the pipe be blackened ? (2 marks)

(ii) The heater is covered by a sheet of glass. Give one reason for this. (1 mark)

(iii) Suggest one material suitable for the lagging. (1 mark)

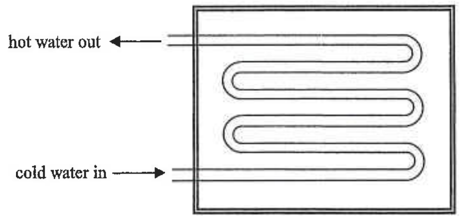
4. (b) When water flows through the pipe in the solar heater at a rate of 0.01 kg s^{-1}, its temperature rises by 7°C.

(Specific heat capacity of water = 4200 J kg^{-1} $°C^{-1}$.)

(i) Find the power supplied by the heater. (3 marks)

(ii) If the rate of flow of water were reduced to 0.04 kg min^{-1}, find the increase in temperature. Briefly comment on your answer. (4 marks)

5.



The above figure shows a solar panel used to heat water.

(a) State the process by which energy is transferred

(i) from the sun to the outside of the pipe in the solar panel ; (1 mark)

(ii) from the outside of the pipe to the water inside it. (1 mark)

(b) The following is a list of materials which are proposed to be used as the pipe material that contains the water.

"polished copper, glass, white plastic, black plastic, black-painted copper"

Suggest the most suitable material for the pipe. Give two reasons to support your choice. (3 marks)

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care

Question Solution

1. (a) Foam is a poor conductor of heat. [1]
   The small air bubbles inside the foam reduce the air convection. [1]

   (b) Vacuum does not have air, thus no conduction of heat. [1]
   Vacuum does not have air, thus no air convection. [1]

   (c) The vacuum flask has silvery surface to reduce radiation. [1]

   (d) Yes ! [1]
   Since the thermal flask can reduce heat transfer, the liquid can be kept cold for a period of time. [1]

2. Put the candle in the glass and light up the candle with the lighter. [1]
   Put the lighted joss stick inside the other side of the glass. [1]
   Observe the movement of the smoke. [1]
   The smoke from the joss stick moves through the bottom of the separator and rises on the side of the candle. [1]

3. (a) To reduce heat lost by convection [1]
   and conduction. [1]

   (b) To reduce heat lost by radiation. [1]
   since silvery surface is a poor emitter of radiation. [1]

   (c) To reduce heat lost by conduction [1]
   and convection. [1]

4. (a) (i) To ensure maximum amount of heat absorbed [1]
   since blackened surface is a good absorber of infra-red radiation. [1]

   (ii) To prevent cooling by convection. [1]
   OR
   To trap heat by greenhouse effect. [1]

   (iii) Any **ONE** of the followings : < **OR** any other suitable insulator > [1]
   * cotton wool
   * foam
   * polystyrene

   (b) (i) By $P\,t = m\,c\,\Delta T$ [1]
   $\therefore\ P\,(1) = (0.01) \times (4200) \times (7)$ [1]
   $\therefore\ P = 294$ W [1]

4. (b) (ii) In 1 minute, heat supplied by the heater $= P\,t = (294)\,(1 \times 60) = 17640$ J [1]
   By $E = m\,c\,\Delta T$
   $\therefore\ (17640) = (0.04)\,(4200)\,\Delta T$ [1]
   $\therefore\ \Delta T = 105$°C [1]
   This is impossible because water would boil at 100°C. [1]

5. (a) (i) radiation [1]

   (ii) conduction [1]

   (b) The most suitable material is black-painted copper. [1]
   Black surface is a good absorber of radiation, thus more solar energy can be absorbed. [1]
   Copper is a good conductor, thus heat can be conducted well from the pipe to the water. [1]

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)

1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普適氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)

1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)

1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)

1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)

1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)

1. The universe seen in different scales (不同空間標度下的宇宙面貌)
2. Astronomy through history (天文學的發展史)
3. Orbital motions under gravity (重力下的軌道運動)
4. Stars and the universe (恆星和宇宙)

Elective 2 – Atomic World (原子世界)

1. Rutherford's atomic model (盧瑟福原子模型)
2. Photoelectric effect (光電效應)
3. Bohr's atomic model of hydrogen (玻爾的氫原子模型)
4. Particles or waves (粒子或波)
5. Probing into nano scale (窺探納米世界)

Elective 3 – Energy and Use of Energy (能量和能源的使用)

1. Electricity at home (家居用電)
2. Energy efficiency in building (建築的能源效率)
3. Energy efficiency in transportation (運輸業的能源效率)
4. Non-renewable energy sources (不可再生能源)
5. Renewable energy sources (可再生能源)

Elective 4 – Medical Physics (醫學物理學)

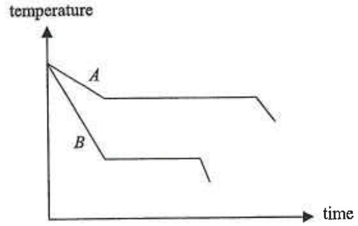
1. Making sense of the eye (眼的感官)
2. Making sense of the ear (耳的感官)
3. Medical imaging using non-ionizing radiation (非電離輻射醫學影像學)
4. Medical imaging using ionizing radiation (電離輻射醫學影像學)

The following list of formulae may be found useful :

Energy transfer during heating or cooling	$E = m c \Delta T$
Energy transfer during change of state	$E = l \Delta m$

Part A : HKCE examination questions

1. **< HKCE 1980 Paper II - 14 >**



Two liquids A and B are cooled in air. Their cooling curves are shown. If A and B have the same mass, which of the following statements is/are true ?

(1) A has a higher freezing point than B.

(2) A has a greater specific latent heat of fusion than B.

(3) Liquid A has a greater specific heat capacity than liquid B.

A. (3) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

2. **< HKCE 1981 Paper II - 10 >**

A liquid placed inside an insulated vessel is kept boiling by a heating coil immersed in it. When the power supplied to the coil is 42 W, the liquid boils away at a rate of 10^{-4} kg s^{-1}. What is the specific latent heat of vaporization of the liquid ?

A. 42×10^3 J kg^{-1}

B. 21×10^4 J kg^{-1}

C. 42×10^4 J kg^{-1}

D. 21×10^5 J kg^{-1}

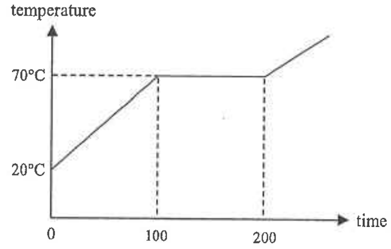
3. **< HKCE 1981 Paper II - 13 >**

0.10 g of steam at 100°C is mixed with 0.10 g of ice at 0°C. No heat is lost to the surroundings. Which of the following describes the final mixture ?

Given : specific heat capacity of water = 4.2 kJ kg^{-1} °C^{-1}
specific latent heat of ice = 336 kJ kg^{-1}
specific latent heat of steam = 2260 kJ kg^{-1}

A. A mixture of water and steam at 100°C
B. Water at 0°C
C. Water at 50°C
D. Water at 100°C

4. < HKCE 1982 Paper II - 10 >



A solid substance of mass 2 kg and specific heat capacity 1000 J kg^{-1} °C^{-1} is heated uniformly by a constant heat source. The temperature-time graph of the substance is shown in the graph. Assuming that no heat is lost, find from the graph the specific latent heat of fusion of the substance.

A. 1000 J kg^{-1}
B. 20000 J kg^{-1}
C. 30000 J kg^{-1}
D. 50000 J kg^{-1}

5. < HKCE 1982 Paper II - 22 >

The following data shows the thermal properties of four substances *P*, *Q*, *R* and *S* :

Substance	*P*	*Q*	*R*	*S*
Melting point	40 K	98 K	114 K	270 K
Boiling point	280 K	880 K	180 K	370 K
Average specific heat capacity in J kg^{-1} °C^{-1}	800	1200	226	40
Specific latent heat of fusion in J kg^{-1}	2×10^4	11×10^4	5×10^4	33×10^4
Specific latent heat of vaporization in J kg^{-1}	30×10^4	34×10^4	40×10^4	230×10^4

When the temperature of each substance is increased from 250 K to 400 K, which one will absorb the greatest amount of energy ?

A. *P*
B. *Q*
C. *R*
D. *S*

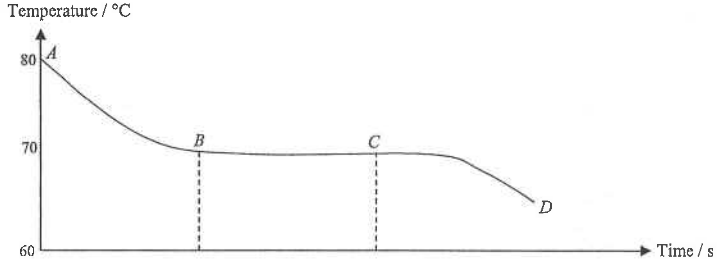
6. < HKCE 1983 Paper II - 15 >

It is given that : the specific latent heat of fusion of ice = 3.3×10^5 J kg^{-1}
the specific latent heat of vaporization of water = 2.3×10^6 J kg^{-1}

If 1 kg of ice at 0°C and 1 kg of steam at 100°C are mixed in a well insulated vessel, the result will be

A. a mixture of ice and ice-cold water.
B. a mixture of steam and boiling water.
C. water at 0°C.
D. water at 50°C.

7. < HKCE 1984 Paper II - 11 >



A cooling curve for liquid naphthalene is shown above. From the graph, which of the following statement(s) is/are true ?

(1) The melting point of naphthalene is around 70°C.
(2) In the period *BC*, only liquid naphthalene is present.
(3) In the period *BC*, no energy is given by naphthalene to the surroundings.

A. (1) only
B. (1) & (2) only
C. (1) & (3) only
D. (2) & (3) only

8. < HKCE 1984 Paper II - 10 >

If an immersion heater takes 10 minutes to bring a cup of water to its boiling point 100°C from the room temperature of 20°C, what will be the time taken for the boiling water to vaporize completely ?
(Specific heat capacity of water = 4.2 kJ kg^{-1} °C^{-1} ; specific latent heat of steam = 2268 kJ kg^{-1}.)

A. 33.75 minutes
B. 54.00 minutes
C. 67.50 minutes
D. 75.40 minutes

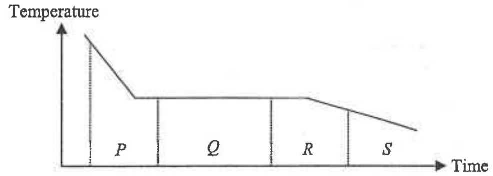
9. < HKCE 1985 Paper II - 13 >

Heat is needed to keep water boiling because energy is required to

(1) increase the potential energy of the water molecules.
(2) increase the kinetic energy of the water molecules.
(3) increase the average speed of the water molecules.

A. (1) only
B. (1) & (2) only
C. (1) & (3) only
D. (2) & (3) only

10. < HKCE 1986 Paper II - 21 >



The graph shows the cooling curve of liquid naphthalene. In which region has naphthalene completely solidified ?

A. *P*
B. *Q*
C. *R*
D. *S*

11. **< HKCE 1987 Paper II - 26 >**

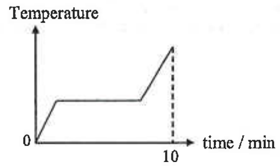
Arrange the following in ascending order.

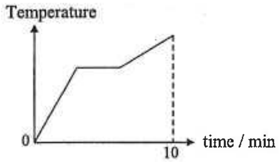
E_1 = Energy required to melt 1 kg of ice at 0°C
E_2 = Energy required to raise the temperature of 1 kg of copper by 1°C
E_3 = Energy required to vaporize 1 kg of water at 100°C
E_4 = Energy required to raise the temperature of 1 kg of water by 1°C

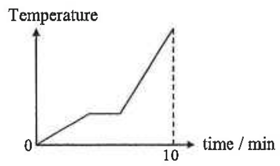
A. $E_2 < E_4 < E_1 < E_3$
B. $E_2 < E_4 < E_3 < E_1$
C. $E_3 < E_1 < E_4 < E_2$
D. $E_4 < E_2 < E_3 < E_1$

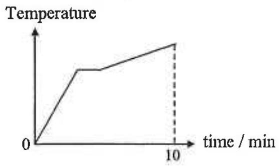
12. **< HKCE 1988 Paper II - 11 >**

Five different solids, each of mass 1 kg, are heated by identical immersion heaters for 10 minutes. The following graphs show their heating curves. Assuming no loss in heat, which solid has the greatest specific latent heat of fusion ?

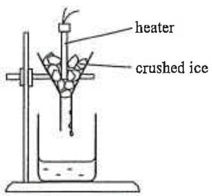
A.


B.


C.


D.


13. **< HKCE 1989 Paper II - 18 >**

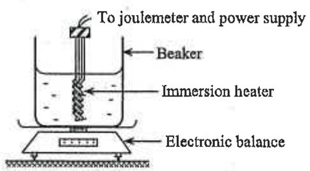


The figure shows an experiment to determine the specific latent heat of fusion of ice. The result obtained is lower than the one expected. The main reason could be that

A. there is heat gain from the surroundings.
B. there is heat loss to the surroundings.
C. there is some water remaining in the funnel, not falling into the beaker.
D. the temperature of ice is below 0°C.

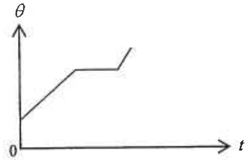
14. **< HKCE 1990 Paper II - 21 >**

The apparatus shown is used to find the specific latent heat of vaporization of water. Which of the following is NOT correct ?

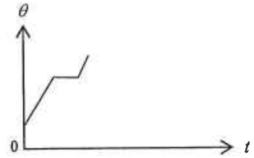


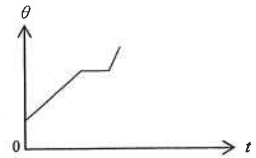
A. Cover the beaker with a lid.
B. Use a suitable heater to prevent boiling the water too vigorously.
C. Surround the beaker with some cotton.
D. Repeat the experiment several times and take the mean of the results.

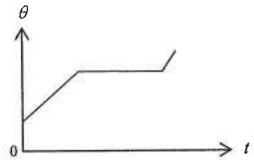
15. **< HKCE 1990 Paper II - 22 >**

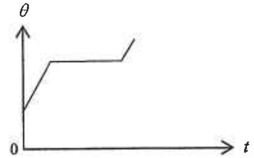


A 20 W heater is used to melt a solid. A graph of temperature θ against time t is plotted as shown above. If a heater of 40 W is used, which graph (using the same scale) would be obtained ?

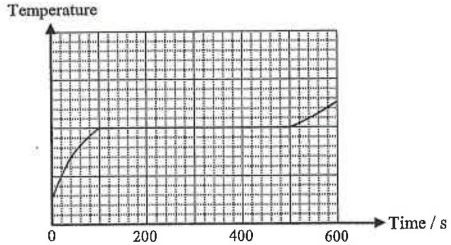
A.


B.


C.


D.


16. **< HKCE 1991 Paper II - 18 >**



A 400 W electric heater is used to heat 0.4 kg of a solid. The graph shows the temperature against time of the substance. The specific latent heat of fusion of the substance is

A. 64 kJ kg^{-1}
B. 160 kJ kg^{-1}
C. 400 kJ kg^{-1}
D. 500 kJ kg^{-1}

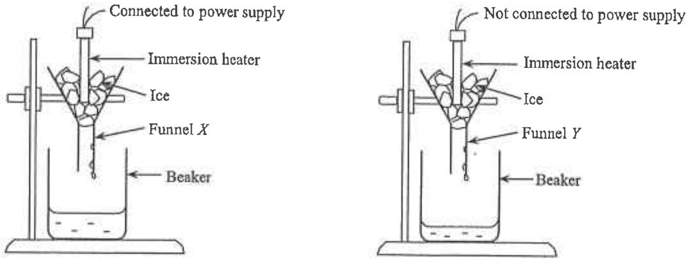
17. **< HKCE 1992 Paper II - 17 >**

An immersion heater is used to heat a cup of water. It takes 10 minutes to bring the water from 20°C to its boiling point 100°C. Find the time taken for the heater to vaporize the boiling water completely.

(Given : specific heat capacity of water = 4200 J kg^{-1} °C^{-1}
specific latent heat of vaporization of water = 2.268×10^6 J kg^{-1}.)

A. 54 minutes
B. 60 minutes
C. 67.5 minutes
D. 77.5 minutes

18. **< HKCE 1994 Paper II - 17 >**



The above apparatus is used to find the specific latent heat of fusion of ice. Which of the following is an essential precaution to ensure an accurate result ?

A. Crushed ice should be used.
B. The ice used should be just taken from the refrigerator so that its temperature is well below 0°C.
C. The amount of ice used in funnel *X* should be larger than that in *Y*.
D. The two funnels should be wrapped in insulating material.

19. **< HKCE 1995 Paper II - 19 >**

Which of the following substances is a liquid at room temperature (about 20°C) ?

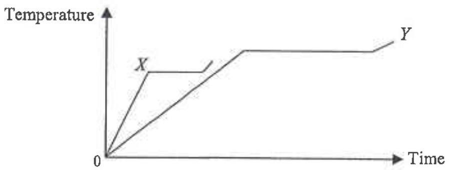
	Substance	Melting point / °C	Boiling point / °C
A.	*P*	25	444
B.	*Q*	−39	357
C.	*R*	44	280
D.	*S*	−218	−183

20. **< HKCE 1995 Paper II - 22 >**

The melting point of copper is 1080°C and its specific latent heat of fusion is 2.1×10^5 J kg^{-1}. How much energy is needed to melt 0.5 kg of copper at its melting point ?

A. $2.1 \times 10^5 / 0.5$ J
B. $0.5 \times 2.1 \times 10^5$ J
C. $2.1 \times 10^5 / (0.5 \times 1080)$ J
D. $0.5 \times 2.1 \times 10^5 / 1080$ J

21. **< HKCE 1996 Paper II - 21 >**

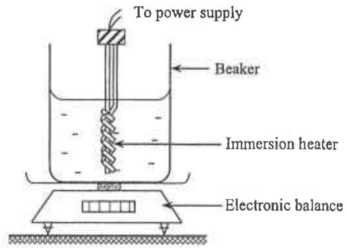


Two solid substances *X* and *Y* of equal mass are separately heated by two identical heaters. The above figure shows the variation of the temperatures of the substances with time. Which of the following statements is/are correct ?

(1) The melting point of *X* is higher than that of *Y*.
(2) The specific heat capacity of *X* is smaller than that of *Y*.
(3) The specific latent heat of fusion of *X* is smaller than that of *Y*.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

Questions 22 and 23 : The following apparatus is used to find the specific latent heat of vaporization of a liquid.



22. **< HKCE 1996 Paper II - 19 >**

When the liquid boils, the reading of the balance is taken. After 200 s, the reading of the balance decreases by 0.02 kg. The power output of the heater is 150 W. If 20% of the energy supplied is lost to the surroundings, find the specific latent heat of vaporization of the liquid.

A. 120 J kg^{-1}
B. 480 J kg^{-1}
C. 3.0×10^5 J kg^{-1}
D. 1.2×10^6 J kg^{-1}

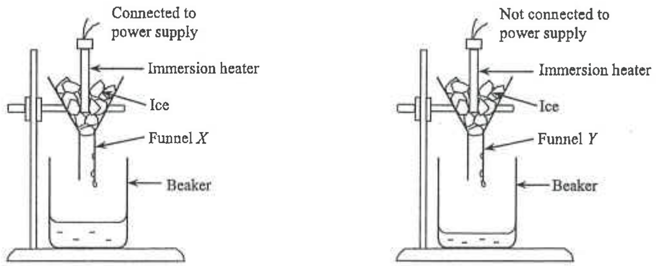
23. **< HKCE 1996 Paper II - 20 >**

Which of the following can improve the accuracy of the experiment ?

(1) covering the beaker with a lid
(2) completely immersing the heating coil in liquid
(3) stirring the liquid throughout the experiment

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

24. **< HKCE 1998 Paper II - 20 >**



The above set-up can be used to find the specific latent heat of fusion of ice. Which of the following is **not** an essential precaution to ensure an accurate result ?

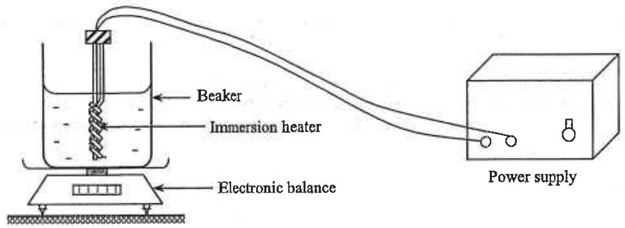
A. covering the funnels with lids
B. using melting ice in the experiment
C. inserting the immersion heater into the ice completely
D. using the same amount of ice in both funnels

25. **< HKCE 1998 Paper II - 22 >**

A block of melting ice with mass 0.02 kg is put into a polystyrene cup containing 0.3 kg of water with initial temperature 20°C. After the mixture is stirred well, the ice block melts completely and the final temperature of the water becomes 14°C. Which of the following equations can be used to find the specific latent heat of fusion of ice, L ?
(Given : Specific heat capacity of water = 4200 J kg^{-1} °C^{-1})

A. $0.3 \times 4200 \times 6 = 0.02\,L + 0.02 \times 4200 \times 14$
B. $0.3 \times 4200 \times 6 = 0.02\,L - 0.02 \times 4200 \times 6$
C. $0.3 \times 4200 \times 6 = 0.02\,L + 0.02 \times 4200 \times 6$
D. $0.3 \times 4200 \times 6 = (0.02\,L + 0.02 \times 4200) \times 14$

26. **< HKCE 1999 Paper II - 17 >**



The above apparatus is used to find the specific latent heat of vaporization of a liquid. Which of the following can improve the accuracy of the experiment ?

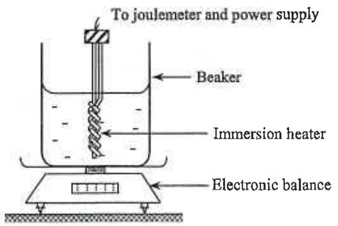
A. Wrapping the beaker with cotton wool
B. Covering the beaker with a lid
C. Stirring the liquid throughout the experiment
D. Using shorter wires to connect the heater and the power supply

27. **< HKCE 2000 Paper II - 18 >**

A cup of fruit juice is of mass 0.2 kg and temperature 70°C. If the specific heat capacity of the fruit juice is 4000 J kg^{-1} °C^{-1}, find the minimum amount of ice at 0°C that should be added to the juice in order to lower its temperature to 0°C.
(Note : Specific latent heat of fusion of ice = 3.34×10^5 J kg^{-1}.)

A. 0.17 kg
B. 0.20 kg
C. 0.37 kg
D. 0.84 kg

28. **< HKCE 2000 Paper II - 21 >**



The above apparatus is used to find the specific latent heat of vaporization of water l_v. Which of the following factors will cause the result obtained to be larger than the true value of l_v ?

(1) Some energy is lost to the surroundings.
(2) Some steam condenses and drips back into the beaker.
(3) Some boiling water inside the beaker splashes out of the beaker.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

29. **< HKCE 2001 Paper II - 16 >**

A melting ice block of mass 0.05 kg is mixed with x kg of water at 0°C in a well-insulated container. If 25 000 J of energy is supplied to the mixture, the mixture changes to water at 4°C. Find the value of x.
(Given : specific latent heat of fusion of ice = 3.34×10^5 J kg^{-1}, specific heat capacity of water = 4200 J kg^{-1} °C^{-1}.)

A. 0.37
B. 0.44
C. 0.49
D. 1.44

30. **< HKCE 2001 Paper II - 30 >**

A cup of liquid P and a cup of liquid Q of equal mass are heated at the same rate. It is found that the temperature of P is rising at a rate faster than that of Q.
Which of the following deductions is/are correct ?

(1) P has a lower specific latent heat of vaporization than Q.
(2) P has a lower boiling point than Q.
(3) P has a lower specific heat capacity than Q.

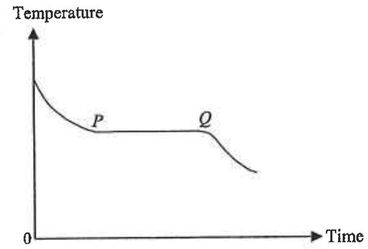
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

31. **< HKCE 2001 Paper II - 18 >**

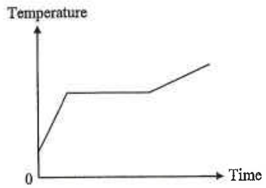
The figure shows the cooling curve of a substance which is initially in the liquid state. The temperature of the substance remains unchanged during the period PQ. Which of the following statements about the substance during the period PQ is/are correct ?

(1) The substance is **not** losing any energy to the surroundings.
(2) Latent heat is absorbed by the substance.
(3) The average potential energy of the molecules of the substance is decreasing.

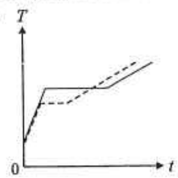
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

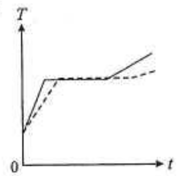


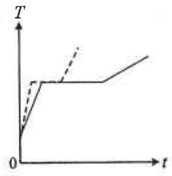
32. **< HKCE 2002 Paper II - 19 >**

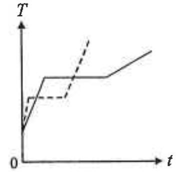


A certain amount of crushed solid is heated and the variation of its temperature T with time t is shown above. If the same heater is used to heat a smaller amount of the solid, which of the following graphs (in dash lines) best shows the variation of the temperature of the solid ?

A.


B.


C.


D.


33. **< HKCE 2003 Paper II - 21 >**

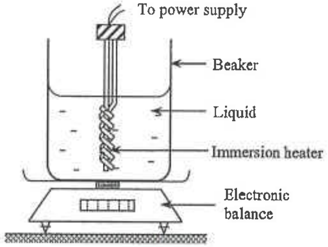


Figure (a)

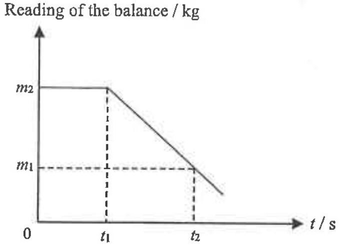
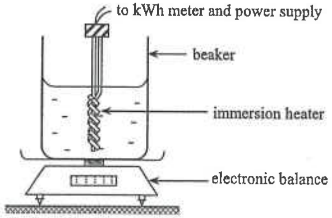


Figure (b)

As shown in Figure (a), some liquid in a beaker is heated by a 1000 W immersion heater. Figure (b) shows the variation of the reading of the electronic balance with time t. Which of the following statements about the liquid is **incorrect** ?

A. It starts to boil at $t = t_1$.
B. Its temperature increases during the period $t = 0$ to t_1.
C. Its specific heat capacity can be estimated by $\frac{1000t_1}{m_2}$.
D. Its specific latent heat of vaporization can be estimated by $\frac{1000(t_2 - t_1)}{m_2 - m_1}$.

Questions 34 and 35 : The following set-up is used to measure ℓ_v, the specific latent heat of vaporization of a liquid.



34. **< HKCE 2004 Paper II - 19 >**

The result of the experiment is as follows:
Initial reading of the balance = 1.60 kg   Final reading of the balance = 1.45 kg
Energy supplied as measured by the kWh meter = 0.10 kWh
Find the measured value of ℓ_v.

A. 2.25×10^5 J kg^{-1}
B. 2.48×10^5 J kg^{-1}
C. 2.40×10^6 J kg^{-1}
D. 6.67×10^6 J kg^{-1}

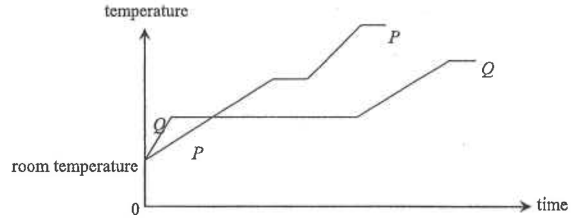
35. **< HKCE 2004 Paper II - 20 >**

How will the value of ℓ_v obtained in the experiment be affected if the following measures are taken separately ?

I. replacing the beaker with a polystyrene container which is a better insulator
II. adding more liquid into the beaker until the heater is completely immersed

	I	II
A.	decreases	increases
B.	decreases	decreases
C.	increases	increases
D.	increases	decreases

36. **< HKCE 2004 Paper II - 18 >**



The graph shows the variation in temperature of equal masses of two substances P and Q when they are separately heated by identical heaters. Which of the following deductions is correct ?

A. The melting point of P is lower than that of Q.
B. The specific heat capacity of P in solid state is larger than that of Q.
C. The specific latent heat of fusion of P is larger than that of Q
D. The energy required to raise the temperature of P from room temperature to boiling point is more than that of Q.

37. **< HKCE 2005 Paper II - 9 >**

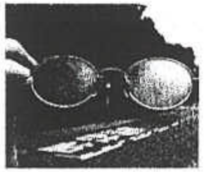


Figure (a)

Figure (b)

When Joanne gets off from an air-conditioned bus in the summer, her glasses become misty (see Figure (a)). After a while, the glasses become clear again (see Figure (b)). Which of the following physical processes are involved in the above phenomena ?

A. condensation followed by evaporation
B. condensation followed by fusion
C. solidification followed by evaporation
D. solidification followed by fusion

38. **< HKCE 2005 Paper II - 33 >**

If equal masses of boiling water and melting ice cubes are mixed, which of the following best describes the state of the mixture ? (Specific heat capacity of water = 4200 J kg^{-1} °C^{-1} ; Specific latent heat of fusion of ice = 3.34×10^5 J kg^{-1})

A. water at 0°C
B. water at a temperature higher than 0°C
C. a mixture of water and ice at 0°C
D. It cannot be determined since the masses of the water and ice are not given.

39. **< HKCE 2006 Paper II - 10 >**

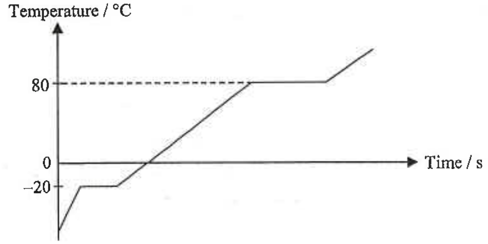
A space shuttle is covered by 'heat shields' over its body so as to protect the interior from getting too hot while entering the atmosphere of the Earth. Which of the following thermal properties is/are desirable for the material of the 'heat shields' ?

(1) It should be a good conductor of heat.
(2) It should have a very high melting point.
(3) It should have high specific heat capacity.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

40. < HKCE 2006 Paper II - 11 >

A substance X is heated at a constant rate and its changing temperature over a time period is recorded. The data are plotted below.



Which of the following statements about the substance X is **incorrect** ?

A. X is in liquid state at 0°C.
B. The boiling point of X is 80°C.
C. The specific heat capacity of X in the solid state is smaller than that of X in the gas state.
D. The specific latent heat of fusion of X is larger than the specific latent heat of vaporization of X.

41. < HKCE 2006 Paper II - 12 >

The initial temperature of a jar of juice is 80°C and the mass of the juice is 2 kg. Susan adds ice cubes into the jar in order to cool down the juice to 20°C. What is the minimum number of ice cubes at 0°C required ?

(Neglect the heat capacity of the jar and assume there is no heat exchange with the surroundings.)

Given : Mass of each ice cube = 0.15 kg
Specific heat capacity of juice = 4700 J kg^{-1} °C^{-1}
Specific heat capacity of water = 4200 J kg^{-1} °C^{-1}
Specific latent heat of fusion of ice = 3.34 × 10^5 J kg^{-1}

A. 9
B. 10
C. 11
D. 12

42. < HKCE 2007 Paper II - 7 >

Water has a very high value of specific latent heat of vaporization. Which of the following statements can be illustrated by this fact ?

(1) Water is used as the coolant in car engines.
(2) Coastal region has milder climate as comparing with inland region.
(3) Steam at 100°C causes more serious injury to skin than boiling water.

A. (1) only
B. (2) only
C. (3) only
D. (1), (2) & (3)

43. < HKCE 2007 Paper II - 34 >

Which of the following statements about evaporation are correct ?

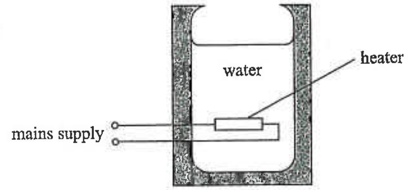
(1) Evaporation occurs only on the surface of the liquid.
(2) The rate of evaporation is higher when the temperature is higher.
(3) After evaporation, the average kinetic energy of the remaining liquid molecules will increase.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

44. < HKCE 2007 Paper II - 8 >

In an experiment, 2 kg of water at 20°C is heated inside a boiler for 20 minutes. Water is boiled to 100°C and 1.7 kg of water remains after boiling. What is the estimated power of the boiler ?

Given : Specific heat capacity of water = 4200 J kg^{-1} °C^{-1}
Specific latent heat of vaporization = 2.26 × 10^6 J kg^{-1}



A. 565 W
B. 649 W
C. 1125 W
D. 3762 W

45. < HKCE 2008 Paper II - 34 >

Which of the following has the highest average speed of the molecules ?

A. 1 g of ice cube at −10°C
B. 10 g of melting ice cube
C. 100 g of water at room temperature
D. 0.1 g of steam at 100°C

46. < HKCE 2008 Paper II - 11 >

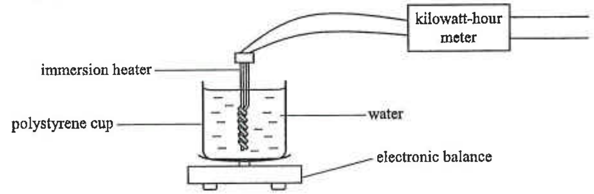
Which of the following statements is/are correct ?

(1) Energy transfers from an object with higher internal energy to an object with lower internal energy.
(2) An object must absorb energy when it changes its state.
(3) Energy transfers from an object with higher temperature to an object with lower temperature.

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

47. < HKCE 2009 Paper II - 12 >

In an experiment, a kilowatt-hour meter is used to measure the energy supplied to an immersion heater. An electronic balance is used to measure the change of the mass. The data obtained is used to estimate the specific latent heat of vaporization of water (l).



If the following experimental error arise :

(I) Water splashes out of the polystyrene cup as the boiling is too vigorous.

(II) Water vapour condenses on the upper part of the heater and drips back into the polystyrene cup.

How would the calculated value of l be affected ?

	(I)	(II)
A.	increases	decreases
B.	increases	increases
C.	decreases	decreases
D.	decreases	increases

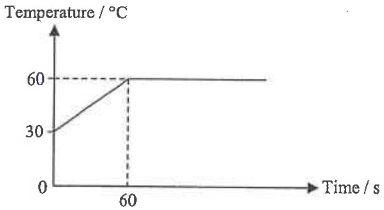
48. **< HKCE 2009 Paper II - 10 >**

Some ice cubes at 0°C are added to 0.3 kg of soft drink at 20°C. What is the minimum amount of ice needed to cool the soft drink to 0°C ?

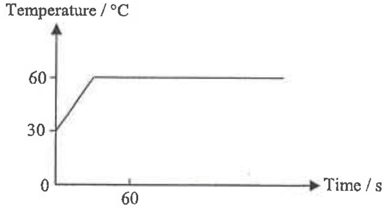
Given : specific heat capacity of the soft drink = 5300 J kg^{-1} °C^{-1}
specific latent heat of fusion of ice = 3.34×10^5 J kg^{-1}

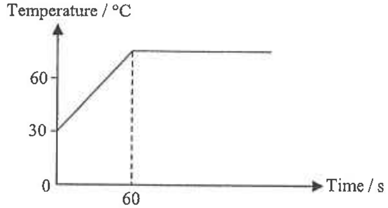
A. 0.08 kg
B. 0.10 kg
C. 0.26 kg
D. 0.32 kg

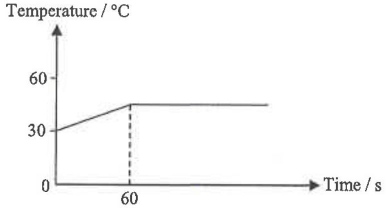
49. **< HKCE 2009 Paper II - 11 >**

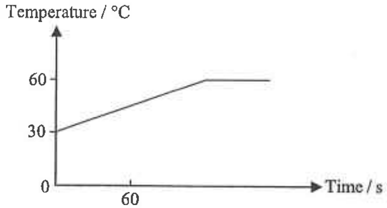


When a certain mass of a solid substance is heated by a heater of constant power, the variation of its temperature with time is shown in the figure above. If a greater mass of the same substance is heated by the same heater, which of the following graphs best represents how its temperature varies with time ? (Assume no heat lost to the surroundings.)

A.


B.


C.


D.


50. **< HKCE 2010 Paper II - 8 >**

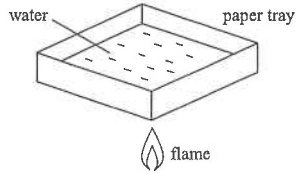
Three different solids, initially at 20°C, are heated at the same power.

solid	heat capacity / J °C^{-1}	melting point / °C
P	300	218
Q	500	132
R	900	84

Which solid will start melting first ?

A. *P*
B. *Q*
C. *R*
D. cannot be determined as the mass is unknown

51. **< HKCE 2010 Paper II - 9 >**



A paper tray contains some water. The tray is heated by a gentle flame from below as shown. The water in the tray starts to boil while the paper does not catch fire. Which of the following statements are correct in this situation ?

(1) Water can transfer heat away from the paper tray very quickly.
(2) Water remains at 100°C when it is boiling.
(3) There is no heat transfer between the paper tray and the flame.

A. (1) & (2) only
B. (2) & (3) only
C. (1) & (3) only
D. (1), (2) & (3)

52. **< HKCE 2010 Paper II - 11 >**

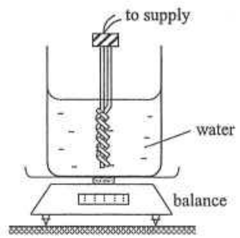


Figure (a)

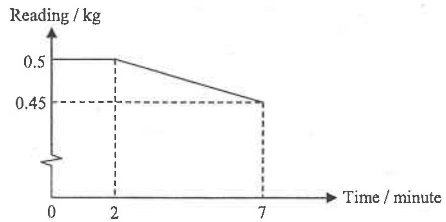


Figure (b)

Figure (a) shows a beaker of water heated by an immersion heater. Figure (b) shows the variation of the reading of the balance with time. What is the estimated output power of the heater ?
(Assume no heat lost to the surroundings.)

Given : specific latent heat of vaporization of water = 2.26×10^6 J kg^{-1}
specific heat capacity of water = 4200 J kg^{-1} °C^{-1}

A. 175 W
B. 269 W
C. 377 W
D. 700 W

53. **< HKCE 2010 Paper II - 10 >**

People feel cooler when they get out of water after swimming. Which of the following is/are the reason(s) ?

(1) The water on the skin evaporates.
(2) The water on the skin absorbs latent heat of fusion.
(3) The water on the skin releases latent heat of vaporization to the surrounding air.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

Questions 54 and 55 :

The setup in Figure (a) is used to determine the specific latent heat of fusion of ice. At time $t = 0$, 0.15 kg of ice cubes at 0°C are added into 1 kg of hot water. The initial temperature of water is 60°C. Figure (b) shows the variation of the water temperature with time. At Q, the mixture achieves the thermal equilibrium.

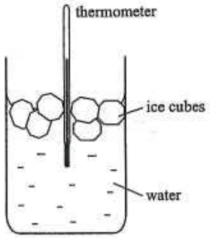


Figure (a)

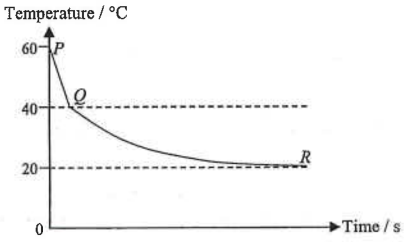


Figure (b)

54. **< HKCE 2011 Paper II - 9 >**

What is the specific latent heat of fusion of ice estimated from this experiment ?
Given : specific heat capacity of water = 4200 J kg^{-1} °C^{-1} ?

A. 3.34×10^5 J kg^{-1}
B. 3.92×10^5 J kg^{-1}
C. 4.48×10^5 J kg^{-1}
D. 5.60×10^5 J kg^{-1}

55. **< HKCE 2011 Paper II - 10 >**

Which of the following statements about the experiment is correct ?

A. Between P and Q, the water is absorbing latent heat of fusion from the ice.
B. Between P and Q, the temperature of the ice is increasing.
C. Between Q and R, the water is absorbing energy from the surroundings.
D. The temperature of the surroundings is 20°C.

Part B : Supplemental exercise

56. An ice-making machine extracts energy at a rate of 500 W. The specific latent heat of fusion of ice is 334 kJ kg^{-1}. How long does it take to change 10 kg of water at 0°C to become ice at 0°C ?

A. $\dfrac{10 \times 334}{500}$ s
B. $\dfrac{10 \times 500}{334}$ s
C. $\dfrac{10 \times 334 \times 1000}{500}$ s
D. $\dfrac{10 \times 500}{334 \times 1000}$ s

57. An immersion heater rated at 150 W is fitted into a large block of ice at 0°C. How long does it take to melt 30 g of ice ?
(Given : Specific latent heat of fusion of ice is 334 000 J kg^{-1}.)

A. 33.4 seconds
B. 66.8 seconds
C. 66800 seconds
D. 66.8 minutes

58. Which of the following statements correctly describe the difference between evaporation and boiling of a liquid ?

(1) Evaporation occurs at all temperatures but boiling occurs at one temperature only.
(2) Evaporation occurs at surface of the liquid but boiling occurs throughout the liquid.
(3) Evaporation does not absorb latent heat of vaporization but boiling absorbs latent heat of vaporization.

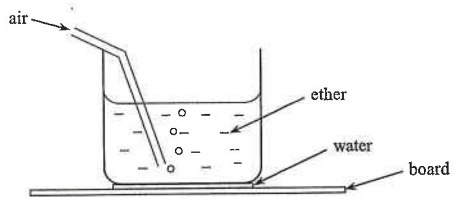
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

59. Which of the following would enable wet clothes to dry more quickly ?

(1) Spread the clothes to increase the surface area.
(2) Increase the temperature of the environment.
(3) Blow air over the clothes.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

60.



The above diagram shows a beaker containing ether which is a volatile liquid. The beaker stands on a wooden board. A thin film of water is put between the board and the base of the beaker. Air is then blown through the tube so that it bubbles out from the immersed end. Which of the following would happen ?

(1) Ether evaporates from the beaker.
(2) Mist forms at the outer surface of the beaker.
(3) The water cools down and freezes.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

61. David sweats 0.1 kg of water in 10 minutes after the athlete meet. What is the rate of cooling of his body by sweating ?
(Specific latent heat of vaporization of water is 2.26×10^6 J kg^{-1})

A. 377 J s^{-1}
B. 754 J s^{-1}
C. 22600 J s^{-1}
D. 37700 J s^{-1}

62. In a refrigerator, the liquid Freon is pumped around the pipes in a circuit. Which of the following are correct ?

(1) As the Freon evaporates, it removes energy from the food.
(2) As the Freon condenses, it gives out energy.
(3) The energy removed from the food is given out at the back of the refrigerator.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

63. A cup of water is placed at the room temperature of 25°C. At which temperatures would evaporation and boiling start to occur respectively ?

	Temperature at which evaporation starts	Temperature at which boiling starts
A.	25°C	50°C
B.	25°C	100°C
C.	50°C	50°C
D.	100°C	100°C

64. When a liquid evaporates, some of the molecules escape from the surface and the temperature of the liquid change. Which of the following best describes the energy of the escaping molecules and the change in temperature of the liquid ?

	Energy of escaping molecules	Temperature of the liquid
A.	low	increase
B.	low	decrease
C.	high	increase
D.	high	decrease

65. The melting points and boiling points of four elements are listed below. Which element is a liquid at 1000°C ?

	Element	Melting point / °C	Boiling point / °C
A.	Aluminium	660	2470
B.	Mercury	– 39	357
C.	Chlorine	– 101	– 35
D.	Iron	1540	2750

66. When Paul goes out from an air-conditioned shopping mall, he found that his glasses become misted-up. Which of the following statements are correct ?
(1) Water vapour condenses onto the glass surfaces.
(2) Cold air holds less water vapour than warm air.
(3) Latent heat of vaporization is absorbed when mist is formed.
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

67. If we come out from a swimming pool and do not dry ourselves, we would feel cool. What is the main reason ?
A. Water is a good conductor of heat.
B. Water is colder than the air.
C. Water has a high specific heat capacity.
D. Water evaporates in air.

68. What is the process that causes water molecules to escape from the surface of the sea to the sky ?
A. boiling
B. convection
C. evaporation
D. radiation

69. When water is heated steadily, its temperature stops to rise when the water starts to
A. release water vapour
B. evaporate.
C. freeze.
D. boil.

70. Mary hangs the wet clothes in a room for drying. Which of the following can help the clothes to dry more quickly ?
(1) Close the window.
(2) Switch on the dehumidifier.
(3) Switch on the heating radiator.
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

71. Peter puts a few drops of alcohol in his right hand and a few drops of water in his left hand at the same time. He feels that his right hand is cooler than his left hand. Which of the following may be the reason ?
(1) Alcohol has evaporation but water does not have evaporation.
(2) The heat conduction of alcohol is better than that of water.
(3) Alcohol has a greater rate of evaporation than water.
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

72. Which of the following statements are correct when a liquid is boiling ?
(1) When the liquid is boiling, large amounts of energy are absorbed.
(2) The average kinetic energy of its molecules is increased during boiling.
(3) The average potential energy of its molecules is increased during boiling.
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

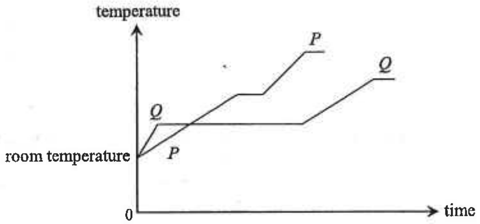
73. When a gas is heated, which of the following statements must be correct ?
(1) The temperature of the gas must increase.
(2) The kinetic energy of the gas molecules must increase.
(3) The molecules of the gas must move faster.
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

74. Which of the following statements is/are correct when a vapour condenses into a liquid at its boiling point ?
(1) When the vapour condenses, its temperature decreases.
(2) The vapour releases energy to the surroundings during condensation.
(3) The average potential energy of the molecules decreases.
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

75. When a body is heated, which of the following statements must be correct ?
A. The internal energy of the body always increases.
B. The temperature of the body always increases.
C. The average kinetic energy of the molecules in the body always increases.
D. The average potential energy of the molecules in the body always increases.

Part C : HKDSE examination questions

76. **< HKDSE Sample Paper IA - 2 >**



The graph shows the variation in temperature of equal masses of two substances P and Q when they are separately heated by identical heaters. Which deduction is correct ?

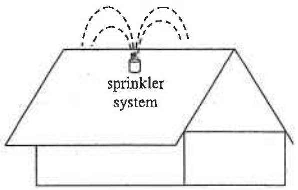
A. The melting point of P is lower than that of Q.

B. The specific heat capacity of P in solid state is larger than that of Q.

C. The specific latent heat of fusion of P is larger than that of Q

D. The energy required to raise the temperature of P from room temperature to boiling point is more than that of Q.

77. **< HKDSE Practice Paper IA - 4 >**



The sprinkler system on a rooftop is able to spray small water droplets onto the rooftop which can lower the temperature of the rooftop on hot sunny days. Which of the following explanations about the sprinkler system is/are reasonable ?

(1) Water is a good conductor, which conducts heat quickly.

(2) Water has a high specific heat capacity, absorbing a lot of energy when its temperature rises.

(3) Water has a high specific latent heat of vaporization, absorbing a lot of energy when it evaporates.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

78. **< HKDSE 2012 Paper IA - 4 >**

Which of the following descriptions is correct ?

A. When water at 25°C is heated to 50°C, both the kinetic energy and potential energy of the water molecules increase.

B. When water at 25°C is heated to 50°C, only the potential energy of the water molecules increases.

C. When water boils at 100°C and turns into steam, the kinetic energy of the water molecules increases.

D. When water boils at 100°C and turns into steam, the potential energy of the water molecules increases.

79. **< HKDSE 2012 Paper IA - 2 >**

When a patient's arm is wiped by a piece of cotton soaked with alcohol, the wiped area will feel cool as that patch of alcohol on the skin evaporates. Which statement explains this phenomenon ?

A. The evaporation of alcohol absorbs heat from the patient's arm.

B. The alcohol on the skin releases latent heat to the surrounding air.

C. The motion of all the molecules in the patch of alcohol slows down.

D. Air molecules remove heat from the patch of alcohol by conduction.

80. **< HKDSE 2013 Paper IA - 1 >**

Which of the following statements about *boiling* and *evaporation* of a liquid is/are correct ?

(1) A liquid absorbs energy when it boils but does not absorb energy when it evaporates.

(2) Boiling occurs at a definite temperature while evaporation takes place above room temperature.

(3) Boiling occurs throughout the liquid while evaporation only takes place at the liquid's surface.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

81. **< HKDSE 2013 Paper IA - 2 >**

In an experiment to measure the specific latent heat of vaporization of water, a beaker of water is boiled off using an electric heater. Which of the following sources of error would lead to an experimental result smaller than the standard value ?

A. Energy is lost to the surroundings.

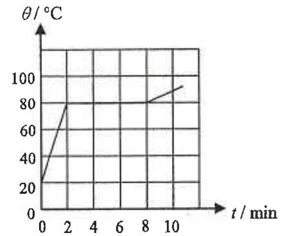
B. Water splashes out of the beaker.

C. Steam condenses on the cooler part of the heater and drops back to the beaker.

D. The heater is not completely immersed in water.

82. **< HKDSE 2014 Paper IA - 2 >**

An electric heater of constant power is used to heat a solid substance X which is insulated from the surroundings. The variation of its temperature θ with time t is shown. X has a specific heat capacity of 800 J kg^{-1} °C^{-1} in its solid state. What is the specific latent heat of fusion of X ?



A. 144 kJ kg^{-1}

B. 192 kJ kg^{-1}

C. 202 kJ kg^{-1}

D. Answer cannot be found as both the mass of X and the power of the heater are not known.

83. **< HKDSE 2016 Paper IA - 2 >**

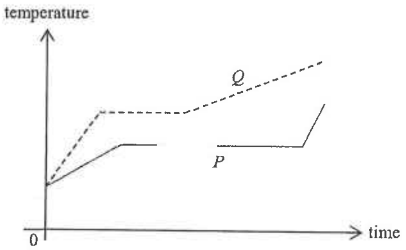
0.3 kg of water at temperature 50°C is mixed with 0.2 kg of ice at temperature 0°C in an insulated container of negligible heat capacity. What is the final temperature of the mixture ?

Given : specific heat capacity of water = 4200 J kg^{-1} °C^{-1}
specific latent heat of fusion of ice = 3.34×10^5 J kg^{-1}

A. − 1.8°C
B. 0°C
C. 1.8°C
D. 3.0°C

84. < HKDSE 2017 Paper IA - 2 >

Same mass of solids P and Q are heated at the same rate. The temperature-time graphs of the two substances are shown below.



Which of the following comparisons about their melting points and specific latent heats of fusion is correct ?

	higher melting point	larger specific latent heat of fusion
A.	P	P
B.	P	Q
C.	Q	P
D.	Q	Q

85. < HKDSE 2017 Paper IA - 3 >

Which of the following statements about the internal energy of a substance are correct ?

(1) When a solid melts, the latent heat of fusion absorbed becomes potential energy of the molecules in the substance.
(2) When a vapour condenses, its internal energy decreases.
(3) When a liquid evaporates, the internal energy of the remaining liquid increases.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

86. <HKDSE 2020 Paper IA-2>

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. D	11. A	21. D	31. B	41. A
2. C	12. A	22. D	32. C	42. C
3. A	13. A	23. B	33. C	43. A
4. D	14. A	24. A	34. C	44. C
5. D	15. A	25. A	35. B	45. D
6. B	16. C	26. A	36. B	46. B
7. A	17. C	27. A	37. A	47. D
8. C	18. A	28. C	38. B	48. B
9. A	19. B	29. B	39. D	49. D
10. D	20. B	30. B	40. D	50. B
51. A	61. A	71. B	81. B	
52. C	62. D	72. B	82. A	
53. A	63. B	73. D	83. B	
54. B	64. D	74. D	84. C	
55. D	65. A	75. A	85. A	
56. C	66. A	76. B	86. B	
57. B	67. D	77. D		
58. A	68. C	78. D		
59. D	69. D	79. A		
60. D	70. C	80. B		

M.C. Solution

1. D

✓ (1) The temperature of the horizontal line is the freezing point, thus, A has a higher freezing point.

✓ (2) A has a greater specific latent heat of fusion because it takes a longer time for the process of freezing.

✓ (3) $E = P\,t = m\,c\,\Delta T$ $\therefore$ slope of graph $= \dfrac{\Delta T}{t} = \dfrac{P}{m \cdot c} \propto \dfrac{1}{c}$

Liquid A has a smaller absolute value of slope, thus A has the greater specific heat capacity.

2. C

$E = m \cdot \ell_v$ $\therefore\ P = \frac{E}{t} = \frac{m}{t} \cdot \ell_v$

$(42) = (10^{-4})\ \ell_v$ $\therefore\ \ell_v = 42 \times 10^4 \text{ J kg}^{-1}$

3. A

As specific latent heat of steam is much greater than the specific latent heat of ice,
part of the latent heat of steam can melt the ice and heat it to become 100°C water to give a mixture of water and steam.

4. D

① $P t_1 = m\ \ell_v$

② $P t_2 = m\, c\, \Delta T$

As t_1 and t_2 are both equal to 100

$\therefore\ m\ \ell_v = m\, c\, \Delta T$

$\therefore\ \ell_v = c\, \Delta T$

$\therefore\ \ell_v = (1000)(70 - 20) = 50\ 000 \text{ J kg}^{-1}$

5. D

S absorbs the greatest amount of energy because

① S undergoes the process of fusion and vaporization when temperature increases from 250 K to 400 K

② S has a higher specific latent heat of fusion and vaporization.

6. B

As specific latent heat of steam is much greater than the specific latent heat of ice,
part of latent heat released by steam can melt the ice and heat it to become 100°C water
to give a mixture of water and steam finally.

7. A

✓ (1) Constant temperature is maintained around 70°C at which solidification occurs.

× (2) Upon state change, liquid and solid are both present.

× (3) Energy is lost to the surroundings during the process of solidification.

8. C

$P t_1 = m\, c\, \Delta T$ and $P t_2 = m\ \ell_v$

Combining the two equations :

$\frac{P t_1}{P t_2} = \frac{m\, c\, \Delta T}{m\, \ell_v}$ $\therefore\ \frac{P(10)}{P t_2} = \frac{m(4.2)(100-20)}{m(2268)}$

$\therefore\ t_2 = 67.5$ minutes

9. A

✓ (1) Supplied energy is used for state change to increase the potential energy of molecules only.

× (2) Since the temperature does not change, the kinetic energy of molecules must be unchanged.

× (3) Since the kinetic energy of molecules is unchanged, the speed must also be unchanged.

10. D

This is a cooling curve of liquid.

Region P : liquid and then start to change into solid

Region Q : liquid and solid exist together

Region R : solidification still carry on and then complete

Region S : solid only

11. A

As $c < \ell_f < \ell_v$ and $c_{copper} < c_{water}$

$\therefore\ E_2 < E_4 < E_1 < E_3$

12. A

Longest horizontal region corresponds to greatest amount of latent heat of fusion.

13. A

By $\ell_v = \frac{E}{m}$

✓ A. Heat gain causes more ice to melt, thus m is larger and ℓ_v is smaller.

× B. Heat loss means more energy is given out by heater, thus E is larger and ℓ_v is greater.

× C. Water remains in funnel means less water is present in beaker, thus m is smaller and ℓ_v is greater.

× D. Some extra energy is used to heat the ice to the melting point of 0°C, thus E is larger and ℓ_v is greater.

14. A

× A. The water vapour cannot come out from the beaker and thus the experiment does not work.

✓ B. To ensure that no water jumps out from the beaker.

✓ C. To reduce the heat loss to surroundings.

✓ D. Take average of several experimental data can improve the accuracy of the experiment.

15. A

By $E = P t$

$\therefore\ P = \frac{E}{t} \propto \frac{1}{t}$ (for same solid to be melted)

If P is doubled, then the time taken t would be halved.

16. C

$P t = m \ell_f$

$\therefore (400) \times (500 - 100) = (0.4) \ell_f$

$\therefore \ell_f = 400 \text{ kJ kg}^{-1}$

17. C

$P t_1 = m c \Delta T$ and $P t_2 = m \ell_v$

Combining the two equations :

$$\frac{P t_1}{P t_2} = \frac{m c \Delta T}{m \ell_v}$$

$$\therefore \frac{P(10)}{P t_2} = \frac{m(4200)(100-20)}{m(2.268 \times 10^6)} \qquad \therefore t_2 = 67.5 \text{ min.}$$

18. A

✓ A. Crushed ice can increase the contact area of ice with the heater, thus ensure all energy is supplied to ice.

× B. Some extra energy is used to increase the temperature of the ice to reach the melting point of 0°C.

× C. The two funnels should contain the same mass of ice.

× D. Funnel *Y* is already a control to find out the heat gained from the surrounding air, thus there is no need to wrap the insulating material.

19. B

Substance *Q*, at 20°C, is in between its melting point and boiling point, thus it is a liquid at room temperature.

20. B

$E = m \ell_f$

$E = (0.5) \times (2.1 \times 10^5)$ J

21. D

× (1) Horizontal part of *X* occurs at a lower temperature. ∴ *X* has a lower melting point.

✓ (2) $E = P t = m c \Delta T$

$\therefore$ slope of graph $= \frac{\Delta T}{t} = \frac{P}{m \cdot c} \propto \frac{1}{c}$

∴ Greater slope means a smaller specific heat capacity, thus *X* has the smaller one.

✓ (3) Shorter horizontal part of *X* means smaller specific latent heat of fusion of *X*.

22. D

$P t = m \ell_v$

$(150)(200) \times (1 - 20\%) = (0.02) \cdot \ell_v$

$\therefore \ell_v = 1.2 \times 10^6 \text{ J kg}^{-1}$

23. B

× (1) The experiment does not work if covered with a lid since steam cannot come out from beaker.

✓ (2) If the heating coil of heater is not immersed completely, some heat is lost to surrounding air.

× (3) All the water in the beaker has the same temperature since the water must be at boiling point, thus no need to stir.

24. A

× A. The control experiment can find out the heat gained from surroundings, thus no need to cover with a lid.

✓ B. Using melting ice to ensure the ice is at 0°C.

✓ C. To ensure no heat lost to the surroundings.

✓ D. The control must have the identical set-up with the experimental apparatus except that the power supply is not connected, Thus the amount of ice used must be the same in two funnels.

25. A

Heat gained by ice = Heat lost by water

$\therefore m_i L + m_i c \Delta T_i = m_w c \Delta T_w$

$\therefore (0.02) L + (0.02)(4200)(14 - 0) = (0.3)(4200)(20 - 14)$

$\therefore 0.3 \times 4200 \times 6 = 0.02L + 0.02 \times 4200 \times 14$

26. A

✓ A. Wrapping the beaker can reduce heat lost to surrounding air, thus improve the accuracy.

× B. If covering the beaker with a lid, the steam cannot escape and thus the experiment does not work.

× C. The boiling water has uniform temperature at boiling point, thus there is no need to stir the water.

× D. Shorter wires would not affect the power given out by heater.

27. A

Heat lost by the juice to change from 70°C to 0°C = Heat absorbed by the ice to melt completely

$m_{juice} \, c \, \Delta T = m_{ice} \, \ell_v$

$(0.2)(4000)(70 - 0) = m_{ice} (3.34 \times 10^5)$

$\therefore m_{ice} = 0.17$ kg

28. C

By $\ell_v = \frac{E}{m}$

✓ (1) If energy is lost to surroundings, *E* is greater and thus ℓ_v is larger than the true value.

✓ (2) If some steam condenses back, then mass of water boiled into steam *m* decreases, thus ℓ_v is larger.

× (3) If some water splashes out, then *m* increases and thus ℓ_v should be smaller than the true value.

29. B

$E = m_i \ell_v + m_w c \Delta T$

$\therefore$ (25000) = (0.05) (3.34 × 10^5) + (0.05 + x) (4200) (4 – 0)

$\therefore$ x = 0.44 kg

30. B

× (1) Specific latent heat involves the change of state, without the change of temperature.

× (2) The change of temperature of a substance does not relate to its boiling point.

✓ (3) By $E = m\,c\,\Delta T$, if c is lower, ΔT is greater, thus the rise of temperature for P is faster

31. B

× (1) Since the substance is still under cooling, it loses energy to surrounding in period PQ.

× (2) Since the substance is changed from liquid to solid in period PQ, latent heat is released.

✓ (3) When the substance is changed from liquid to solid, its potential energy is decreased.

32. C

For the same kind of solid, the smaller amount of solid will have the same melting point.

The smaller amount of solid will reach the melting point in a shorter time and also melt in a shorter time.

(by $E = m\,c\,\Delta T$, for the same temperature rise, $m\downarrow \therefore E\downarrow$, by $E = P\,t$, $t\downarrow$ for the same heater)

So the new curve will be steeper and become horizontal (during melting) in a shorter time.

33. C

✓ A. At $t = t_1$, the mass of liquid starts to decrease,
thus the liquid starts boiling and changes to vapour and goes away from the beaker

✓ B. Before boiling at t_1, the temperature of the liquid increases as it absorbs heat.

× C. The specific heat capacity of the liquid should be found by

$$c = \frac{E}{m \cdot \Delta T} = \frac{P \cdot t}{m \cdot \Delta T} = \frac{1000\,t_1}{m_2 \cdot \Delta T}$$

✓ D. The specific latent heat of vaporization of the liquid is found by

$$\ell = \frac{E}{m} = \frac{P \cdot t}{m} = \frac{1000\,(t_2 - t_1)}{m_2 - m_1}$$

34. C

Mass of steam vaporized = 1.60 – 1.45 = 0.15 kg

Energy supplied = 0.10 kWh = 0.10 × 3600 000 = 360 000 J

$$\ell_v = \frac{E}{m} = \frac{360000}{0.15} = 2.40 \times 10^6 \text{ J kg}^{-1}$$

35. B

I. If a polystyrene container is used, less heat is lost to the surrounding air.

By $\ell_v = \dfrac{E}{m}$ $\therefore E\downarrow \Rightarrow \ell_v\downarrow$

II. If the heater is completely immersed, less heat is lost to the surrounding air.

By $\ell_v = \dfrac{E}{m}$ $\therefore E\downarrow \Rightarrow \ell_v\downarrow$

36. B

× A. At room temperature, both substances are at solid state.
When temperature stops rising, melting point is reached.
As shown by the graph, melting point of P is higher than that of Q.

✓ B. The slope of the graph is inversely proportional to the specific heat capacity.
As slope of P at solid state is smaller, P has a larger specific heat capacity.

× C. As P takes shorter time for fusion to complete, P has a smaller specific latent heat of fusion.

× D. The time taken for P to reach its boiling point is shorter than that of Q.
Thus the energy required is smaller for P since $E = P\,t$.

37. A

Mist is the condensation of water vapour into liquid on the cold surface.

Evaporation is the vaporization of liquid into vapour at temperature below boiling point to make the glasses become clear.

38. B

Assume no heat lost to surroundings : $m_i \ell_f + m_i c \Delta T_i = m_w c \Delta T_w$

Since m_i and m_w are equal, thus $\ell_f + c \Delta T_i = c \Delta T_w$

$\therefore$ (3.34 × 10^5) + (4200) (θ – 0) = (4200) (100 – θ)

$\therefore$ θ = 10.2°C (water at a temperature higher than 0°C)

39. D

× (1) It should be a poor conductor of heat so that heat can hardly enter the interior of the space shuttle.

✓ (2) High melting point can prevent the space shuttle from melting.

✓ (3) High specific heat capacity can make the temperature rise be smaller,
so that the shuttle would not be too hot.

40. D

✓ A. 0°C is between the melting point and the boiling point of the substance, thus it should be in liquid state.

✓ B. The upper temperature for state change is the boiling point.

✓ C. Slope is inversely proportional to the specific heat capacity.
Since the slope in solid state is greater, the specific heat capacity is smaller.

× D. The time taken for the solid to change to liquid is shorter than that for the liquid to change to gas,
thus the specific latent heat of fusion should be smaller than the specific latent heat of vaporization.

41. A

Assume no heat loss to surroundings, energy gained by ice = energy lost by juice

$m_i \cdot \ell_f + m_i \cdot c_w \cdot \Delta T_i = m_j \cdot c_j \cdot \Delta T_j$

$m_i (3.34 \times 10^5) + m_i (4200)(20 - 0) = (2)(4700)(80 - 20)$

$\therefore \; m_i = 1.35$ kg

Number of ice cubes $= \dfrac{1.35}{0.15} = 9$

42. C

× (1) It makes use of the large value of specific heat capacity of water.

× (2) It is due to the large value of specific heat capacity of water.

✓ (3) Steam stores large amount of internal energy. It causes more serious injury to skin as it condenses.

43. A

✓ (1) The molecules escape from the surface of the liquid in evaporation, so it occurs at the surface only.

✓ (2) When the temperature is higher, more molecules can have enough energy to escape from the liquid.

× (3) Since the more energetic molecules have escaped,
the average kinetic energy of the remaining liquid molecules should decrease.

44. C

$P\,t = m\,c\,\Delta T + m'\,\ell_v$

$\therefore \; P(20 \times 60) = (2)(4200)(100 - 20) + (2 - 1.7)(2.26 \times 10^6)$

$\therefore \; P = 1125$ W

45. D

The average speed of the molecules depends on the average kinetic energy, which in turn depends on the temperature.

Steam at 100°C has the highest temperature, thus the molecules have the highest average speed.

46. B

× (1) Since internal energy depends on mass, material, temperature and state,
an object with higher internal energy may have lower temperature,
and energy must transfer from higher temperature to lower temperature.

× (2) An object may absorb energy or release energy when it changes its state.

✓ (3) The only condition for heat or energy to transfer is temperature difference, from high to low.

47. D

(I) If water splashes out, the mass of water escapes from the cup increases,
by $l = E / m$, the increase of m causes the decrease of l.

(II) If water vapour condenses and drips back, the mass of water escapes from the cup decreases,
by $l = E / m$, the decrease of m causes the increase of l.

48. B

Heat gained by ice = Heat lost by soft drink

$m(3.34 \times 10^5) = (0.3)(5300)(20 - 0)$

$\therefore \; m = 0.0952 \approx 0.10$ kg

49. D

By $E = P\,t = m\,c\,\Delta T$, longer time is needed to heat greater mass of the solid from 30°C to 60°C.

When the temperature reaches 60°C which is the melting point of the solid,

the solid is undergoing state change and thus the temperature remains unchanged.

50. B

Heat required by $P = (300)(218 - 20) = 59400$ J

Heat required by $Q = (500)(132 - 20) = 56000$ J

Heat required by $R = (900)(84 - 20) = 57600$ J

As Q requires the smallest amount of heat, the time needed is smallest, thus Q starts to melt first.

51. A

✓ (1) The heat from the flame conducts through the paper to the water quickly,
thus the heat would not make the paper catch fire.

✓ (2) The maximum temperature of water remains at 100°C, and at this temperature,
the paper would not catch fire.

× (3) Heat transfer from high temperature to low temperature,
thus heat transfer from the flame to the paper tray continuously.

52. C

Between $t = 2$ min to $t = 7$ min, there is (0.5 – 0.45) kg of water boils off to become steam.

By $E = P\,t = m\,\ell_v$

$\therefore \; P(7 - 2) \times 60 = (0.5 - 0.45)(2.26 \times 10^6)$

$\therefore \; P = 377$ W

53. A

✓ (1) The water on the skin evaporates to give the cooling effect.

× (2) During evaporation, the water should absorb latent heat of vaporization from the skin,
not latent heat of fusion.

× (3) When steam condenses, latent heat of vaporization is released,
but water cannot release latent heat of vaporization.

54. B

From P to Q, the ice melted to water and then its temperature rises to 40°C

while the temperature of the hot water drops from 60°C to 40°C.

Heat gained by the ice = heat lost by the hot water

$m_i l_f + m_i c \Delta T_i = m_w c \Delta T_w$

$(0.15) l_f + (0.15)(4200)(40-0) = (1)(4200)(60-40)$

$\therefore l_f = 392\ 000$ J kg^{-1}

55. D

× A. Between P and Q, water is losing heat to the ice.

× B. Between P and Q, the ice is melting, and thus the temperature is unchanged during melting.

× C. At Q, the mixture achieves the same temperature of 40°C and starts to lose heat to the surroundings.

✓ D. As the temperature of the water tends to 20°C, the temperature of the surroundings is 20°C.

56. C

$P t = m l_f$

$\therefore (500) t = (10)(334 \times 1000)$ $\therefore t = \dfrac{10 \times 334 \times 1000}{500}$ s

57. B

$P t = m l_f$

$\therefore (150) t = (0.03) \times (334000)$ $\therefore t = 66.8$ s

58. A

✓ (1) Evaporation can occur at any temperature but boiling can only occur at the boiling point.

✓ (2) Evaporation can only occur at the surface of liquid but boiling takes places inside the liquid.

× (3) Both evaporation and boiling involve latent heat of vaporization.

59. D

✓ (1) Evaporation increases as surface area increases.

✓ (2) Evaporation increases as temperature increases.

✓ (3) Evaporation increases in windy environment.

60. D

✓ (1) Ether would evaporate and the blowing air increases its rate of evaporation.

✓ (2) As evaporation carries away heat, ether cools down. Thus mist forms at the outer surface of the beaker.

✓ (3) As evaporation has cooling effect, water cools and freezes.

61. A

Rate of cooling = $\dfrac{0.1 \times 2.26 \times 10^6}{10 \times 60}$ = 377 J s^{-1}

62. D

✓ (1) Freon absorbs latent heat of vaporization from the food to evaporate.

✓ (2) Freon condenses to release the latent heat of vaporization.

✓ (3) The refrigerator releases heat at the back through the cooling fins.

63. B

Since the water is placed at the room temperature of 25°C, evaporation starts at 25°C.

Boiling can only start at the boiling point of water which is 100°C.

64. D

When evaporation occurs, high energy molecules escape from the surface of the liquid.

After high energy molecules escape, the average K.E. of the remaining molecules decreases, thus temperature decreases.

65. A

To be a liquid, the temperature should be above the melting point and below the boiling point.

At 1000°C : Aluminium is a liquid ; Mercury is a vapour ; Chlorine is a vapour ; Iron is a solid.

66. A

✓ (1) Since his glasses are cold when he goes out, water vapour would condense onto the cold surface.

✓ (2) Warm air can hold more water vapour before saturation occurs.

× (3) Latent heat of vaporization should be released when water vapour condenses to become water.

67. D

As water evaporates, it absorbs latent heat of vaporization from our bodies, thus we would feel cool.

68. C

The water molecules evaporate from the surface of the sea to the sky to form clouds.

69. D

When water boils, the temperature remains at the boiling point of 100°C and does not rise.

70. C

× (1) Close the window reduces the wind blowing over the clothes, thus the clothes would dry less quickly.

✓ (2) Switch on the dehumidifier makes the air dry, thus the clothes would dry more quickly.

✓ (3) Switch on the radiator increases the temperature of the room, thus the clothes would dry more quickly.

71. B

× (1) Both alcohol and water have evaporation on the two hands.

× (2) Both water and alcohol are liquid, their heat conductivity are similar.

✓ (3) Since alcohol has a greater rate of evaporation,
it absorbs latent heat of vaporization from the right hand at a greater rate, thus the right hand feel cooler.

72. B

✓ (1) Boiling requires latent heat of vaporization, thus energy are absorbed by the liquid.

× (2) During boiling, temperature remains unchanged, thus average kinetic energy remains unchanged.

✓ (3) Average potential energy of vapour is greater than that of water, thus it is increased during boiling.

73. D

✓ (1) A gas cannot change state, thus its temperature must increase when it is heated.

✓ (2) As temperature increases, the average kinetic energy of molecules must increase.

✓ (3) As kinetic energy increases, the molecules must move faster.

74. D

× (1) During condensation, the temperature should remain unchanged.

✓ (2) The vapour releases latent heat of vaporization, thus energy is released to the surroundings.

✓ (3) Average potential energy of liquid is less than that of vapour, thus potential energy decreases.

75. A

✓ A. The internal energy must increase as heat is absorbed by the body.

× B. If the body changes state when it is heated, the temperature would remain unchanged.

× C. If the temperature is unchanged, then the average kinetic energy would also be unchanged.

× D. If the body does not change state during heating, then the average potential energy remains unchanged.

76. B

× A. At R.T., both substances are at solid state. When temperature stops rising, melting point is reached.
As shown by the graph, melting point of P is higher than that of Q.

✓ B. The slope of the graph is inversely proportional to the specific heat capacity.
As slope of P at solid state is smaller, P has a larger specific heat capacity.

× C. As P takes shorter time for fusion to complete, P has a smaller specific latent heat of fusion.

× D. The time taken for P to reach its boiling point is shorter than that of Q.
Thus the energy required is smaller for P since $E = P\,t$.

77. D

× (1) Water is not a good conductor, it does not conduct heat quickly.

✓ (2) Water has high specific heat capacity, thus it can absorb much energy when it reaches the rooftop.

✓ (3) Water has high specific latent heat of vaporization,
thus it can absorb much energy from the rooftop when it evaporates at the rooftop.

78. D

When the temperature increases, only kinetic energy of molecules increases.

When the state changes, only potential energy of molecules changes.

When water boils, it changes the state from liquid to vapour, thus the potential energy of water molecules increases.

79. A

Evaporation is the change of liquid state to vapour state, it needs to absorb the latent heat from the skin,

thus the skin feel cool when it loses heat.

80. B

× (1) Both boiling and evaporation absorb energy (latent heat of vaporization).

× (2) Boiling occurs at a definite temperature is correct,
but evaporation takes place at any temperature, not only room temperature.

✓ (3) Boiling occurs throughout the liquid while evaporation occurs at the surface only.

81. B

× A. By $\ell_v \uparrow = \dfrac{E\uparrow}{m}$, measured energy supplied E is greater, result of ℓ_v is greater.

✓ B. By $\ell_v \downarrow = \dfrac{E}{m\uparrow}$, mass escaped from the beaker is greater, result of ℓ_v is smaller.

× C. By $\ell_v \uparrow = \dfrac{E}{m\downarrow}$, mass escaped from the beaker is smaller, result of ℓ_v is greater.

× D. By $\ell_v \uparrow = \dfrac{E\uparrow}{m}$, more heat is lost to air and thus E is greater, result of ℓ_v is greater.

82. A

Let the power be P and the mass of the substance be m.

The time for the solid to rise from 20°C to 80°C takes 2 minutes. $\therefore\ P \times (2) = m\,(800) \times (80 - 20)$

The time for the solid to melt completely takes 6 minutes. $\therefore\ P \times (6) = m\, l_f$

Combine the two equations :

$$\therefore\ \frac{P \times (2)}{P \times (6)} = \frac{m\,(800) \times (60)}{m\, l_f}$$

$$\therefore\ l_f = 144\,000 \text{ J kg}^{-1} = 144 \text{ kJ kg}^{-1}$$

83. B

Assume all the ice is melted finally.

Heat gained by the ice = heat lost by the hot water

$m_i l_f + m_i c \Delta T_i = m_w c \Delta T_w$

$(0.2)(3.34 \times 10^5) + (0.20)(4200)(\theta - 0) = (0.3)(4200)(50 - \theta)$

$\therefore \ \theta = -1.8\ °C$

Since the final temperature cannot be lower than 0 °C for a mixture of ice and water,

the ice has not been completely melted.

Thus, the final temperature should be 0 °C.

84. C

The horizontal part represents the change of state from solid to liquid.

As Q is at a higher position, thus the melting point of Q is higher.

By $P t = m l_v$

$\therefore \ l_v \propto t$ for same m and same P

$\therefore$ P has a larger specific latent heat of fusion as it takes longer time to melt.

85. A

✓ (1) When a solid melts, it absorbs latent heat of fusion.
This energy becomes the potential energy of the molecules.
As the temperature remains unchanged during melting,
the kinetic energy of the molecules remains unchanged.

✓ (2) When a vapour condenses to liquid state, its potential energy decreases, thus internal energy decreases.

× (3) When a liquid evaporates, the temperature of the remaining liquid decreases,
thus the internal energy of the remaining liquid decreases.

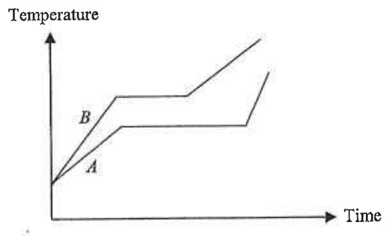
The following list of formulae may be found useful :

Energy transfer during heating or cooling	$E = m c \Delta T$
Energy transfer during change of state	$E = l \Delta m$

Part A : HKCE examination questions

1. **< HKCE 1979 Paper I - 4 >**

(a) Two solids A and B of the same mass are placed in a hot bath and their temperatures are plotted against time as shown in the below figure. Assume that the rates of heat supplied to A and B are the same.



(i) Which of the solids A and B has a higher melting point ? (1 mark)

(ii) Making use of the figure, explain why A should have a higher specific latent heat of fusion than B. (2 marks)

(b) A student carried out an experiment to find the specific latent heat of fusion of ice by the method of mixtures. He placed 0.02 kg of ice at 0°C into a plastic cup (of negligible heat capacity and with good insulation) containing 0.05 kg of water at 20°C. (Specific latent heat of fusion of ice = 336000 J kg^{-1}).

(i) What is the amount of heat required for the ice to change into water at 0°C ? (2 marks)

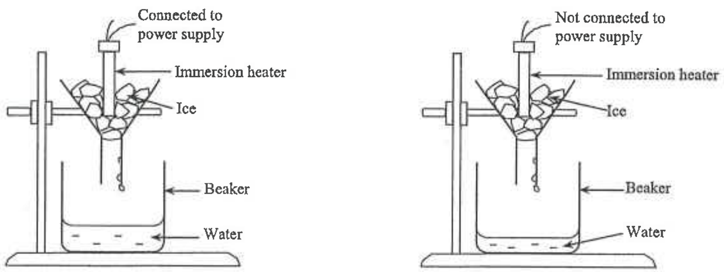
(ii) What is the amount of heat supplied by the water in the cup as it is cooled from 20°C to 0°C ?
(Specific heat capacity of water = 4200 J kg^{-1} °C^{-1}). (2 marks)

(iii) What is the final temperature of the mixture ? (1 mark)

(iv) The student found that he could not obtain a value for the specific latent heat of fusion of ice from the experiment. Why ? Explain briefly. (2 marks)

2. < HKCE 1985 Paper I - 6 >

The below figure shows an experimental set-up to determine the specific latent heat of fusion of ice. The ice used is crushed and melting. In the left hand side, *A*, the electrical energy consumed by the heater is measured by a joulemeter. The water from the melted ice was collected in a beaker. In the right hand side, *B*, shows a control experiment of *A* set up without power supply to the heater.



A *B*

(a) What is the purpose of the control experiment in *B* ? (2 marks)

(b) Why should the ice used in the experiments be (4 marks)

(i) crushed, and

(ii) melting ?

(c) Calculate the specific latent heat of fusion of ice from the following experimental data:

Initial joulemeter reading	=	39428 J
Final joulemeter reading	=	50328 J
Mass of water collected in *A*	=	0.04 kg
Mass of water collected in *B*	=	0.01 kg

(5 marks)

(d) Would you expect the latent heat of fusion of ice obtained to be higher than, equal to or lower than the result you have been obtained in (c), if the experiment were repeated

(i) neglecting the control experiment ?

(ii) using ice at −5°C ?

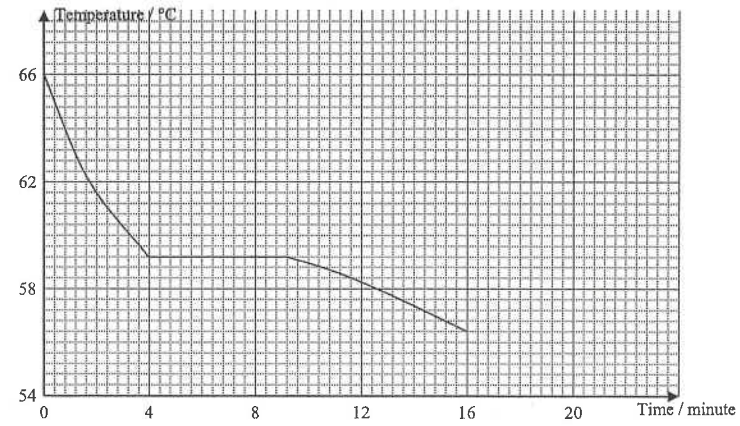
Explain briefly in each case. (4 marks)

(i)

(ii)

3. < HKCE 1990 Paper I - 4 >

The below figure shows the cooling curve of a substance changing from liquid to solid state.



(a) Given a boiling tube half filled with this substance in its solid state, describe, with the help of a diagram, an experiment to obtain the cooling curve of the substance. (5 marks)

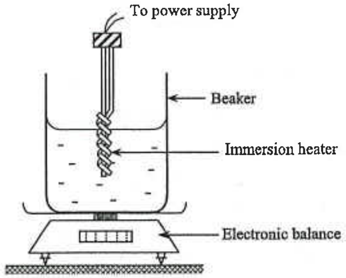
Diagram

(b) Read from the above cooling curve the melting point of the substance. (1 mark)

(c) Explain why the temperature remains constant as the substance solidifies at its melting point, even though heat is lost to the surroundings. (2 marks)

(d) If the mass of substance used is 0.05 kg and the rate of heat loss to the surroundings is 25 W at its melting point, find the specific latent heat of fusion of the substance. (3 marks)

4. < HKCE 1993 Paper I - 4 >



A student performs an experiment to find the specific latent heat of vaporization of water. A beaker containing water is placed on an electronic balance. The water is heated by a 100 W immersion heater, which is immersed in the water such that it does not touch the beaker, as shown in the figure above.

(a) It is found that there is a slight decrease in the mass of water in the beaker before the water boils. Explain briefly in terms of molecular motion. (3 marks)

(b) When the water boils, the reading of the balance is taken. After 240 s, the reading of the balance is taken again. The following results are obtained :

Initial reading of the balance = 525.4 g Final reading of the balance = 515.2 g

Calculate (4 marks)

(i) the energy supplied by the heater in 240 s,

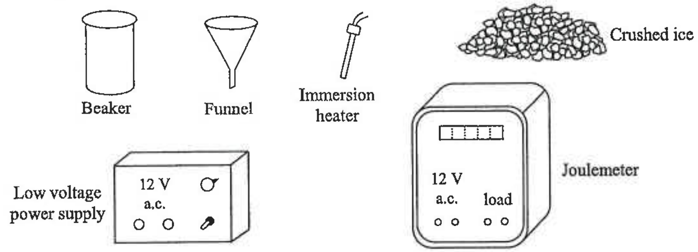
(ii) the specific latent heat of vaporization of water.

(c) The value obtained in (b)(i) is found to be higher than the actual specific latent heat of vaporization of water. Suggest a reason for this and explain briefly. (3 marks)

(d) If the student covers the beaker with a lid, how would the result of the experiment be affected ? Explain briefly. (3 marks)

(e) Suggest TWO improvements on the set-up to increase the accuracy of the experiment. (2 marks)

5. < HKCE 1997 Paper I - 4 >



A student uses the apparatus shown in the above figure to perform an experiment to measure the specific latent heat of fusion of ice. He uses a joulemeter to measure the energy required to melt a certain amount of ice.

(a) Draw a diagram to show how the apparatus can be set up for the experiment. (3 marks)

(b) The following data are obtained in the experiment :

Initial joulemeter reading = 28 000 J
Final joulemeter reading = 40 400 J
Mass of water collected in the beaker = 0.045 kg.

Calculate the specific latent heat of fusion of ice. (3 marks)

(c) Why should the ice used in the experiment be crushed ? (2 marks)

(d) A teacher comments that the result of this experiment is not accurate. He points out that a control experiment is required in order to improve the accuracy of the experiment.

(i) Describe how the control experiment can be set up and explain its function. (4 marks)

(ii) After setting up the control experiment, the student repeats the above experiment. Would you expect the specific latent heat of fusion obtained to be higher or lower than that obtained in (b) ? Explain your answer. (2 marks)

6. < HKCE 1999 Paper I - 2 >

0.1 kg of melting ice is added to 0.5 kg of water at 30°C in a foam cup. Find the final temperature of the mixture. (Specific heat capacity of water = 4200 J kg^{-1} °C^{-1} , Specific latent heat of fusion of ice = 3.4×10^5 J kg^{-1}.) (4 marks)

7. < HKCE 2001 Paper I - 6 >

Explain the following phenomena :

(i) Steam at 100°C causes more severe burns to human skin than boiling water. (2 marks)

(ii) A cup of water gradually loses his weight when it is placed at room temperature. (2 marks)

(iii) We feel cold when we get out of the swimming pool without drying our body. (2 marks)

8. < HKCE 2002 Paper I - 9 >

Yunnan Guoqiao-mixian (雲南過橋米線) is a famous Chinese food. In preparing the food, the first step is to cook a pot of chicken soup : A pot of water containing chickens is heated over a high flame until boils. A low flame is then used to keep the soup boiling for 3 hours.

(a) Explain why the temperature of the boiling soup remains unchanged, even though it is being heated. (2 marks)

(b) (i) The power output of the low flame is 300 W. If 70% of the energy supplied is lost to the surroundings, calculate the mass of soup that would be vaporized after being heated for 3 hours. Assume that the specific latent heat of vaporization of the soup is 2.26×10^6 J kg^{-1}. (3 marks)

(ii) Explain why it is undesirable to use a high flame to keep the soup boiling. (1 mark)

8. (c)

Customers ordering the food are served with the following :

a bowl of hot soup with a layer of oil on the surface,
a dish of thin slices of raw meat, and
a bowl of pre-cooked mixian (noodles)

The meat is first put into the soup. Later, the mixian is also added.

(i) Explain why the meat has to be sliced into thin pieces. (1 mark)

(ii) What is the purpose of adding a layer of oil to the bowl ? (2 marks)

(iii) The following data are given :

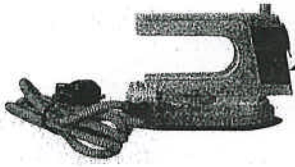
Mass of the soup = 1 kg
Mass of each slice of meat = 0.02 kg
Initial temperature of the soup = 97°C
Initial temperature of the meat = 27°C
Specific heat capacity of the soup = 4200 J kg^{-1} °C^{-1}
Specific heat capacity of the meat = 3500 J kg^{-1} °C^{-1}

For health reasons, the meat has to be heated to a minimum temperature of 82°C. Estimate the maximum number of slices of meat that can be added to the soup.

State one assumption in your calculation. (4 marks)

(iv) A customer places the mixian into the soup before adding the meat. Explain why this is undesirable. (2 marks)

9. **< HKCE 2003 Paper I - 8 >**



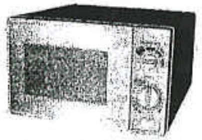
The Figure above shows a travel steam iron with a rated power output of 1100 W. The water tank in the iron is filled with water. When the iron is turned on, water drips continuously from the tank to a hot plate inside the iron, generating steam for ironing clothes. Assume the initial temperature of the water drops is 20°C.

Given : Specific heat capacity of water = 4200 J kg^{-1} °C^{-1}, specific latent heat of vaporization of water = 2.26×10^6 J kg^{-1}.

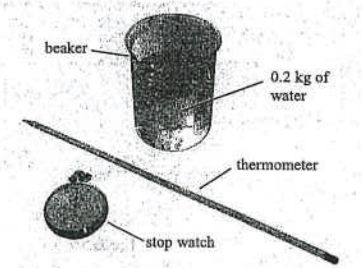
(a) Calculate the energy required to vaporize 1 kg of water at 20°C into steam. (2 marks)

(b) Assume that 80% of the power output of the iron is used to generate steam. Estimate the maximum mass of steam that can be generated by the iron in 1 s. (2 marks)

10. **< HKCE 2004 Paper I - 8 >**



The Figure above shows a microwave oven. Mary wants to conduct an experiment to estimate the useful output power of the oven. She is provided with the apparatus and material shown in the Figure below.



(a) Describe how Mary should conduct the experiment. Specify all measurements that Mary has to take and write down an equation for calculating the useful output power. (4 marks)

10. (b) The value obtained by Mary is found to be smaller than the specified power of the oven. Suggest one possible reason to account for this difference. (1 mark)

(c) Mary suggests that the following measures would improve the accuracy of the experiment :

1. Replacing the beaker with a container with a smaller heat capacity.
2. Increasing the mass of water used in the experiment.

Explain whether each of the above measures would work. (3 marks)

(d) Mary uses the oven to defrost a piece of meat of mass 0.2 kg. The meat is taken from a freezer, the temperature of which is maintained at -20°C. Assume that 70% of the mass of the meat is made up of water.

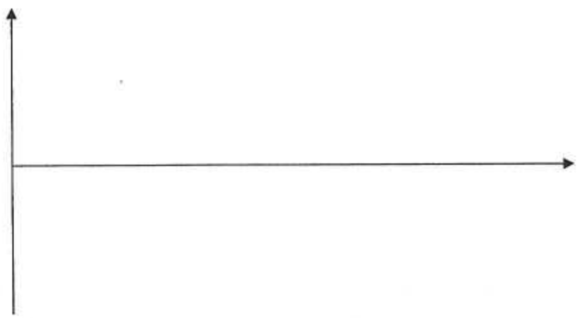
Given : specific heat capacity of the frozen meat = 1700 J kg^{-1} °C^{-1},
specific latent heat of fusion of ice = 3.34×10^5 J kg^{-1}.

(i) Find

(1) the energy required to raise the temperature of the meat from -20 °C to 0 °C, and

(2) the energy required to change the ice in the meat at 0 °C to water. (4 marks)

(ii) Sketch a graph to show the variation of the temperature of the meat with time during the defrosting process. (2 marks)



11. < HKCE 2005 Paper I - 3 >

William makes a glass of hot tea (as shown in Figure 1). After a while, he adds some ice cubes into the tea. William uses a temperature sensor to measure the temperature of the tea. Figure 2 shows the temperature-time graph obtained.

Figure 1

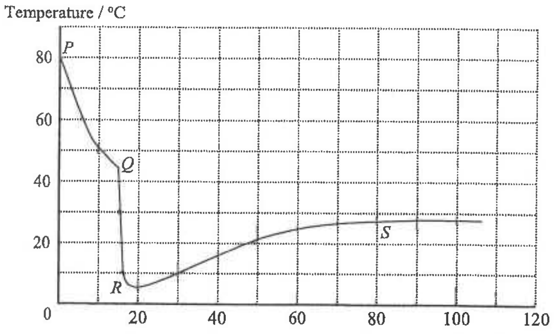


Figure 2

(a) William stirs the tea throughout the experiment. Why does he need to do this ? (1 mark)

(b) P, Q, R and S are four points on the graph. State the point which corresponds to each of the following :

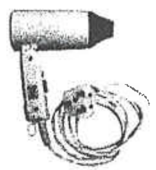
(i) The instant at which the ice cubes are added. (1 mark)

(ii) The instant at which all the ice cubes melt. (1 mark)

(c) Explain why the temperature of the tea increases from R to S. (2 marks)

(d) Estimate the temperature of the surroundings. (1 mark)

12. < HKCE 2005 Paper I - 11 >



The above hairdryer can generate warm air. Carmen uses the above dryer to dry her wet hair. Explain, in terms of molecular motion, how the dryer can speed up the rate of evaporation of water from wet hair. (2 marks)

13. < HKCE 2006 Paper I - 10 >

Dehumidifiers (see Figure 1) are used to lower the humidity of air. Wet air flows into Part A of the dehumidifier and dry air flows out from Part B of the dehumidifier as shown in Figure 2. A liquid called the refrigerant circulates through the coiled tube. The refrigerant absorbs heat from the wet air and evaporates inside the coiled tube in Part A. The vapour of the refrigerant is then pumped to the coiled tube in Part B where it is compressed and condenses into a liquid. The liquid refrigerant then passes back to the coiled tube in Part A and the process is repeated.

Dehumidifier

Figure 1

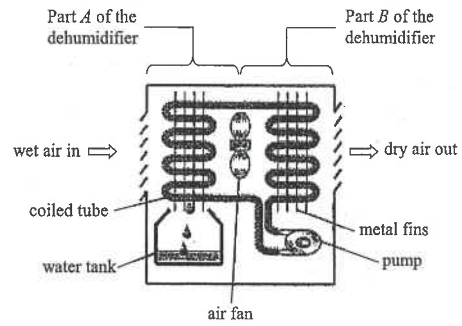


Figure 2

(a) In terms of molecular motion, explain why the temperature of the refrigerant drops when it evaporates inside the coiled tube in Part A. (2 marks)

(b) Explain why the coiled tube in Part A is designed in a coiled shape. (2 marks)

(c) In the coiled tube in Part B, the vapour of the refrigerant is compressed and condenses into liquid. State the change of the average potential energy of the refrigerant molecules during this process of changing state. (1 mark)

(d) When the dehumidifier is in operation, the coiled tube in Part B gives out heat. State and explain two designs that could prevent the dehumidifier from overheating. (2 marks)

13. (e) The dehumidifier is turned on for a few hours in a closed room. Water vapour in the incoming wet air condenses and 1.5 kg of water is collected in the water tank (see Figure 2).

(i) Estimate the total energy released by the water vapour. Given that the specific latent heat of vaporization of water is 2.26×10^6 J kg^{-1}. (2 marks)

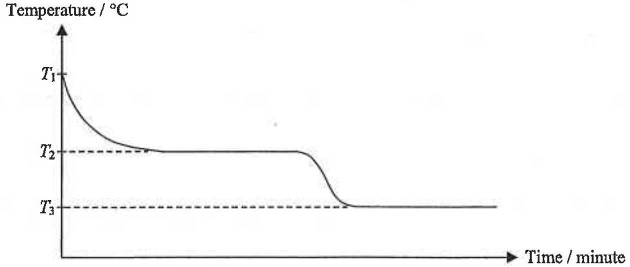
(ii) Using the data and the formula in the below Table, estimate the increase in temperature of the air in the room, assuming that all the energy released in Part *B* is used to raise the temperature of the air inside the room. (3 marks)

Volume of the air in the room = 400 m^3
Density of the air = 1.3 kg m^{-3}
Specific heat capacity of the air = 1030 J kg^{-1} °C^{-1}
Mass = density × volume

14. **< HKCE 2007 Paper I - 4 >**

Karen puts 0.12 kg of water at room temperature T_1 into the freezer of a refrigerator to make ice cubes. The cooling curve of the water is shown in the Figure below.

Given : specific latent heat of fusion of ice = 3.34×10^5 J kg^{-1}



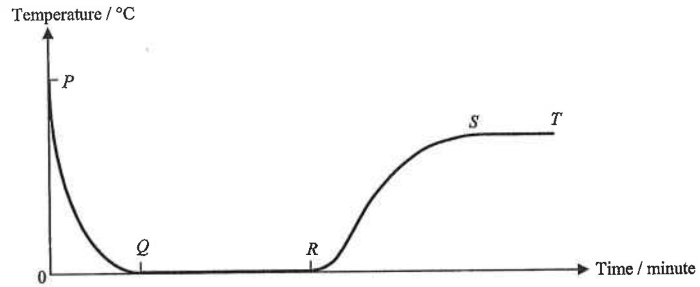
(a) State the physical meaning of temperature T_2. (1 mark)

(b) Find the latent heat released in the above process. (2 marks)

14. (c) If an ice cube from the freezer is placed at room temperature T_1, sketch a graph in the figure below to show the expected change in temperature of the ice cube. (3 marks)

15. **< HKCE 2009 Paper I - 3 >**

At time $t = 0$, Mary adds several ice cubes at 0°C into a glass of warm water. The temperature-time graph of the water is shown in the Figure below.



(a) State the instant at which all ice cubes melt. (1 mark)

(b) Explain why there is no change in temperature

(i) from Q to R, (2 marks)

(ii) from S to T. (1 mark)

16. < HKCE 2009 Paper I - 4 >

The figures below show an electric steam iron. The iron is automatically switched off when the ironing plate is heated to 200°C. When the 'jet steam' button is pressed once, 20 g of water at 28°C will be pumped onto the heated plate at 200°C and the water is converted into steam at 100°C instantly.

Given : specific heat capacity of water = 4200 J kg^{-1} °C^{-1}
specific latent heat of vaporization of water = 2.26×10^6 J kg^{-1}

(a) (i) Estimate the energy required to produce 20 g of steam from water at 28°C. (3 marks)

(ii) Given that the heat capacity of the ironing plate is 637 J °C^{-1}. Estimate the temperature of the plate after producing 20 g of steam. (2 marks)

(b) The iron cannot convert 40 g of water at 28°C to steam when the button has been pressed twice quickly. Explain why. (2 marks)

17. < HKCE 2010 Paper I - 4 >

The Figure shows an electric kettle connected to the mains supply.

Power of the kettle = 1500 W
Mass of water in the kettle = 1.3 kg
Initial temperature of water in the kettle = 25°C
Specific heat capacity of water = 4200 J kg^{-1} °C^{-1}
Specific latent heat of vaporization of water = 2.26×10^6 J kg^{-1}

The kettle is switched on and it takes 5 minutes for the water to start boiling. Assume all electrical energy supplied is transferred to the kettle and water inside, and their temperatures are the same.

(a) Estimate the heat capacity of the kettle. (4 marks)

(b) The kettle is kept switched on for 10 more minutes after boiling. Estimate the mass of water remaining in the kettle. Assume all the steam produced escapes from the kettle. (2 marks)

18. < HKCE 2011 Paper I - 4 >

Figure (a) shows a fish tank heater that is used to regulate the temperature of water in the fish tank. It is fully immersed in the water as shown in Figure (b)

Figure (a)

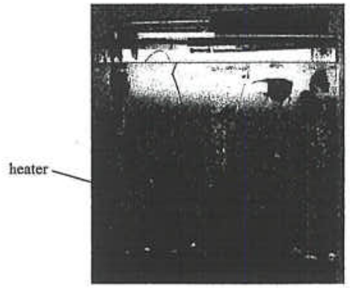


Figure (b)

Given : specific heat capacity of water = 4200 J kg^{-1} °C^{-1}
specific latent heat of vaporization of water = 2.26×10^6 J kg^{-1}

(a) Explain why the heater should be placed near the bottom of the tank. (2 marks)

(b) The mass and initial temperature of water inside the tank are 90 kg and 25°C respectively. The heater is switched on to heat the water.

(i) The power of the heater is 100 W. Estimate the time required for the heater to heat the water to 27°C. (3 marks)

(ii) In practice, there is heat loss to the surroundings during heating. Explain how this would affect the time calculated in (b) (i). (2 marks)

(c) After a few days, it is found that the amount of water inside the tank decreases due to evaporation.

(i) Suggest a method to reduce the rate of evaporation of the water inside the tank. (1 mark)

(ii) On average, the mass of water inside the tank decreases by 0.2 kg in one day. Estimate the energy carried away by evaporation in one day. (2 marks)

Part B : HKDSE examination questions

19. **< HKDSE 2012 Paper IB - 1 >**

Figure 1

Cappuccino is an Italian style coffee topped with a layer of frothy milk (Figure 1).

metallic jug

Figure 2

steam wand

cappuccino machine

Figure 3

Frothy milk is made by bubbling steam through milk, which is held in a metallic jug (Figure 2). Steam is ejected from the steam wand of a cappuccino machine (Figure 3).

Given : specific latent heat of vaporization of water = 2.26×10^6 J kg^{-1}
specific heat capacity of water = 4200 J kg^{-1} °C^{-1}
specific heat capacity of steam = 2000 J kg^{-1} °C^{-1}
specific heat capacity of milk = 3900 J kg^{-1} °C^{-1}

(a) Calculate the total amount of heat released when 20 g of steam at 110°C cools to 100°C and condenses to water at 100°C. (3 marks)

(b) 20 g of steam at 110°C is bubbled through 200 g of milk at 15°C to make frothy milk. Using the result in (a), calculate the temperature of the frothy milk. (2 marks)

(c) Would the actual temperature of frothy milk be higher than, equal to or lower than the value found in (b) ? Explain. (2 marks)

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

Question Solution

1. (a) (i) B has a higher melting point. [1]

(ii) The time taken by A to melt is longer than that of B. [1]

Therefore, A requires larger heat (**OR** greater energy) for melting. [1]

(b) (i) $E = m\ell$

$= (0.02) \times (336000)$ [1]

$= 6720$ J [1]

(ii) $E = mc\Delta T$

$= (0.05) \times (4200) \times (20 - 0)$ [1]

$= 4200$ J [1]

(iii) The final temperature of the mixture is 0°C. [1]

(iv) The student has used too much ice. (**OR** The student has used too little water.) [1]

Therefore, the ice would not melt completely after the experiment. [1]

2. (a) ANY **ONE** of the followings : [2]

- ∗ To find out the mass of ice melted due to the heat gained from the surroundings
- ∗ To find out the mass of ice actually melted by the heater.

(b) (i) The ice should be crushed to increase the surface area of the ice and [1]

ensure good contact of the ice with the heater. [1]

(ii) To ensure the temperature of the ice is at 0°C. [2]

(c) Energy transfer $= (50328 - 39428) = 10900$ J [1]

Mass of ice actually melted by heater $= 0.04 - 0.01 = 0.03$ kg [1]

By $E = ml$ [1]

$\therefore (10900) = (0.03)\,l$ [1]

$\therefore l = 3.63 \times 10^5$ J kg^{-1} [1]

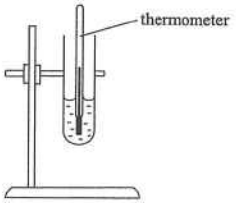
(d) (i) Lower [1]

Since mass of ice melted is larger than the actual value. [1]

(ii) Higher [1]

Since extra amount of energy is used to raise the ice from −5°C to 0°C [1]

3. (a)



[1]

Heat the substance until all changes into liquid and is about 10°C above the melting point. [1]
Allow the tube to cool in air. [1]
Record the temperature at 1 minute interval [1]
until a few degrees below the melting point. [1]

(b) 59.2°C [1]

(c) The substance is losing latent heat of fusion in changing from liquid to solid state. [2]

OR

Potential energy is lost when molecules come close together to form the solid state. [2]

(d) Time = 9.2 – 4 = 5.2 min < 5.2 to 5.6 is acceptable > [1]

$P\,t = m\,\ell$ [1]

$\therefore$ $(25) \times (5.2 \times 60) = (0.05)\,\ell$

$\therefore$ $\ell = 1.56 \times 10^5$ J kg^{-1} < 1.56 to 1.68 is acceptable > [1]

4. (a) Kinetic energy (**OR** speed) of the water molecules increases with temperature. [1]
Some fast moving molecules [1]
then escape from the water, so the mass of water decreases. [1]

(b) (i) $E = P\,t = (100) \times (240)$ [1]
$= 2.4 \times 10^4$ J [1]

(ii) $\ell = \dfrac{E}{m} = \dfrac{(2.4 \times 10^4)}{(525.4 - 515.2) \times 10^{-3}}$ [1]

$= 2.36 \times 10^6$ J kg^{-1} [1]

(c) There is heat loss to the surrounding from the beaker [1]
so energy supplied by the heater is greater than the energy absorbed by the water. [2]

OR

Some water vapour condenses on the beaker, [1]
so the change in mass measured is smaller than the actual mass of water vaporized. [2]

4. (d) The experiment does not work. [1]
As the water vapour cannot escape freely, [1]
so the actual mass of water vaporized cannot be measured. [1]

OR

The value obtained is higher. [1]
As some vapour will condense on the beaker and the lid [1]
so that the change in mass is smaller. [1]

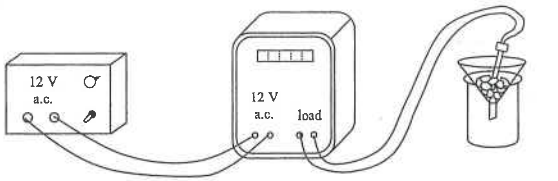
(e) ① Completely immerse the heating coil into the water. [1]

② Either **ONE** of the following : [1]

* Wrap the beaker with insulating material.
* Use a plastic beaker.
* Replace the beaker by a polystyrene cup

< Note that well stir the water **OR** cover the beaker with a lid **are not acceptable** >

5. (a)



< heater and ice in the funnel > [1]
< beaker under the funnel > [1]
< connection of joulemeter > [1]

(b) Energy supplied = 40400 – 28000 = 12400 J [1]

Specific latent heat of fusion :

$\ell = \dfrac{E}{m} = \dfrac{12400}{0.045}$ [1]

$= 2.76 \times 10^5$ J kg^{-1} [1]

(c) Any **ONE** of the following : [2]

* To ensure a good contact between the ice and the heater.
* To increase the surface area of contact between the ice and the heater.
* To enable the temperature of ice to be more close to 0°C

(d) (i) The set-up for the control experiment is identical to the original set-up [1]
except that the heater is not connected to the power supply. [1]
The control experiment can measure the amount of ice melted [1]
due to energy gained from the surrounding air. [1]

5. (d) (ii) The value obtained is higher than that in (b) as some ice melts due to heat gained from surrounding air, [1]
so the true amount of ice melted by the heater is smaller than that collected in the beaker. [1]

6. Energy gained by the ice = Energy lost by the water [1]

$\therefore\ m_i \ell + m_i c \Delta T_i = m_w c \Delta T_w$

$\therefore\ 0.1 \times 3.4 \times 10^5 + 0.1 \times 4200 \times \theta = 0.5 \times 4200 \times (30 - \theta)$ [2]

$\therefore\ \theta = 11.5°C$ [1]

7. (i) Steam will give out a large amount of latent heat of vaporization [1]
when it condenses. [1]

(ii) Evaporation occurs [1]
since high energy water molecules escape from the surface of water. [1]

(iii) Evaporation occurs [1]
and latent heat of vaporization is absorbed from the body. [1]

8. (a) The soup is absorbing latent heat of vaporization in changing its state. [2]

(b) (i) Energy given out by the flame $= P t = 300 \times 3 \times 3600 = 3\ 240\ 000$ J [1]

By $E = m\, l_v$ [1]

$\therefore\ (3240\ 000 \times 30\%) = m\,(2.26 \times 10^6)$

$\therefore\ m = 0.430$ kg [1]

(ii) If a high flame is used, a large amount of soup will be vaporized in 3 hours. [1]

(c) (i) To increase the contact area between the meat and the soup. [1]

(ii) The layer of oil reduces the heat lost to the surrounding air [1]
due to evaporation. [1]

(iii) Energy lost by the soup = Energy gained by the meat

$(1)\,(4200)\,(97 - 82) = (0.02\, n)\,(3500)\,(82 - 27)$ [2]

$\therefore\ n = 16.4$

The maximum number of slices of meat that can be added is 16. [1]

Assumption : There is no heat lost to the surroundings. [1]

(iv) If the mixian is placed into the soup first, the temperature of the soup would largely drop, [1]
thus the soup may not have sufficient energy to cook the meat. [1]

9. (a) $E = m\, c\, \Delta T + m\, l_v$

$= (1)\,(4200)\,(100 - 20) + (1)\,(2.26 \times 10^6)$ [1]

$= 2\ 596\ 000$ J [1]

(b) Useful energy output in 1 s = $(1100)\,(1) \times 80\% = 880$ J [1]

Maximum mass of steam generated in 1 s = $\dfrac{880}{2596000} = 3.39 \times 10^{-4}$ kg [1]

10. (a) Put the thermometer into the water to measure its initial temperature T_1. [1]
Put the beaker of water into the oven and turn on the oven. [1]
Record the time of heating t by using the stop watch. [1]
Take out the beaker of water from the oven and measure its final temperature T_2.

Output power is found by : $P = \dfrac{0.2 \times c \times (T_2 - T_1)}{t}$ [1]

(b) Any **ONE** of the following : [1]

* Some energy is absorbed by the beaker.
* Some energy is lost to the surrounding air.
* Some energy is lost to evaporate (OR vaporize) the water.

(c) 1. Energy absorbed by the container would become smaller, [1]
thus it can improve the accuracy.

2. The percentage of energy lost would become smaller, [1]
thus it can improve the accuracy. [1]

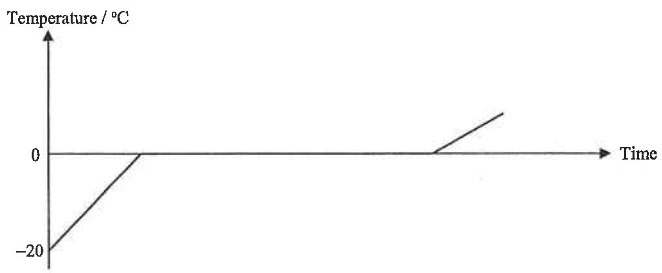
(d) (i) (1) $E = m\, c\, \Delta T = (0.2) \times (1700) \times (20)$ [1]

$= 6800$ J [1]

(2) $E = m\, \ell = (0.2 \times 70\%) \times (3.34 \times 10^5)$ [1]

$= 46\ 760$ J < accept 46 800 J OR 46.8 kJ > [1]

(ii)



< Temperature rises from −20°C to 0°C > [1]

< Temperature remains at 0°C for a period of time > [1]

11. (a) To ensure uniform temperature of the tea. [1]

(b) (i) point Q [1]

(ii) point R [1]

(c) Since the temperature of the tea is lower than the surroundings, [1]
heat flows from the surroundings to the tea. [1]

(d) 28°C < 26°C to 29°C acceptable > [1]

12. The average kinetic energy of the water molecules in the hair will increase,
thus more water molecules at the water surface gain enough energy to escape from the water. [1]

Moreover, the water molecules escaped from the water surface will be blown away by the wind from the dryer. [1]

13. (a) When the fast moving molecules escape from the liquid, [1]
the average kinetic energy of the molecules in the liquid decreases, thus temperature drops. [1]

(b) It can increase the area of contact with air [1]
and thus help to condense the water vapour in the air. [1]

(c) Average potential energy is decreased. [1]

(d) Any **TWO** of the followings : [2]
* The tube is in dark colour to increase the radiation of heat.
* The air fan increase the flow of air.
* The metal fins carry away heat by conduction.
* The vent hole in part B increase the flow of air.

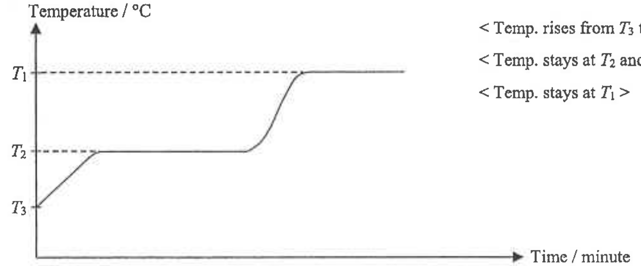
(e) (i) $E = m\,\ell$ [1]
$= (1.5) \times (2.26 \times 10^6)$
$= 3390\ 000$ J [1]

(ii) Mass of air $= 400 \times 1.3 = 520$ kg [1]
By $E = m\,c\,\Delta T$ [1]
$\therefore\ (3390\ 000) = (520) \times (1030) \times \Delta T$
$\therefore\ \Delta T = 6.33$°C [1]

14. (a) T_2 is the melting point of ice. **OR** T_2 is the freezing point of water. [1]

(b) $E = m\,\ell$ [1]
$= (0.12)\,(3.34 \times 10^5) = 40100$ J [1]

14. (c)



< Temp. rises from T_3 to T_2 and stays at T_2 > [1]
< Temp. stays at T_2 and then rises to T_1 > [1]
< Temp. stays at T_1 > [1]

15. (a) R [1]

(b) (i) Water temperature decreases to the melting point of 0°C. [1]
Ice at 0°C is still melting. [1]

(ii) Water reaches the room temperature. [1]

16. (a) (i) $E = m\,c\,\Delta T + m\,l$ [2]
$= (0.02)\,(4200)\,(100 - 28) + (0.02)\,(2.26 \times 10^6)$
$= 51248$ J < accept 51200 J > [1]

(ii) $(51248) = (637)\,(200 - T)$ [1]
$T = 120$°C [1]

(b) To produce 40 g of steam, the temperature of the plate will be decreased by 160°C. [1]
It will then be lower than the boiling point of water. [1]

17. (a) Energy supplied by the kettle
$= P\,t$ [1]
$= (1500) \times (5 \times 60) = 450000$ J

Energy gained by water
$= m\,c\,\Delta T = (1.3)\,(4200)\,(100 - 25) = 409500$ J

$\therefore\ 450000 = 409500 + C\,(100 - 25)$ [2]
$\therefore\ C = 540$ J °C^{-1} [1]

< OR >

$P\,t = m\,c\,\Delta T + C\,\Delta T$ [3]
$(1500)\,(5 \times 60) = (1.3)\,(4200)\,(100 - 25) + C\,(100 - 25)$
$C = 540$ J °C^{-1} [1]

17. (b) $P t = m l$ [1]

$(1500)(10 \times 60) = m(2.26 \times 10^6)$

$m = 0.398$ kg

mass of water remaining in the kettle $= 1.3 - 0.398 = 0.902$ kg [1]

18. (a) By convection, [1]

the temperature of water in the tank will become uniform faster. [1]

(b) (i) $P t = m c \Delta T$ [1]

$(100)\, t = (90)(4200)(27 - 25)$ [1]

$\therefore\ t = 7560$ s [1]

(ii) More energy need to be supplied to compensate the heat lost. [1]

So it takes a longer time to heat up the water. [1]

(c) (i) Evaporation can be reduced by covering the top of the tank. [1]

(ii) $E = m l_v$ [1]

$= (0.2)(2.26 \times 10^6)$

$= 452000$ J [1]

19. (a) $E = m c \Delta T + m l_v$ [1]

$= 0.020 \times 2000 \times (110 - 100) + 0.020 \times 2.26 \times 10^6$ [1]

$= 45600$ J [1]

(b) $E + m_s c_w \Delta T_w = m_m c_m \Delta T_m$

$(45600) + (0.02)(4200)(100 - \theta) = (0.200)(3900)(\theta - 15)$ [1]

$\therefore\ \theta = 76.0$ °C [1]

(c) The actual temperature of the frothy milk is lower. [1]

Some heat is lost to the surrounding air. (**OR** to the metallic jug) [1]

Hong Kong Diploma of Secondary Education Examination

The following list of formulae may be found useful :

Equation of state for an ideal gas $pV = nRT$

Use the following data wherever necessary :

Molar gas constant $R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$

Avogadro constant $N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$

Part A : HKCE examination questions

1. **< HKCE 1980 Paper II - 13 >**

$6 \times 10^{-3}\ \text{m}^3$ of a gas is contained in a vessel at 91°C and a pressure of 4×10^5 Pa. If the density of the gas at s.t.p. (0°C and 10^5 Pa) is $1.2\ \text{kg m}^{-3}$, what is the mass of the gas ?

A. 7.2 g
B. 14.4 g
C. 21.6 g
D. 28.8 g

2. **< HKCE 1981 Paper II - 14 >**

An inexpansible vessel contains 1.2 kg of a gas at 300 K. What is the mass of gas expelled from the vessel if it is heated from 300 K to 400 K under constant pressure ?

A. 0.9 kg
B. 0.75 kg
C. 0.6 kg
D. 0.3 kg

3. **< HKCE 1983 Paper II - 12 >**

A fixed mass of gas has its temperature changed from 127°C to 27°C at constant pressure. The ratio of the new volume to the old volume is

A. 27 : 127
B. 127 : 27
C. 3 : 4
D. 4 : 3

4. **< HKCE 1985 Paper II - 12 >**

The initial pressure of a fixed mass of gas at 25°C is 2×10^5 Pa. What would its pressure be if the gas were reduced to half of its original volume and its temperature were increased to 95°C ?

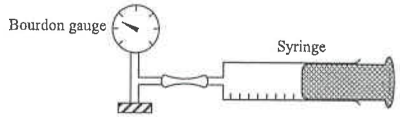
A. 1.23×10^5 Pa
B. 3.24×10^5 Pa
C. 4.94×10^5 Pa
D. 15.2×10^5 Pa

5. **< HKCE 1986 Paper II - 22 >**

If the pressure of a fixed mass of gas of initial volume V is doubled and its absolute temperature halved, its volume becomes

A. $\frac{1}{4}V$
B. $\frac{1}{2}V$
C. $2V$
D. $4V$

6. **< HKCE 1986 Paper II - 17 >**

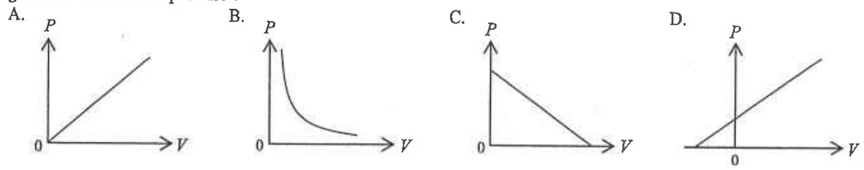


In the experiment shown in the diagram, volume of the air inside the syringe is 25 ml when the pressure is $1.0 \times 10^5\ \text{N m}^{-2}$. What is the volume of the air when the pressure is $0.5 \times 10^5\ \text{N m}^{-2}$? (Assume that mass of the air in the syringe is constant.)

A. 30 ml
B. 50 ml
C. 70 ml
D. 100 ml

7. **< HKCE 1986 Paper II - 20 >**

Which of the following graphs correctly shows the relation between the pressure (P) and the volume (V) of a fixed mass of gas under constant temperature ?



8. **< HKCE 1989 Paper II - 22 >**

A cylinder contains a gas at a pressure of 10^5 Pa and a temperature of 20°C. It is compressed to half of its original volume and the temperature increases to 55°C. What is the final pressure of the gas ?

A. 0.56×10^5 Pa
B. 0.73×10^5 Pa
C. 1.79×10^5 Pa
D. 2.24×10^5 Pa

9. **< HKCE 1990 Paper II - 19 >**

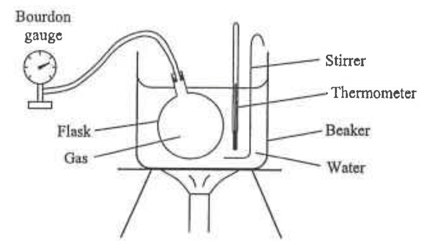
The pressure of a fixed mass of gas at 25°C is 2×10^5 Pa. How would its pressure be if the gas were reduced to half its volume and its temperature were increased to 95°C ?

A. 1.23×10^5 Pa
B. 2.47×10^5 Pa
C. 4.94×10^5 Pa
D. 15.2×10^5 Pa

10. **< HKCE 1991 Paper II - 20 >**

The apparatus shown is used to study the relation between the temperature and the pressure of a fixed mass of gas at constant volume. Which of the following is NOT correct ?

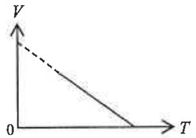
A. Stir the water before taking a reading.
B. Immerse the whole flask in water.
C. Prevent the thermometer from touching the bottom of the beaker.
D. Connect the Bourdon gauge to the flask with a long tube.



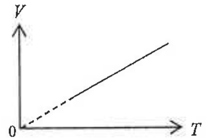
11. **< HKCE 1991 Paper II - 17 >**

Which of the following graphs correctly shows the variation of volume V with absolute temperature T of a fixed mass of gas at constant pressure ?

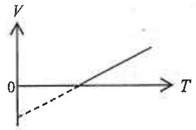
A.



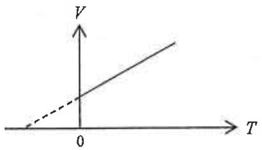
B.



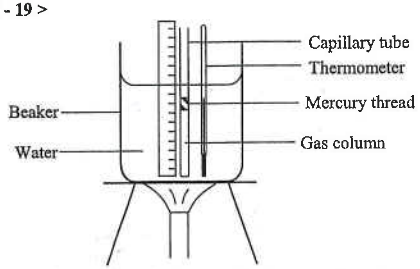
C.



D.



12. **< HKCE 1992 Paper II - 19 >**

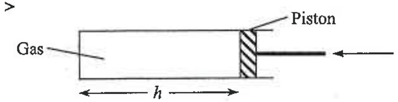


The apparatus shown in the figure is used to study the relation between the volume and temperature of a fixed mass of gas at constant pressure. Which of the following statements is/are correct ?

(1) Immersing the whole gas column in water.
(2) Sealing the capillary tube at both ends.
(3) Preventing the thermometer from touching the bottom of the beaker.

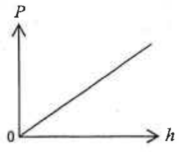
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

13. **< HKCE 1992 Paper II - 21 >**

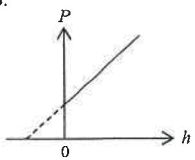


A column of gas is compressed slowly as shown in the figure above. Which of the following graphs correctly shows the relation between the gas pressure P and the length of the gas column h ?

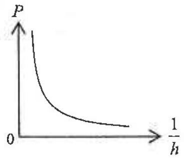
A.



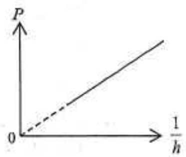
B.



C.



D.



14. **< HKCE 1993 Paper II - 21 >**

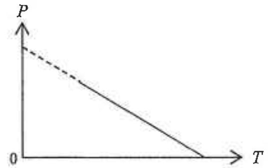
The absolute temperature of a fixed mass of gas is T. If the pressure and volume of the gas are both doubled, its absolute temperature becomes

A. $\frac{1}{4}T$
B. $\frac{1}{2}T$
C. $2T$
D. $4T$

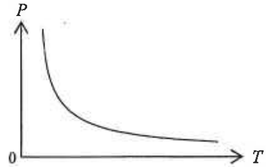
15. **< HKCE 1994 Paper II - 18 >**

Which of the following graphs correctly shows the relation between the pressure P and the absolute temperature T of a fixed mass of gas at constant volume ?

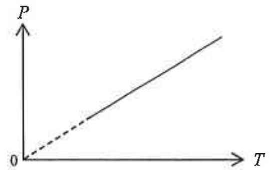
A.



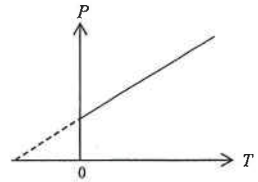
B.



C.



D.

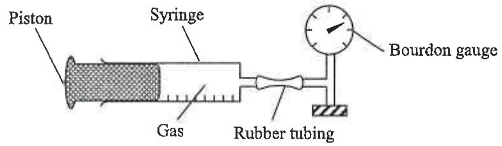


16. **< HKCE 1994 Paper II - 19 >**

The pressure of a fixed mass of gas at 30°C is 3×10^5 Pa. What would be its pressure if the volume of the gas is doubled and its temperature is increased to 60°C ?

A. 1.65×10^5 Pa
B. 3.00×10^5 Pa
C. 5.46×10^5 Pa
D. 6.59×10^5 Pa

17. **< HKCE 1995 Paper II - 20 >**



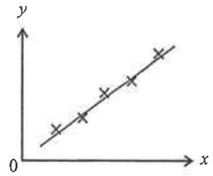
The above apparatus is used to study the relationship between the pressure and volume of a fixed mass of gas at constant temperature. Which of the following can improve the accuracy of the experiment ?

(1) Pressing the piston quickly.
(2) Using a large syringe.
(3) Using a short length of rubber tubing.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

18. **< HKCE 1995 Paper II - 21 >**

The graph shows the result obtained when an experiment is performed to study Boyle's Law. What do the axes of the graph represent ?



	y axis	*x* axis
A.	Volume	Temperature
B.	Volume	1 / Temperature
C.	Pressure	Volume
D.	Pressure	1 / Volume

19. **< HKCE 1996 Paper II - 22 >**

The volume of a fixed mass of gas is V. If the pressure of the gas is doubled and its absolute temperature is reduced to half of the initial value, the volume of the gas becomes

A. $V/4$.
B. $V/2$.
C. $2V$.
D. $4V$.

20. **< HKCE 1996 Paper II - 16 >**

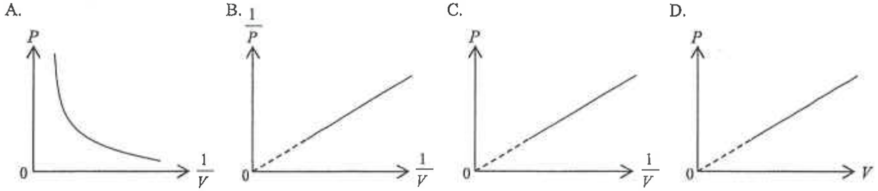
The temperature of two gases are 0°C and 100°C respectively. Express the temperature difference of the two gases in absolute temperature scale.

A. 0 K
B. 100 K
C. 273 K
D. 373 K

21. **< HKCE 1997 Paper II - 18 >**

Which of the following graphs correctly shows the relation between the pressure P and volume V of a fixed mass of gas at constant temperature ?

A. B. C. D.



22. **< HKCE 1997 Paper II - 17 >**

A fixed mass of gas at 120°C is heated at constant volume so that its pressure is tripled. Find the new temperature of the gas.

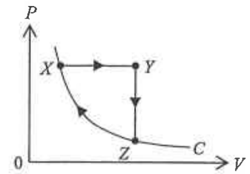
A. 40°C
B. 360°C
C. 906°C
D. 1179°C

23. **< HKCE 1999 Paper II - 18 >**

A cylinder contains a fixed mass of gas at a pressure of 10^5 N m^{-2} and a temperature of 27 °C. The cylinder is compressed to half of its original volume and the pressure increases to 3×10^5 N m^{-2}. Find the final temperature of the gas.

A. 40.5 °C
B. 177 °C
C. 313.5 °C
D. 450 °C

24. **< HKCE 2000 Paper II - 23 >**

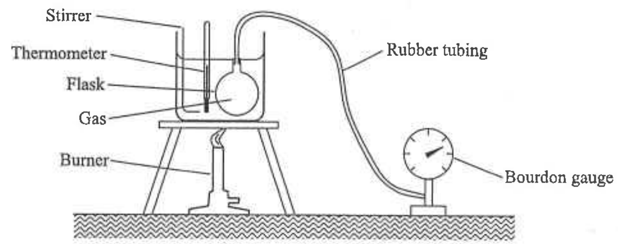


The curve C in the graph shows the P-V relation of a fixed mass of ideal gas at a certain temperature. Point X denotes the initial state of the gas. The state of the gas is now changed along the path shown from X to Y, then from Y to Z, and finally from Z back to X along the curve C. Which of the following statements is/are correct ?

(1) The temperature of the gas remains unchanged in the transition from X to Y.
(2) The temperature of the gas decreases in the transition from Y to Z.
(3) The temperature of the gas remains unchanged in the transition from Z to X.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

25. **< HKCE 2001 Paper II - 20 >**



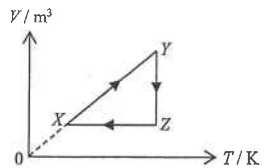
The above apparatus is used to study the relation between pressure and temperature of a fixed mass of gas at constant volume. Which of the following can improve the accuracy of the experiment ?

(1) using a larger flask
(2) using a shorter length of rubber tubing to connect the gauge and the flask
(3) setting up a control experiment with the burner removed

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

26. **< HKCE 2001 Paper II - 21 >**

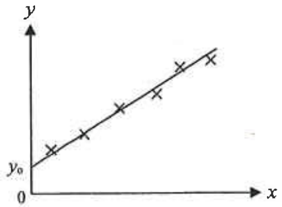
The graph shows the V-T relation of a fixed mass of ideal gas. Point X denotes the initial state of the gas. The gas changes its state from X to Y, then from Y to Z and finally from Z back to X along the path shown. Which of the following statements about the pressure of the gas is/are correct ?



(1) The pressure remains unchanged in the transition from X to Y.
(2) The pressure increases in the transition from Y to Z.
(3) The pressure decreases in the transition from Z to X.

A. (3) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

27. **< HKCE 2002 Paper II - 22 >**



The above graph shows the result obtained when an experiment is performed to study the relation between the pressure and temperature of a fixed mass of gas at constant volume. Which of the following statements is/are correct ?

(1) The y- and x-axes denote the pressure and temperature of the gas respectively.
(2) The slope of the graph denotes the volume of the gas.
(3) The intercept y_0 denotes the absolute zero temperature.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

28. **< HKCE 2003 Paper II - 20 >**

The difference in absolute temperature of two bodies is 100 K. Express the temperature difference in degree Celsius.

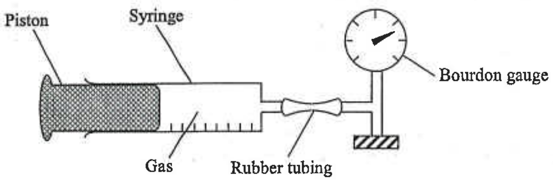
A. −173°C
B. 100°C
C. 273°C
D. 373°C

29. **< HKCE 2003 Paper II - 23 >**

A tyre of a car is filled with air at a temperature of 20°C and a pressure of 200 kPa. After driving for some time, the temperature of the air insider the tyre increases to 30°C and the capacity of the tyre increases by 1%. Find the pressure inside the tyre.

A. 188 kPa
B. 205 kPa
C. 273 kPa
D. 297 kPa

30. **< HKCE 2003 Paper II - 24 >**



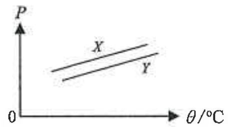
The above apparatus is used to study the relation between the pressure and volume of a fixed mass of gas at constant temperature. Which of the following can improve the accuracy of the experiment ?

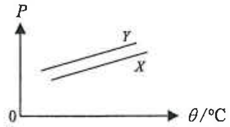
A. using a larger syringe
B. pushing the piston quickly
C. using a longer length of rubber tubing
D. setting a control experiment with the bourdon gauge removed

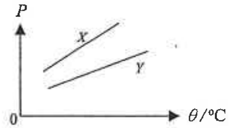
Part B : HKAL examination questions

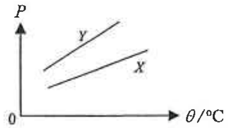
31. **< HKAL 1987 Paper I - 14 >**

Two vessels X and Y contain equal masses of an ideal gas. X has a greater volume than Y. When the temperature θ changes, which of the following represents the variation of the pressure P of the gas in each vessel with temperature θ ?

A.


B.


C.


D.


32. **< HKAL 1988 Paper I - 20 >**

A metal vessel with a small opening contains 1.2 kg of gas at 300 K. Find the mass of gas expelled from the vessel if it is heated from 300 K to 400 K under constant pressure.

A. 0.25 kg
B. 0.30 kg
C. 0.60 kg
D. 0.75 kg

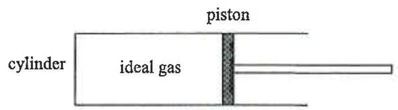
33. **< HKAL 1993 Paper I - 17 >**

An inexpansible vessel contains air at 50°C. What percentage of air remains in the vessel if it is heated to 150°C under constant pressure ?

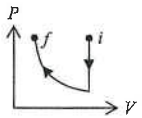
A. 76%
B. 67%
C. 63%
D. 53%

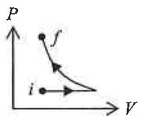
34. **< HKAL 1993 Paper I - 16 >**

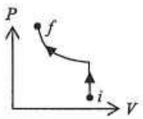
A cylinder fitted with a smooth piston contains an ideal gas as shown below.

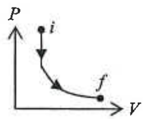


Firstly, the piston is held fixed and the gas is cooled. Secondly, the piston is pushed inwards slowly under constant temperature. If i is the initial state and f is the final state, which of the following graphs represents the variation of gas pressure P with gas volume V ?

A.


B.


C.


D.


35. **< HKAL 1995 Paper IIA - 20 >**

The pressure of an ideal gas in a container is P_o. If the number of gas molecules is halved, the volume of the container is doubled and the temperature is kept constant, what would then be the pressure in the container ?

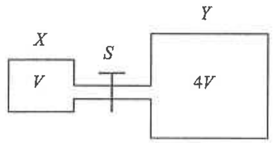
A. $\frac{1}{4}P_o$

B. $\frac{1}{2}P_o$

C. P_o

D. $2P_o$

36. **< HKAL 1999 Paper IIA - 37 >**



Two different containers X and Y of volume V and $4V$ respectively are connected by a narrow tube as shown. Initially the tap S is closed and an ideal gas is contained in X at a pressure of 400 kPa while container Y is evacuated. The tap S is then opened. Which of the following statements is correct when equilibrium is finally reached ?

A. The gas pressure in X is 100 kPa.

B. There are still gas molecules moving through the tap S.

C. The product of pressure and volume of the gas in X is equal to that in Y.

D. The density of gas molecules in X is greater than that in Y.

37. **< HKAL 2001 Paper IIA - 4 >**

Which of the following quantities is/are vector ?

(1) change of momentum

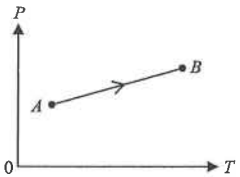
(2) work

(3) pressure

A. (1) only
B. (1) & (2) only
C. (1) & (3) only
D. (2) & (3) only

38. **< HKAL 2002 Paper IIA - 38 >**

The graph shows the relation between the pressure P and the absolute temperature T of a fixed mass of an ideal gas, which changes from state A to state B along the path AB. Which of the following statements s/are correct ?



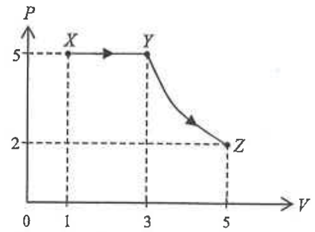
(1) The graph shows that P is directly proportional to T.

(2) All the points on line AB satisfy the relation $\frac{PV}{T}$ = constant.

(3) From state A to state B, the volume V of the gas increases.

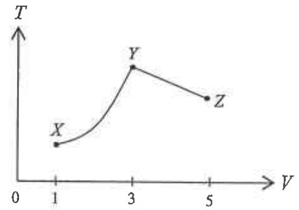
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

39. **< HKAL 2003 Paper IIA - 38 >**

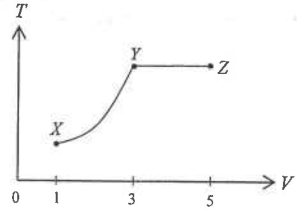


A fixed mass of an ideal gas changes from state X to state Y, then to state Z as shown in the pressure P against volume V graph. Which of the below graphs best shows how the variation of the absolute temperature T of the gas with its volume V ?

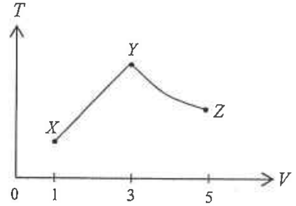
A.



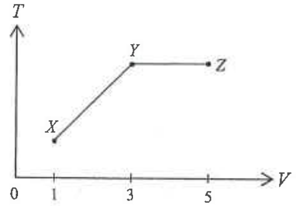
B.



C.

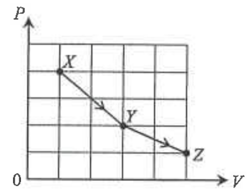


D.



40. **< HKAL 2004 Paper IIA - 37 >**

An ideal gas undergoes a change from state X to state Y, then to state Z as shown in the pressure P against volume V graph. Which of the following descriptions about the temperature of the gas at X, Y and Z is correct ?



A. The temperature of the gas is lowest at X and highest at Y.

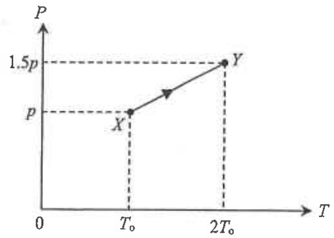
B. The temperature of the gas is lowest at X and highest at Z.

C. The temperature of the gas is lowest at Y and highest at X.

D. The gas has the same temperature at X, Y and Z.

41. **< HKAL 2005 Paper IIA - 21 >**

A gas in a vessel of fixed volume leaks gradually. The gas changes from state X of pressure p and absolute temperature T_o to state Y of pressure $1.5p$ and absolute temperature $2T_o$ as shown in the pressure P against absolute temperature T graph. What percentage of the original mass of the gas leaks out from the vessel in this process ?



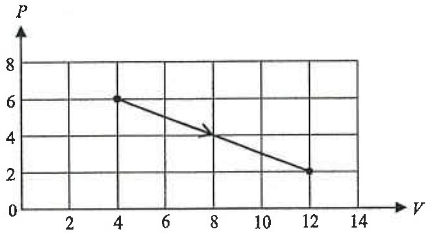
A. 10%

B. 20%

C. 25%

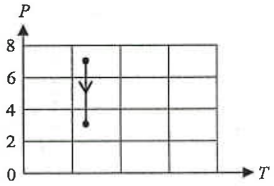
D. 50%

42. **< HKAL 2009 Paper IIA - 35 >**

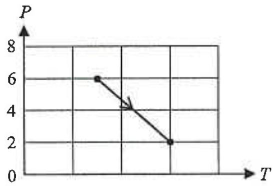


The pressure P of a fixed mass of ideal gas varies with its volume V as shown in the above figure. Which of the following graph best shows the corresponding pressure-temperature ($P - T$) relationship ?

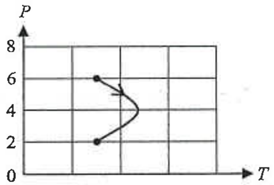
A.



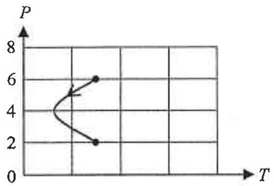
B.



C.



D.



43. **< HKAL 2012 Paper IIA - 28 >**

A closed container of volume 1 m^3 contains an ideal gas. The temperature of the gas is 25°C and the pressure of the gas is 1.01×10^5 Pa. Calculate the number of gas molecules in the container.

A. 2.46×10^{25}
B. 2.93×10^{25}
C. 2.46×10^{26}
D. 2.93×10^{26}

44. **< HKAL 2013 Paper IIA - 35 >**

A vessel contains an ideal gas at the temperature of 25°C and a pressure of 1.10×10^{-7} Pa. Estimate the number of gas molecules per unit volume in the vessel.

A. 2.67×10^{13}
B. 2.92×10^{13}
C. 3.19×10^{14}
D. 3.49×10^{14}

Part C : Supplemental exercise

45. A car tyre has a constant volume of 0.025 m^3. It contains 1.2 mol of air at a pressure of 280 kPa. An air pump delivers 8×10^{-3} mol of air into the tyre on each stroke of the pump. Calculate the minimum number of complete strokes of the pump so as to increase the air pressure in the tyre to 320 kPa. Assume the temperatures of air in the tyre and the pump are the same.

A. 20
B. 21
C. 22
D. 23

46. A car tyre has a constant volume of 12500 cm^3. The pressure of the air in the tyre is 275 kPa at a temperature of 30°C. Assume air is an ideal gas, what is the amount of air in the tyre ?

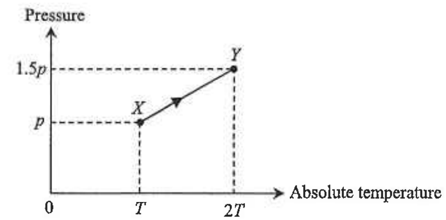
A. 1.2 mol
B. 1.4 mol
C. 1.6 mol
D. 1.8 mol

47. For air at room temperature of 25°C and atmospheric pressure of 10^5 Pa, calculate the order of magnitude of the number of molecules in 1 cm^3 of air.

A. 10^{25}
B. 10^{19}
C. 10^{16}
D. 10^{13}

Part D : HKDSE examination questions

48. **< HKDSE Sample Paper IA - 3 >**



As the gas in a vessel of fixed volume is heated, it gradually leaks out. The gas in the vessel changes from state X to state Y along the path XY shown in the plot of pressure against absolute temperature. What percentage of the original mass of the gas leaks out from the vessel in this process ?

A. 10%
B. 20%
C. 25%
D. 50%

Part C : Supplemental exercise

45. A car tyre has a constant volume of 0.025 m³. It contains 1.2 mol of air at a pressure of 280 kPa. An air pump delivers 8×10^{-3} mol of air into the tyre on each stroke of the pump. Calculate the minimum number of complete strokes of the pump so as to increase the air pressure in the tyre to 320 kPa. Assume the temperatures of air in the tyre and the pump are the same.

A. 20
B. 21
C. 22
D. 23

46. A car tyre has a constant volume of 12500 cm³. The pressure of the air in the tyre is 275 kPa at a temperature of 30°C. Assume air is an ideal gas, what is the amount of air in the tyre ?

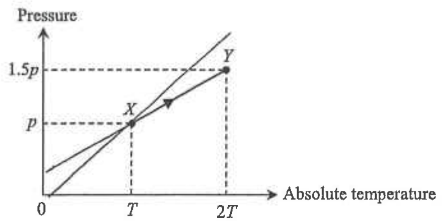
A. 1.2 mol
B. 1.4 mol
C. 1.6 mol
D. 1.8 mol

47. For air at room temperature of 25°C and atmospheric pressure of 10^5 Pa, calculate the order of magnitude of the number of molecules in 1 cm³ of air.

A. 10^{25}
B. 10^{19}
C. 10^{16}
D. 10^{13}

Part D : HKDSE examination questions

48. **< HKDSE Sample Paper IA - 3 >**

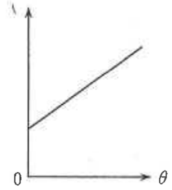


As the gas in a vessel of fixed volume is heated, it gradually leaks out. The gas in the vessel changes from state X to state Y along the path XY shown in the plot of pressure against absolute temperature. What percentage of the original mass of the gas leaks out from the vessel in this process ?

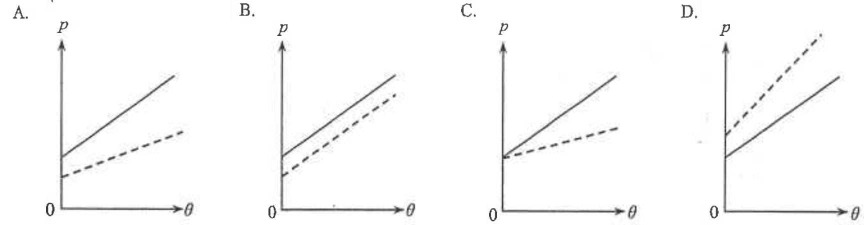
A. 10%
B. 20%
C. 25%
D. 50%

49. **< HKDSE 2012 Paper IA - 3 >**

An ideal gas is contained in a closed vessel of fixed volume. The graph below shows the variation of pressure p of the gas against its Celsius temperature θ.



If the number of gas molecules in the vessel is halved, which graph of the dotted line best shows the relationship between p and θ ?



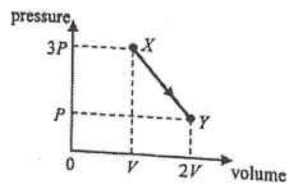
50. **< HKDSE 2017 Paper IA - 4 >**

The pressure of a fixed mass of an ideal gas at 10°C is 2×10^5 N m^{-2}. If the volume of the gas is reduced to half of its original volume and its temperature is increased to 100°C, what would the pressure be ?

A. 1.00×10^5 N m^{-2}
B. 1.32×10^5 N m^{-2}
C. 4.00×10^5 N m^{-2}
D. 5.27×10^5 N m^{-2}

51. <HKDSE 2020 Paper IA-3>

A fixed mass of an ideal gas expands from state X to state Y through a process as represented in the pressure-volume graph below.



If the temperature of the gas at state Y is 25 °C, what is its temperature at state X ?

A. −74.3 °C
B. 16.7 °C
C. 37.5 °C
D. 174 °C

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. C	11. B	21. C	31. D	41. C	51. D
2. D	12. C	22. C	32. B	42. C	
3. C	13. D	23. B	33. A	43. A	
4. C	14. D	24. D	34. A	44. A	
5. A	15. C	25. C	35. A	45. C	
6. B	16. A	26. D	36. B	46. B	
7. B	17. D	27. A	37. A	47. B	
8. D	18. D	28. B	38. D	48. C	
9. C	19. A	29. B	39. C	49. A	
10. D	20. B	30. A	40. A	50. D	

M.C. Solution

1. C

By $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$\therefore \frac{(4\times10^5)(6\times10^{-3})}{(91+273)} = \frac{(10^5)\cdot V_2}{(273)}$ $\therefore V_2 = 0.018\ \text{m}^3$

mass = density × volume = 1.2 × 0.018 = 0.0216 kg = 21.6 g

2. D

$\frac{V_1}{300} = \frac{V_2}{400}$

$\therefore \frac{V_1}{V_2} = \frac{3}{4}$

$\therefore \frac{1}{4}$ volume of gas inside the vessel is expelled.

$\therefore$ mass expelled $= 1.2\times\frac{1}{4} = 0.3$ kg

3. C

By $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\therefore \frac{V_1}{(127+273)} = \frac{V_2}{(27+273)}$ $\therefore \frac{V_2}{V_1} = \frac{3}{4}$

4. C

By $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$\therefore \frac{(2\times10^5)V}{25+273} = \frac{P_2\cdot(\frac{1}{2}V)}{95+273}$

$\therefore P_2 = 4.94\times10^5$ Pa

5. A

By $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$\therefore \frac{P\cdot V}{T} = \frac{(2P)\cdot V_2}{\frac{1}{2}T}$

$\therefore V_2 = \frac{V}{4}$

6. B

By $P_1 V_1 = P_2 V_2$

$\therefore (1.0\times10^5)(25) = (0.5\times10^5)\ V_2$

$\therefore V_2 = 50$ ml

7. B

$P\ V$ = constant

$\therefore P \propto \frac{1}{V}$

$\therefore P \sim V$ graph is a curve.

8. D

By $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$\therefore \frac{(10^5)\cdot V}{(20+273)} = \frac{P_2\cdot(\frac{1}{2}V)}{(55+273)}$

$\therefore P_2 = 2.24\times10^5$ Pa

9. C

By $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$\therefore \frac{(2\times10^5)V}{25+273} = \frac{P_2\cdot(\frac{1}{2}V)}{95+273}$

$\therefore P_2 = 4.94\times10^5$ Pa

10. D

✓ A. Stir the water ⇒ to ensure uniform temperature of water

✓ B. Immerse the whole flask ⇒ to ensure that all the gas inside the flask is heated by the water bath

✓ C. Since the bottom of beaker is hotter than the water in beaker

× D. Long tube ⇒ volume of air in the tube is not negligible but the air cannot be heated by the water

11. B

By Volume-Temperature relation : $\frac{V}{T} = \text{constant}$

$\therefore\ V \propto T$

as T is the absolute temperature in Kelvin scale

12. C

✓ (1) Immerse the whole column in water ⇒ all the gas can be heated by the water

× (2) Seal the tube ⇒ pressure of the trapped gas cannot be kept constant

✓ (3) Bottom of beaker is hotter than the water in beaker

13. D

Boyle's Law : $P\,V = \text{constant}$ and $V \propto h$,

$\therefore\ P \propto \frac{1}{V} \propto \frac{1}{h}$

$\therefore\ P \sim 1/h$ is a straight line passing through the origin

14. D

By $\frac{P_1\,V_1}{T_1} = \frac{P_2\,V_2}{T_2}$

$\therefore\ \frac{(P)\cdot(V)}{(T)} = \frac{(2P)\cdot(2V)}{T_2}$ $\therefore\ T_2 = 4\,T$

15. C

By Pressure-Temperature relation : $\frac{P}{T} = \text{constant}$

$\therefore\ P \propto T$ as T is the absolute temperature in Kelvin scale

$\therefore$ The graph is a straight line passing through the origin of 0 K.

16. A

By $\frac{P_1\,V_1}{T_1} = \frac{P_2\,V_2}{T_2}$

$\therefore\ \frac{(3\times10^5)\cdot(V)}{(30+273)} = \frac{P_2\cdot(2V)}{(60+273)}$ $\therefore\ P_2 = 1.65 \times 10^5$ Pa

17. D

× (1) Press the piston quickly ⇒ Temperature of the gas rises
$\therefore$ Boyle's Law cannot be held

✓ (2) Use larger syringe ⇒ volume of gas in rubber tubing becomes negligible and can be neglected

✓ (3) Shorter rubber tubing ⇒ volume of gas in rubber tubing becomes negligible

18. D

Boyle's Law :

$P\,V = \text{constant}$

OR

$P \propto \frac{1}{V}$.

$\therefore$ The graph of P against $\frac{1}{V}$ gives a straight line passing through the origin.

19. A

By $\frac{P_1\,V_1}{T_1} = \frac{P_2\,V_2}{T_2}$

$\therefore\ \frac{(P)\cdot(V)}{(T)} = \frac{(2P)\cdot V_2}{\frac{1}{2}T}$

$\therefore\ V_2 = \frac{V}{4}$

20. B

$\Delta T = (100+273) - (0+273) = 100$ K

21. C

Boyle's Law :

$P\,V = \text{constant}$

$\therefore\ P \propto \frac{1}{V}$.

$\therefore$ The graph of P against $\frac{1}{V}$ gives a straight line passing through the origin.

22. C

By $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\therefore\ \frac{(P)}{(120+273)} = \frac{(3P)}{(\theta_2+273)}$

$\therefore\ \theta_2 = 906°\text{C}$

23. B

By $\dfrac{P_1 V_1}{T_1} = \dfrac{P_2 V_2}{T_2}$

$\therefore \dfrac{(10^5)(V)}{(27+273)} = \dfrac{(3\times10^5)(\frac{V}{2})}{T_2}$ $\therefore T_2 = 450\text{ K} = 177°\text{C}$

24. D

× (1) From X to Y, P is constant $\therefore V\uparrow \Rightarrow T\uparrow$

✓ (2) From Y to Z, V is constant $\therefore P\downarrow \Rightarrow T\downarrow$

✓ (3) From Z to X, T is constant as C is the curve represents the P-V relation at a certain temperature

25. C

✓ (1) By using a large flask, the volume of the gas inside the tubing would become negligible

✓ (2) Shorter length of tubing enables the volume of gas inside the tubing to be negligible

× (3) No control apparatus is needed ; if the burner is removed, the experiment does not work

26. D

✓ (1) From X to Y, it is part of the straight line passing through origin which indicates $V \propto T$
since $V \propto T$ can only be held under constant pressure $\therefore$ pressure remains unchanged

✓ (2) From Y to Z, the temperature T remains unchanged, thus $P \propto 1/V$
as volume is decreased from Y to Z, the pressure must increase

✓ (3) From Z to X, the volume V remains unchanged, thus $P \propto T$
as temperature T is decreased from Z to X, the pressure must decrease

27. A

✓ (1) $P \propto T$ (in K), the graph shows the relationship between pressure but the temperature is in °C.

× (2) By $PV = nRT$ and $T = \theta + 273$

$\therefore P = \dfrac{nR}{V}(\theta + 273)$ $\therefore$ slope $= \dfrac{nR}{V}$

The slope is related to the volume but does not represent the volume of the gas.

× (3) The absolute zero temperature should be at −273°C.

28. B

Temperature difference ΔT : 1 K = 1°C

$\therefore \Delta T = 100\text{ K} = 100°\text{C}$

29. B

By $\dfrac{P_1 V_1}{T_1} = \dfrac{P_2 V_2}{T_2}$

$\therefore \dfrac{(200)(V)}{(20+273)} = \dfrac{P_2(1.01V)}{(30+273)}$ $\therefore P_2 = 205\text{ kPa}$

30. A

✓ A. By using a larger syringe, the volume of air inside the rubber tubing becomes negligible.

× B. Pushing the piston quickly would make the temperature increase.

× C. By using a longer length of tubing, the volume of air inside the tubing becomes significant,
but this volume is not counted in the experiment.

× D. In this experiment, no control is needed ; if the bourdon gauge is removed, pressure cannot be read.

31. D

By $PV = nRT$ $\therefore P = \dfrac{nR}{V}\cdot T$ $\therefore$ slope of the graph $= \dfrac{nR}{V}$

$\therefore$ X : greater volume $\Rightarrow$ smaller slope

Note that both lines when extrapolated should cut the T-axis at −273°C.

32. B

By $PV = nRT$

Let the pressure inside the vessel be P and the volume of the vessel be V.

At 300 K : $PV = n_1 R(300)$

At 400 K : $PV = n_2 R(400)$

$\therefore n_2 = \frac{3}{4} n_1$

Mass of gas remains in the vessel $= 1.2 \times \frac{3}{4} = 0.9$ kg

Mass of gas expelled from the vessel $= 1.2 - 0.9 = 0.3$ kg

33. A

By $PV = nRT$

Let the pressure inside the vessel be P and the volume of the vessel be V.

At 50°C : $PV = n_1 R(50 + 273)$

At 100°C : $PV = n_2 R(150 + 273)$

$n_2 = 0.76\, n_1$

Percentage of air remains in the vessel $= \dfrac{n_2}{n_1} = 0.76 \times 100\% \approx 76\%$

34. A

Fixed piston and cooled : no change in V $\therefore T\downarrow \Rightarrow P\downarrow$

Piston pushed inward slowly : no change in T $\therefore V\downarrow \Rightarrow P\uparrow$

35. A

Originally : $(P_o)\, V = nRT$

Finally : $P'(2V) = (\frac{1}{2}n)RT$

$\therefore P' = \frac{1}{4} P_o$

36. B

× A. Since the temperature remains unchanged,

$P_X V_X + P_Y V_Y = P(V_X + V_Y)$

$\therefore$ $(400)(V) + (0)(4V) = P(V + 4V)$ $\therefore$ $P = 80$ kPa

✓ B. At equilibrium, there are still gas molecules interflowing, although the net flow becomes zero.

× C. Finally, they have the same pressure. As their volume are not the same, PV cannot be the same.

× D. By $PV = nRT = \frac{M}{M_m}RT$, where M is the mass of the gas and M_m is the molar mass of the gas,

$\therefore$ $P = \frac{M}{V} \times \frac{RT}{M_m}$

as both containers have same pressure P, same temperature T, and same molar mass M_m,

they have the same $\frac{M}{V}$, that is, the same density ρ, as $\rho = \frac{M}{V}$.

37. A

✓ (1) Change of momentum is a vector as momentum is a vector.

× (2) Work is a process to transfer energy, work does not have direction, it is a scalar.

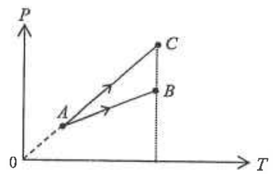
× (3) Pressure is a scalar, it exerts at every direction, thus it is not a vector.

38. D

× (1) Since the graph does not pass through the origin, P is not directly proportional to T.

✓ (2) Since the mass is fixed and it is an ideal gas, PV/T must be constant.

✓ (3) If the volume is constant,
then the line would pass through the origin
and changes from state A to state C as shown.
Compare with state C at the same temperature,
the pressure at B is smaller,
so its volume must be greater.



39. C

① From X to Y, pressure P is constant, thus V is proportional to the absolute temperature T.
The process represented in a T-V graph should be a straight line through origin.

② From Y to Z, since $P_Y V_Y \neq P_Z V_Z$, thus the temperature must not be constant.
The process represented in a T-V graph must not be a horizontal line.

40. A

By $PV = nRT$ $\therefore$ $T \propto PV$

$\therefore$ $T_X = 4k$ $T_Y = 6k$ $T_Z = 5k$

$\therefore$ The gas has highest temperature at Y and lowest temperature at X.

41. C

① $pV = n_1 R T_o$

② $(1.5p)V = n_2 R (2T_o)$

$\therefore$ $\frac{n_2}{n_1} = \frac{3}{4}$

$\therefore$ Percentage of mass of gas leaks out $= 1 - \frac{3}{4} = 25\%$

42. C

When $P = 6$, $PV = (6) \times (4) = 24$

When $P = 4$, $PV = (4) \times (8) = 32$

When $P = 2$, $PV = (2) \times (12) = 24$

As $PV = nRT$ $\therefore$ $PV \propto T$

$\therefore$ T (at $P = 6$) is equal to T (at $P = 2$)

but T (at $P = 4$) is greater than T (at $P = 6$).

43. A

By $PV = nRT$

$\therefore$ $(1.01 \times 10^5)(1) = n(8.31)(25 + 273)$ $\therefore$ $n = 40.8$ mol

Number of gas molecules $= 40.8 \times 6.02 \times 10^{23} = 2.46 \times 10^{25}$

44. A

$PV = nRT = \frac{N}{N_A}RT$

$\frac{N}{V} = \frac{PN_A}{RT} = \frac{(1.10 \times 10^{-7})(6.02 \times 10^{23})}{(8.31)(25 + 273)} = 2.67 \times 10^{13}\ \text{m}^{-3}$

45. C

By $PV = nRT$

$\therefore$ $P \propto n$ (V and T are constant)

$\therefore$ $\frac{P_1}{P_2} = \frac{n_1}{n_2}$ $\therefore$ $\frac{(280)}{(320)} = \frac{(1.2)}{n_2}$ $\therefore$ $n_2 = 1.37$ mol

Consider the amount of air before and after the pumping :

$\therefore$ $1.2 + n \times (8 \times 10^{-3}) = 1.37$ $\therefore$ $n = 21.3$

$\therefore$ Minimum number of strokes $= 22$

46. B

By $PV = nRT$

$\therefore$ $(275 \times 10^3) \times (12500 \times 10^{-6}) = n \times (8.31) \times (30 + 273)$

$\therefore$ $n = 1.4$ mol

47. B

By $P V = n R T$

$\therefore$ $(10^5)(1\times10^{-6}) = n(8.31)(25+273)$ $\quad\therefore$ $n = 4.0\times10^{-5}$

$\therefore$ $N = n\times N_A = 4.0\times10^{-5}\times6.02\times10^{23} = 2.4\times10^{19}$

$\therefore$ order of magnitude of $N = 10^{19}$

48. C

① $(p)\,V = n_X R\,(T)$

② $(1.5p)\,V = n_Y R\,(2T)$

$\therefore$ $\dfrac{n_Y}{n_X} = \dfrac{3}{4}$

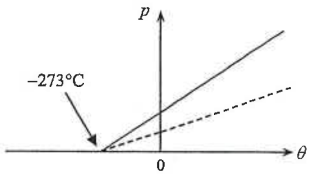
$\therefore$ Percentage of mass of gas leaks out $= 1 - \dfrac{3}{4} = 25\%$

49. A

By $p V = n R T = n R(\theta + 273)$ $\quad\therefore$ $p = \dfrac{nR}{V}(\theta+273)$

As compared with the slope-intercept form : $y = m x + c$

$\therefore$ slope $= \dfrac{nR}{V}$



If the number of gas molecules is halved,
the number of mole n is halved, the slope is halved.
Moreover, the x-intercept is the absolute zero (− 273°C) which should be unchanged.

50. D

By $\dfrac{P_1 V_1}{T_1} = \dfrac{P_2 V_2}{T_2}$

$\therefore$ $\dfrac{(2\times10^5)(V)}{(10+273)} = \dfrac{P_2(V/2)}{(100+273)}$ $\quad\therefore$ $P_2 = 5.27\times10^5\ \mathrm{N\,m^{-2}}$

The following list of formulae may be found useful :

Equation of state for an ideal gas $\qquad p V = n R T$

Use the following data wherever necessary :

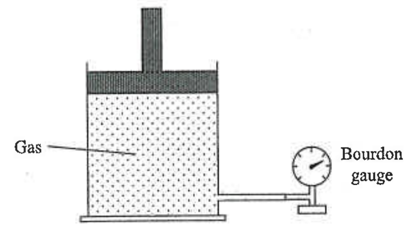
Molar gas constant $\qquad R = 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$

Avogadro constant $\qquad N_A = 6.02\times10^{23}\ \mathrm{mol^{-1}}$

Part A : HKCE examination questions

1. **< HKCE 1981 Paper I - 4 >**

A gas is contained in a cylinder fitted with a piston as shown in the below figure. Its volume is given by the calibration on the cylinder as 0.0015 m³. The pressure reading on the Bourdon gauge is $2.5\times10^5\ \mathrm{N\,m^{-2}}$.



(a) If the volume of the gas is reduced to $\frac{1}{4}$ of its original value without altering its temperature, find the new pressure of the gas. (3 marks)

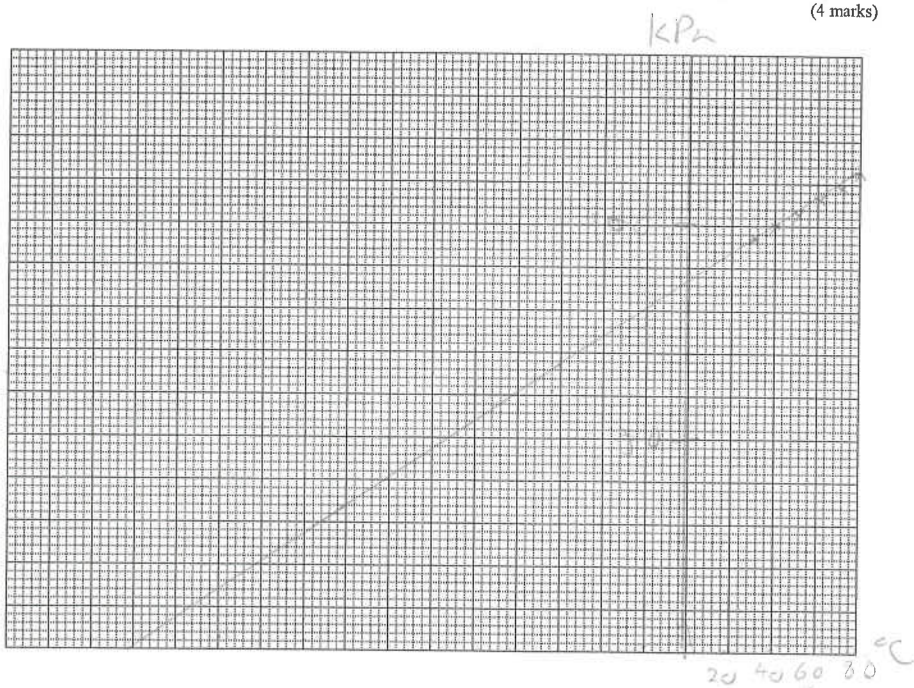
(b) If the temperature of the gas is raised from its initial value of 27°C to 327°C, but with the volume kept constant at 0.0015 m³, find the new pressure of the gas. (3 marks)

2. < HKCE 1983 Paper I - 4 >

The table below shows the relationship of the pressure and temperature of a fixed mass of a gas :

Temperature / °C	30	40	50	60	70	80
Pressure / kPa	97	100	103	106	109	112

(a) Plot the pressure-temperature graph for temperatures ranging from −300°C to 100°C and pressures ranging from 0 kPa to 140 kPa. (You are recommended to use a scale of 1 cm to represent 20°C and 1 cm to represent 10 kPa). (4 marks)



(b) What is the intercept of your graph on the temperature axis ? (2 marks)

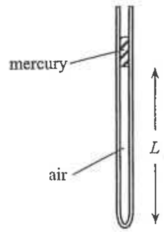
(c) If the Celsius temperature is converted to a temperature in a new scale by adding the absolute value of the intercept you obtained in (b), find the relation between the pressure and the new temperature from your graph. (2 marks)

(d) If the pressure of the gas in the experiment were increased to 150 kPa, what would be the temperature of the gas on the temperature scale you constructed in (c) ? (2 marks)

2. (e) Draw a diagram to show the experimental set-up you would use to obtain the above data. State TWO precautions that should be taken in this experiment. (5 marks)

Diagram

3. < HKCE 1987 Paper I - 4 >



In the above figure, a mercury thread is trapped in a uniform bored capillary tube which is used in an experiment to verify the volume-temperature relationship. The following data are recorded :

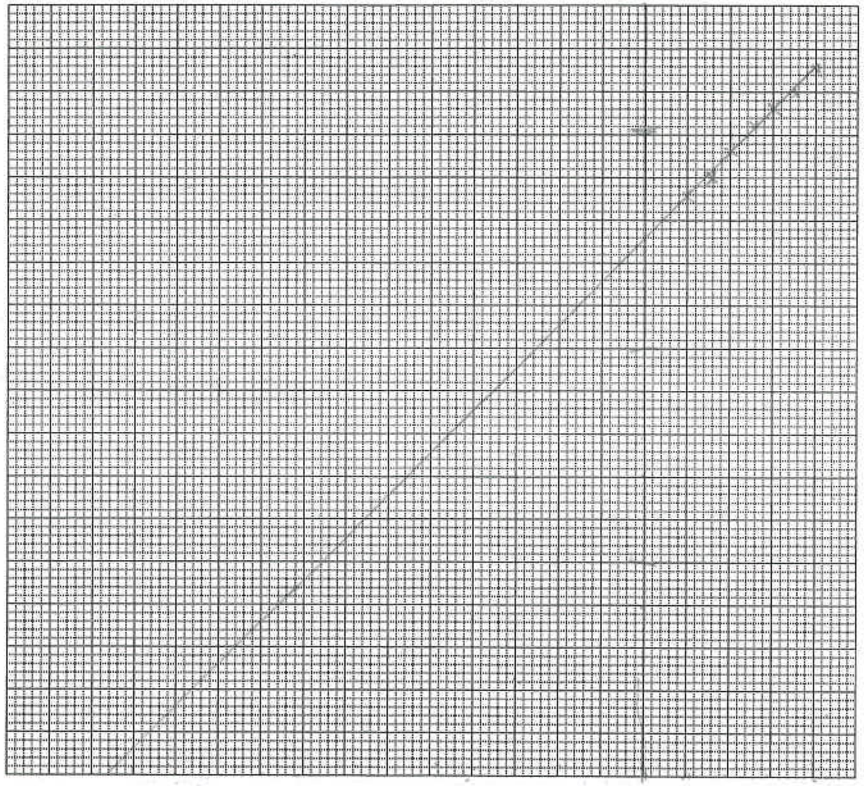
Temperature θ / °C	20	30	40	50	60	70	80
Length of air column L / mm	136	140	146	152	156	160	166

(a) Draw a diagram to show an experimental set-up and describe briefly the procedure in order to obtain the above data. (4 marks)

Diagram

(b) Name any TWO precautions in this experiment. (2 marks)

3. (c) Plot the graph of L against θ with θ ranging from –300°C to 100°C. (3 marks)



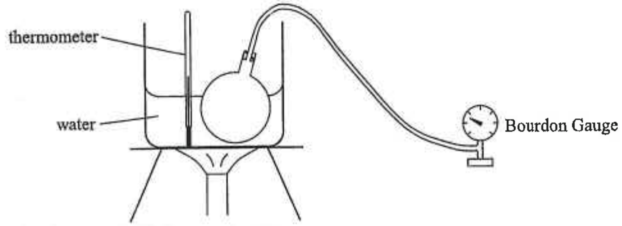
(d) What is the "absolute zero" as obtained from this experiment ? (2 marks)

(e) What is the relationship among L, θ and the "absolute zero" in (d) ? (2 marks)

(f) How does the pressure of the trapped air in the tube change with temperature ? (2 marks)

4. **< HKCE 1989 Paper I - 4 >**

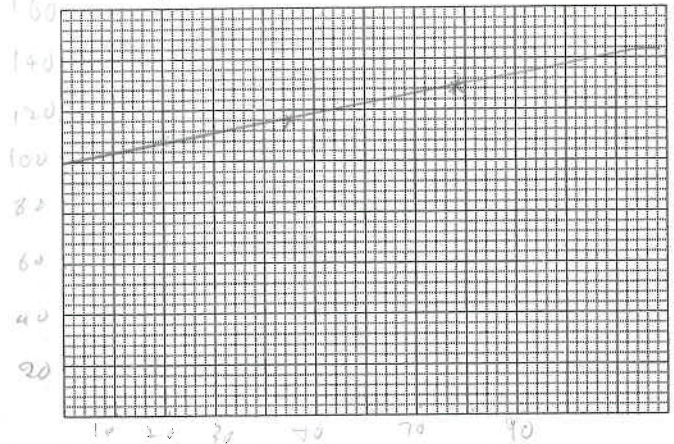
The below figure shows an experiment done by a student to find the variation of pressure of air inside a flask with temperature. The pressure P and the temperature θ are measured by Bourdon Gauge and a thermometer respectively.



(a) The following data are recorded in the experiment:

θ / °C	20	35	45	60	78	90	100
P / kN m^{-2}	107	112.5	116	121.5	128	132.5	136

Using a scale that 2 cm represents 10 kN m^{-2} and 1 cm represents 10°C, plot a graph of P against θ ranging from 0°C to 100°C. (5 marks)



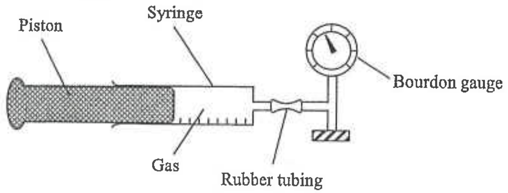
(b) Find the equation relating the pressure and temperature from the graph in (a). (2 marks)

(c) The flask is then transferred into a trough of oil and the gauge reading is 118 kN m^{-2}. What is the temperature of the oil ? (2 marks)

(d) Give THREE suggestions to improve the experimental setup as shown in the figure. (3 marks)

5. **< HKCE 1994 Paper I - 4 >**

A student uses the set-up shown in the below figure to study the relationship between the pressure and volume of a fixed mass of gas at constant temperature. The piston is pushed in or pulled out to vary the volume of gas and the corresponding pressure is measured by the Bourdon gauge.



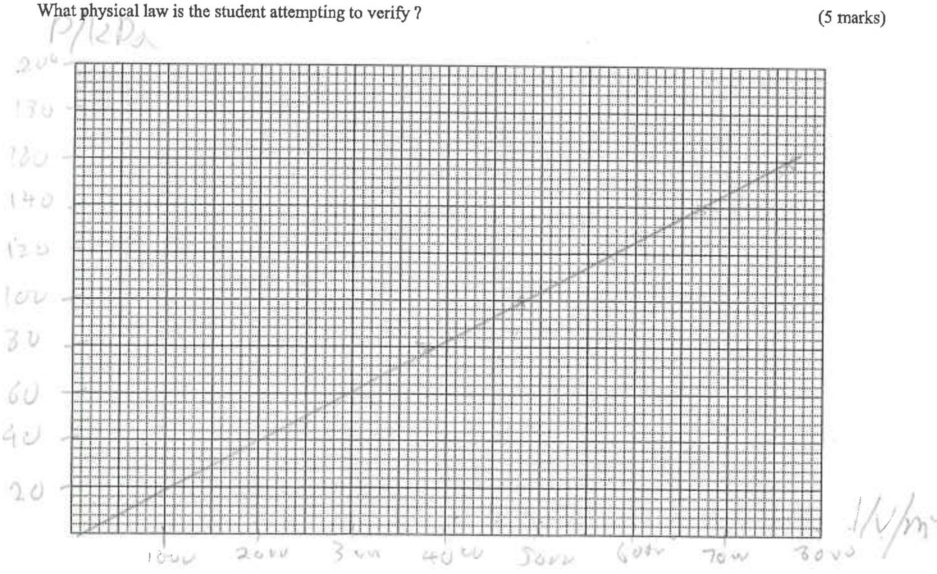
(a) Should the rubber tubing be long or short ? Explain briefly. State TWO other precautions that should be taken to improve the accuracy of the experiment. (4 marks)

(b) The following results are obtained in the experiment:

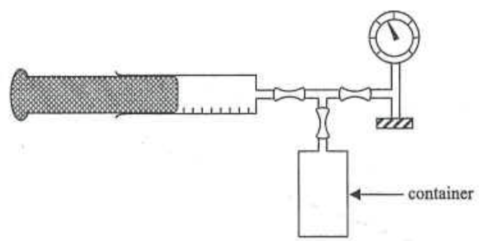
Pressure P / kPa	80	100	120	140	160
Volume V / m^3	2.60×10^{-4}	2.10×10^{-4}	1.75×10^{-4}	1.50×10^{-4}	1.31×10^{-4}
$1/V$ m^{-3}	3846	4762	5714	6667	7634

Plot P against $1/V$ on graph paper, with P ranging from 0 to 160 kPa and $1/V$ ranging 0 to 8000 m^{-3}.

What physical law is the student attempting to verify ? (5 marks)

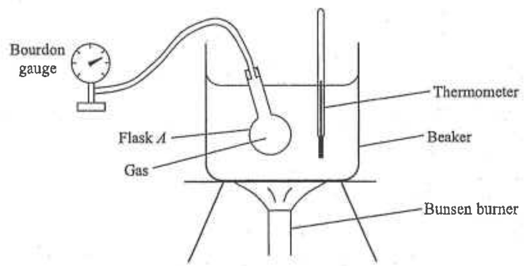


5. (c)



The student uses another set of apparatus as shown in the above figure to measure the volume of a container. Initially the readings of the syringe and the gauge are 1.8×10^{-4} m^3 and 100 kPa respectively. The piston is then completely pushed in and the reading of the gauge becomes 210 kPa. Assuming that temperature remains unchanged, calculate the volume of the container. (3 marks)

6. **< HKCE 1999 Paper I - 9 >**



David uses the set-up shown in the above figure to study the relationship between the pressure P and temperature θ of a fixed mass of gas inside a flask A. The following results are obtained :

Temperature θ / °C	20	36	50	64	80	98
Pressure P / kPa	102	109	111	115	124	129

(a) Using a scale of 1 cm to 10 kPa and 1 cm to 10°C, plot a graph of P against θ on graph paper, with P ranging from 0 to 140 kPa and θ ranging from 0 to 100°C. (4 marks)

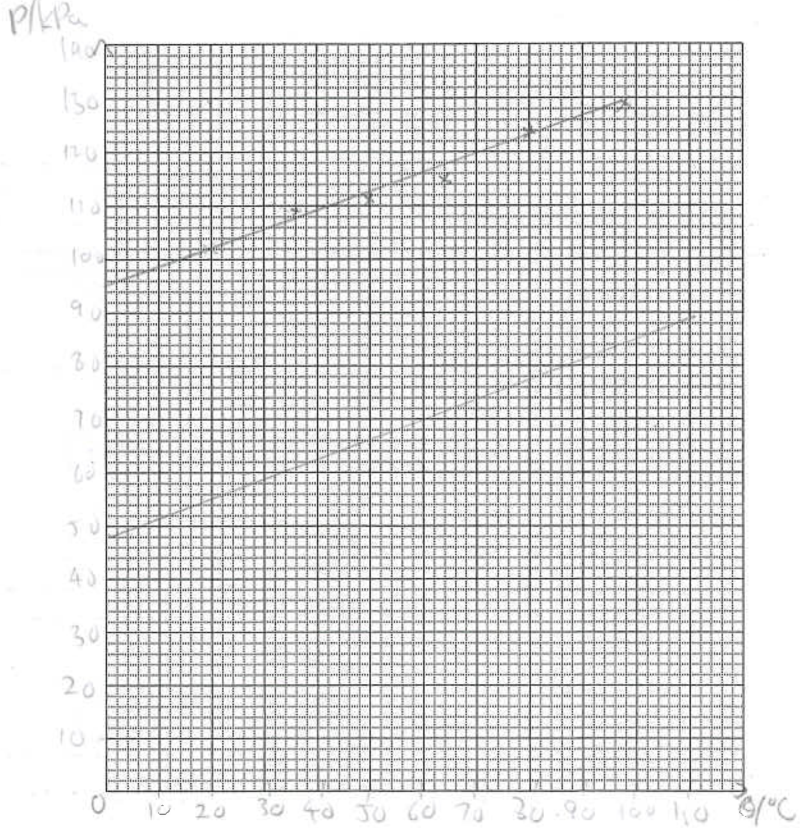
< Graph on next page >

(b) From the graph in (a), David concludes that

The pressure (in kPa) of the gas is directly proportional to its temperature (in °C).

Comment on David's conclusion. (2 marks)

6.



(c) State **two** precautions that should be taken to improve the accuracy of the experiment. (2 marks)

(d) David uses a larger flask *B* to replace flask *A* and repeats the experiment. The volume of flask *B* is twice that of *A*. Assume that the masses of the gas in both flasks are the same.

(i) Estimate the gas pressure in flask *B* at 0°C. (2 marks)

(ii) On the graph in (a), draw the graph of *P* against θ you expect to obtain in this experiment. (1 mark)

7. **< HKCE 2001 Paper I - 2 >**

A metal can containing compressed gas at 200 kPa and 30°C is placed under direct sunlight for some time. If the temperature of the gas rises to 60°C, find the gas pressure inside the can. Assume that the volume of the can remains unchanged. (2 marks)

8. **< HKCE 2002 Paper I - 2 >**

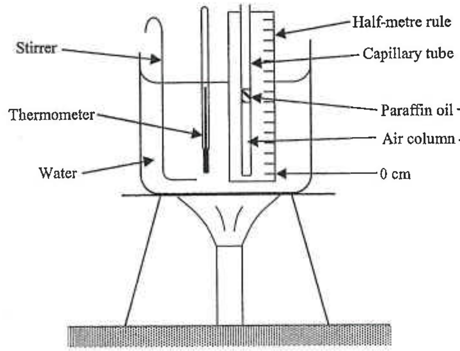


Figure 1

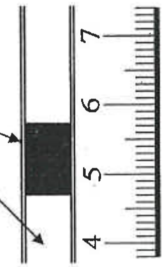


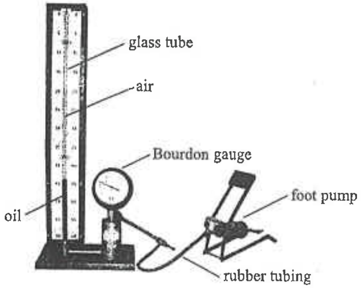
Figure 2

Figure 1 shows a set-up to study the relation between the volume and temperature of a column of air trapped in a uniform capillary tube by a drop of paraffin oil. Figure 2 shows the position of the paraffin oil when the temperature of the water is 25°C. A half-metre rule is used to measure the length of the air column in cm.

(a) Write down the length of the air column as shown in Figure 2. (1 mark)

(b) Estimate the length of the air column when the temperature of the water is increased to 80°C. State one assumption in your calculation. (3 marks)

9. **< HKCE 2004 Paper I - 3 >**

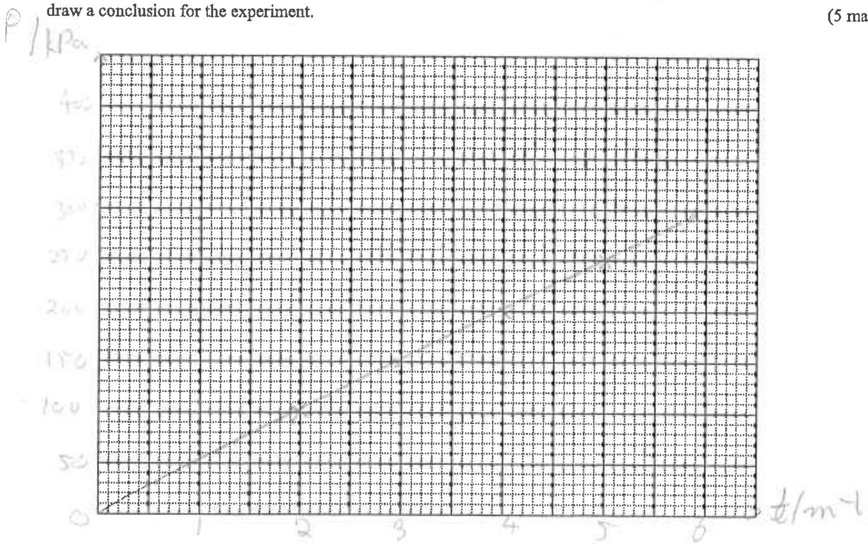


The Figure above shows a set-up used to study the relationship between the pressure and volume of a column of air trapped in a glass tube at constant temperature. The cross-section of the glass tube is uniform.

(a) The Table shows the results obtained.

Pressure P / kPa	100	150	200	250	300
Length of air column ℓ / m	0.49	0.34	0.25	0.20	0.17
$\frac{1}{\ell}$ / m^{-1}	2.04	2.94	4	5	5.88

Plot a graph of P against $\frac{1}{\ell}$ on graph paper, with P ranging from 0 to 400 kPa, and $\frac{1}{\ell}$ ranging from 0 to 6 m^{-1}. Hence draw a conclusion for the experiment. (5 marks)



____

(b) Suggest one precaution that should be taken to improve the accuracy of the experiment. (1 mark)

____

Part B : HKAL examination questions

10. **< HKAL 1986 Paper IIB - 2 >**

The density of a gas is equal to 1.43 kg m^{-3} at the standard temperature of 0°C and pressure of 1.01×10^5 Pa. What is the mass of 1 mole of the gas ? (2 marks)

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11. **< HKAL 1990 Paper IIB - 8 >**

A cylinder fitted with a piston contains 0.2 mol of an ideal gas at a pressure of 10^5 Pa and a temperature of 301 K. The gas is

(1) first heated at constant pressure to 400 K, and then

(2) compressed at the constant temperature of 400 K to its initial volume, and finally

(3) cooled at constant volume to its initial pressure of 10^5 Pa and temperature of 301 K.

(a) Find the initial volume V_1 of the gas and determine its volume V_2 after process (1) is completed. (2 marks)

____

____

____

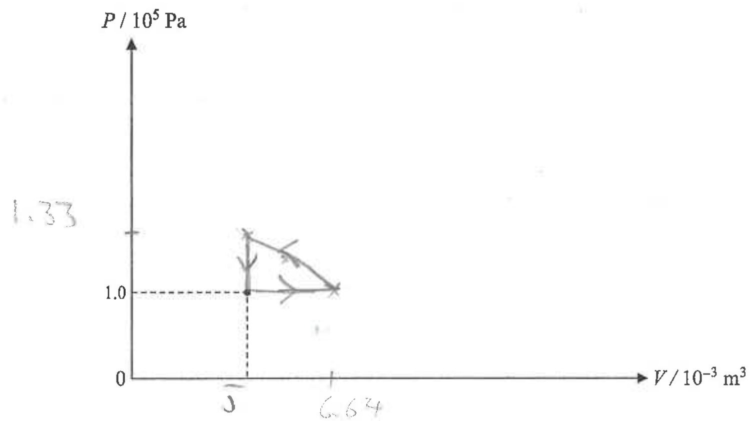
(b) Find the final pressure after the compression process of (2) is completed. (2 marks)

____

____

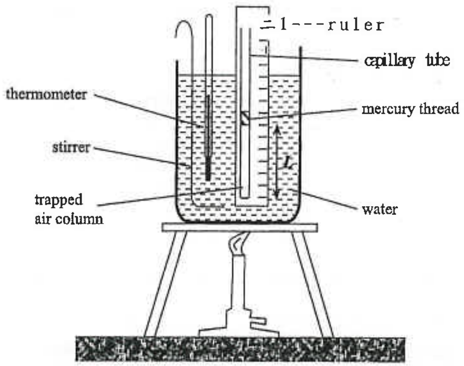
____

(c) Hence sketch the above changes on a P - V diagram, inserting all the initial and final pressure and volume values for each of the processes (1), (2) and (3) (4 marks)



Part C : HKDSE examination questions

12. <HKDSE 2013 Paper 1B-2>



The Figure above shows an air column trapped by a small mercury thread inside a uniform capillary tube. The set-up is heated by a water bath. The length of the air column L is measured at various temperature θ. Some of the results are tabulated below:

Temperature θ / °C	20	
Length of air column L / mm	64	

(a) Describe the procedure(s) to be done before taking a reading in order to ensure that the trapped air reaches the same temperature as the water. (2 marks)

(b) Assume that length L increases linearly with temperature θ throughout.

(i) Estimate the length of the air column when the temperature indicated by the thermometer is 65 °C. (2 marks)

(ii) Find the 'absolute zero' as obtained from this experiment. (2 marks)

13. <HKDSE 2015 Paper 1B-2>

The aqua-lung (a cylinder containing compressed air) for divers has a capacity of 1.0 x 10^4 cm^3. When the aqua-lung is filled, the air inside has a pressure of 210 atm (atmospheric pressure) at 24 °C. The air in the aqua-lung is allowed to expand through a pressure-reducing valve until its pressure equals that of the surrounding water before it is supplied to divers. Assume that the temperature of the air inside the aqua-lung is always equal to that of the surrounding water.

(a) A diver stays in water of temperature 24 °C and pressure 2.0 atm at a depth of 10 m. Find the total volume of air (in m^3) available for the diver from the aqua-lung at this water pressure. (2 marks)

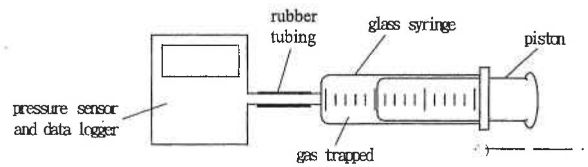
(b) The supply of air in (a) is sufficient for the diver to remain at such a depth for 1 hour.

(i) If the diver breathed in the same volume V_0 (in cm^3) of air per minute, find V_0. (1 mark)

(ii) If the diver dives deeper where the water is of temperature 20 °C and pressure 4.5 atm, estimate how long (in minutes) the air in a fully-filled aqua-lung would last. Assume that the diver breathes in the same volume of air per minute as that found in (b) (i). (3 marks)

14. <HKDSE 2016 Paper 1B-2>

Figure (a)

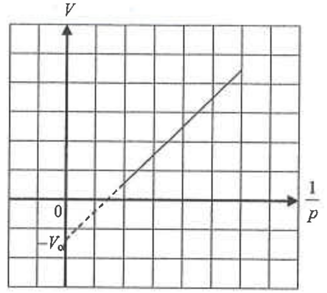


Judy uses the set-up shown in the Figure (a) to study the relationship between the pressure and volume of a fixed mass of gas at constant temperature. The volume V of the gas trapped is read directly from the syringe and the corresponding pressure p is measured by a data-logger via a pressure sensor.

(a) The initial volume and pressure of the gas are 6.0 x 10^{-5} m^3 and 1.0 x 10^5 Pa respectively at a room temperature of 25 °C. Estimate the number of gas molecules trapped in the syringe. (3 marks)

14. (b) The piston is then pushed in or pulled out to vary V and p such that several pairs of readings are recorded. Figure (b) shows the graph of V against $\frac{1}{p}$ plotted.

Figure (b)



(i) State **ONE** experimental precaution for keeping the gas temperature constant. (1 mark)

(ii) The straight line graph does not pass through the origin but cuts the vertical axis at $-V_o$ instead. Suggest what V_o stands for. (1 mark)

(iii) If the experiment is repeated at a higher room temperature using this set-up with the same mass of the same gas, sketch the expected graph in Figure (b). (2 marks)

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

Question Solution

1. (a) $P_1 V_1 = P_2 V_2$ [1]

$\therefore$ $(2.5 \times 10^5) \times (0.0015) = P_2 (0.0015 / 4)$ [1]

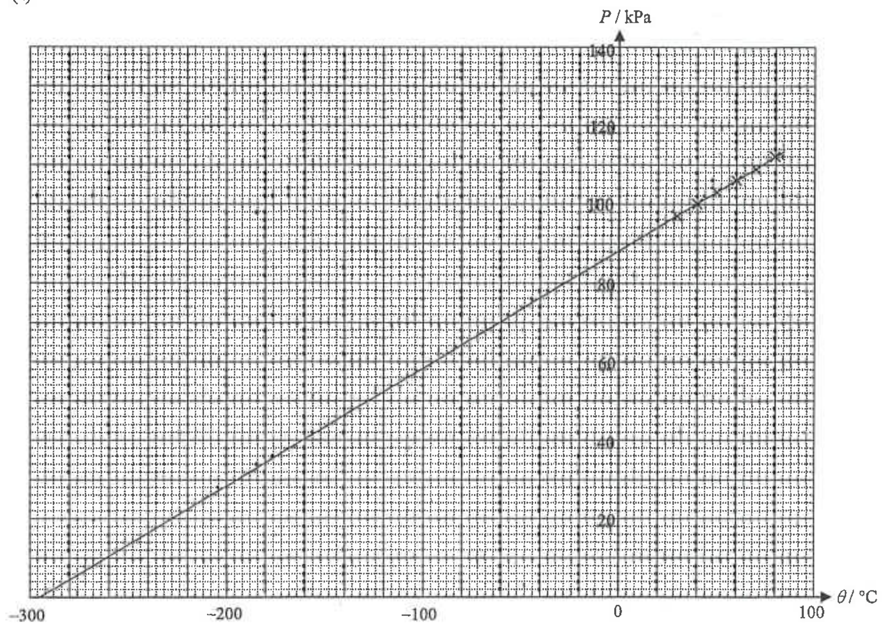
$\therefore$ $P_2 = 10^6$ Pa [1]

(b) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ [1]

$\therefore$ $\frac{(2.5 \times 10^5)}{(27 + 273)} = \frac{P_2}{(327 + 273)}$ [1]

$\therefore$ $P_2 = 5 \times 10^5$ Pa [1]

2. (a)



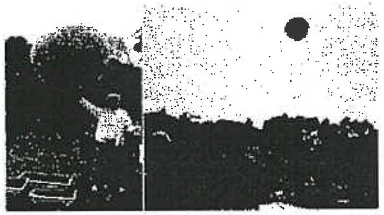
< Two axes correctly labelled with proper units > [1]

< Scale correctly marked > [1]

< At least 4 points plotted correctly > [1]

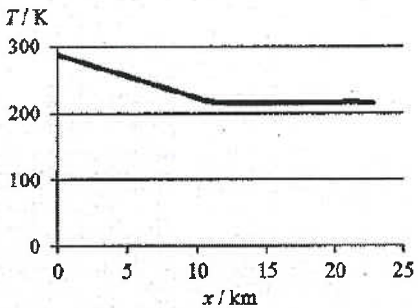
< Best fitted straight line correctly drawn and extrapolated > [1]

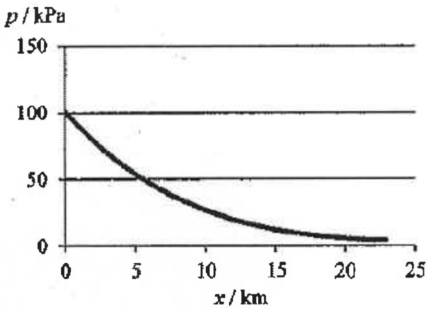
A weather balloon of volume 0.52 m^3 is filled with helium gas of temperature 15 °C and pressure 100 kPa at ground level.



(a) Find the amount of helium gas (in mol) in the balloon. (2 marks)

(b) The following graphs show the variation of air temperature T and atmospheric pressure p with height x above ground level.





The weather balloon is released and rises to the upper atmosphere. Assume that the temperature and pressure of the helium gas in the balloon are the same as those of the air outside at any height x.

(i) A student believes that as the air temperature decreases in the first 10 km, the volume of the balloon decreases. Referring to the graphs above, explain qualitatively why this belief is not correct. (2 marks)

(ii) In fact the weather balloon keeps on expanding when it rises. The air temperature becomes steady at 216 K from a height of 12 km onwards. When the balloon rises further beyond 12 km and its volume reaches 8 m^3,

(1) estimate the gas pressure in the balloon; (2 marks)

(2) hence find the corresponding height reached by the balloon. The variation of atmospheric pressure p with height x (in km) is given by

$$p = p_0 e^{-kx},$$

where p_0 is the atmospheric pressure at ground level and $k = 0.138\ \text{km}^{-1}$. (2 marks)

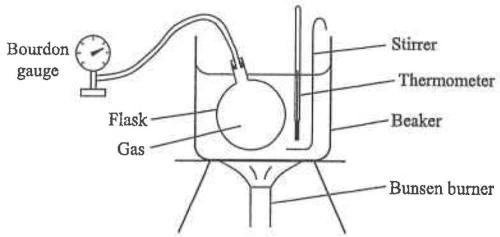
2. (b) intercept = -295 °C <accept -285°C to -305°C> [2]

(c) $\dfrac{P}{T}$ = constant where $T = \theta + 295$ **OR** $\dfrac{P}{\theta + 295}$ = constant [2]

(d) $\dfrac{(88)}{(0+295)} = \dfrac{(150)}{T}$ [1]

$\therefore\ T = 503$ <accept 497 to 509> [1]

(e)



<flask in water> [1]

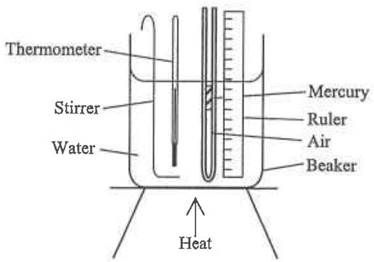
<thermometer> [1]

<Bourdon Gauge> [1]

Any **TWO** of the following : [2]

* Rubber tubing should be as short as possible.
* The flask should be fully immersed in water.
* Water must be well stirred before taking the reading of temperature.
* The thermometer should not touch the bottom of the beaker.
* Sufficient time must be allowed for the flask to be heated up.

3. (a)



[1]

Tie the tube against a ruler and put them into a beaker of water. [1]

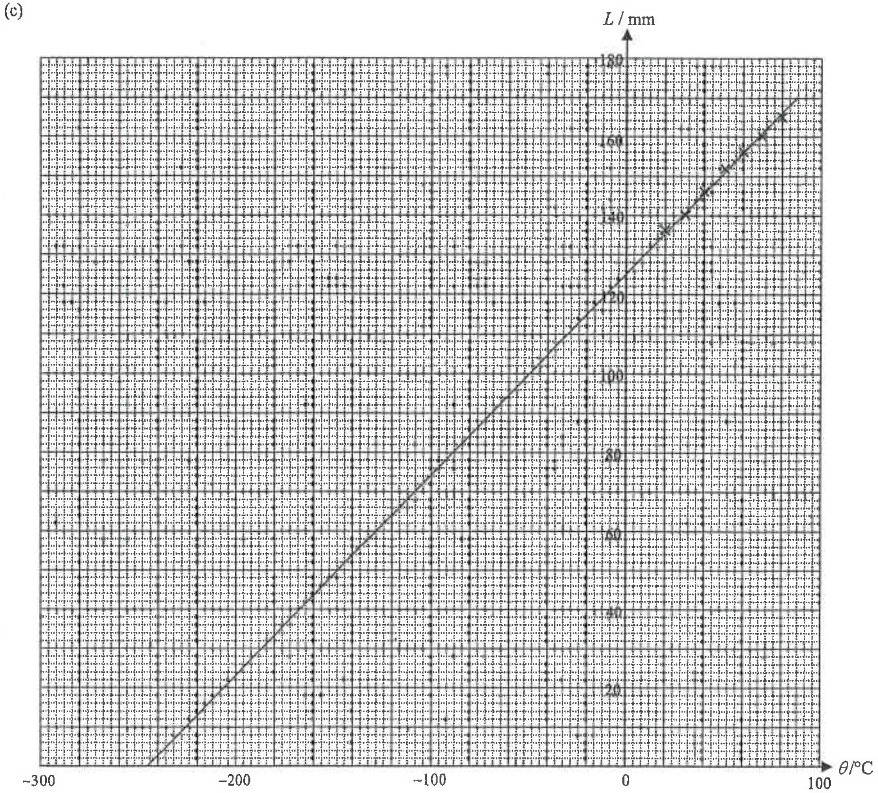
Heat the water gently. [1]

Record the temperature θ and the length L at certain temperature intervals. [1]

(b) Any **TWO** of the following : [2]

* The water must be well stirred to ensure uniform temperature before readings are taken.
* The air column should be completely immersed into the water.
* The thermometer and the tube should not touch the bottom of the beaker.
* Allow sufficient time for the air to reach the temperature of the water.

3. (c)



<correct label of axis and correct scale> [1]

<correct points plotted> [1]

<best fit line drawn> [1]

(d) Absolute zero = -245°C <accept -240°C to -260°C> [2]

(e) $\dfrac{L}{\theta+245}$ = constant [2]

OR

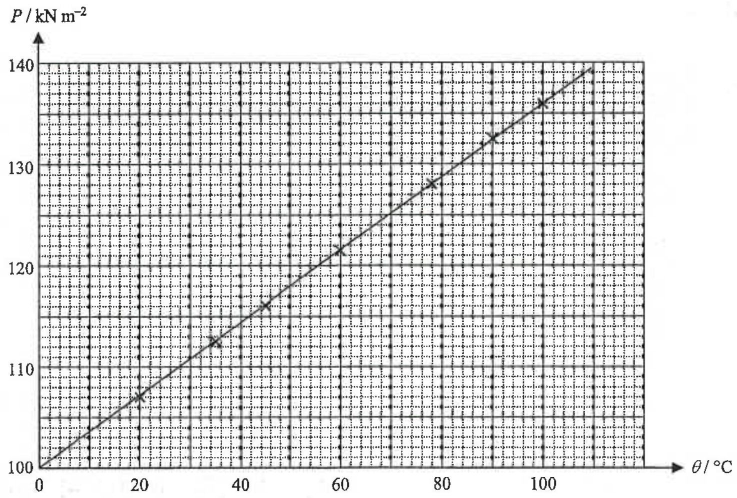
$L \propto (\theta + 245)$ [2]

OR

$L \propto T$ where $T = \theta + 245$ [2]

(f) The pressure remains no change. [2]

4. (a)



< correct label of 2 axes with units > [1]

< correct scale and range > [1]

< correct points plotted (0.5 marks each point, up to maximum of 2 marks) > [2]

< straight line drawn > [1]

(b) slope $= \dfrac{136-107}{100-20} = 0.36$ < from 0.34 to 0.38 is acceptable > [1]

P-intercept $= 100$ < from 98 to 102 is acceptable > [1]

The equation : $P = 0.36\,\theta + 100$

(c) From the graph, when $P = 118$;

$\theta = 50°C$ [2]

OR

From the equation, put $P = 118$;

$\therefore\ (118) = 0.36\,\theta + 100$

$\therefore\ \theta = 50°C$ [2]

(d) Any **THREE** of the following : [3]

* The flask should be completely immersed in water.
* The rubber tubing joining the flask and the Bourdon Gauge should be shorter.
* A stirrer should be used to stir the water.
* The thermometer should not touch the bottom of the beaker.
* The flask should not touch the bottom of the beaker.

5. (a) The length of the rubber tubing should be short [1]

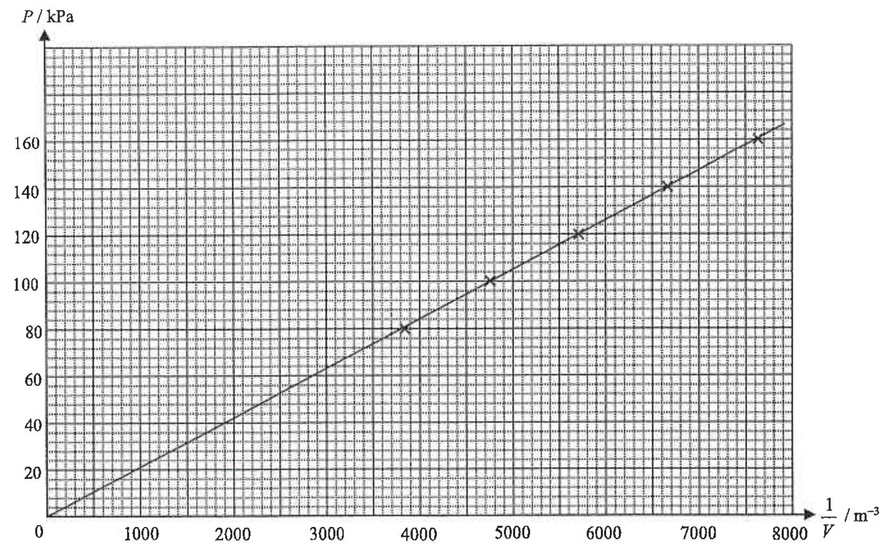
to reduce the volume of the gas inside the tubing. [1]

Any **TWO** of the following : [2]

* Move the piston slowly.
* Lubricate the piston.
* Do not take reading immediately after the piston is moved.

(b)

Pressure P / kPa	80	100	120	140	160
Volume V / m^3	2.60×10^{-4}	2.10×10^{-4}	1.75×10^{-4}	1.50×10^{-4}	1.31×10^{-4}
$\dfrac{1}{V}$ / m^{-3}	3850	4760	5710	6670	7630



< Labelled axes with units > [1]

< Appropriate scales > [1]

< Correct points plotted > [1]

< A suitable straight line drawn > [1]

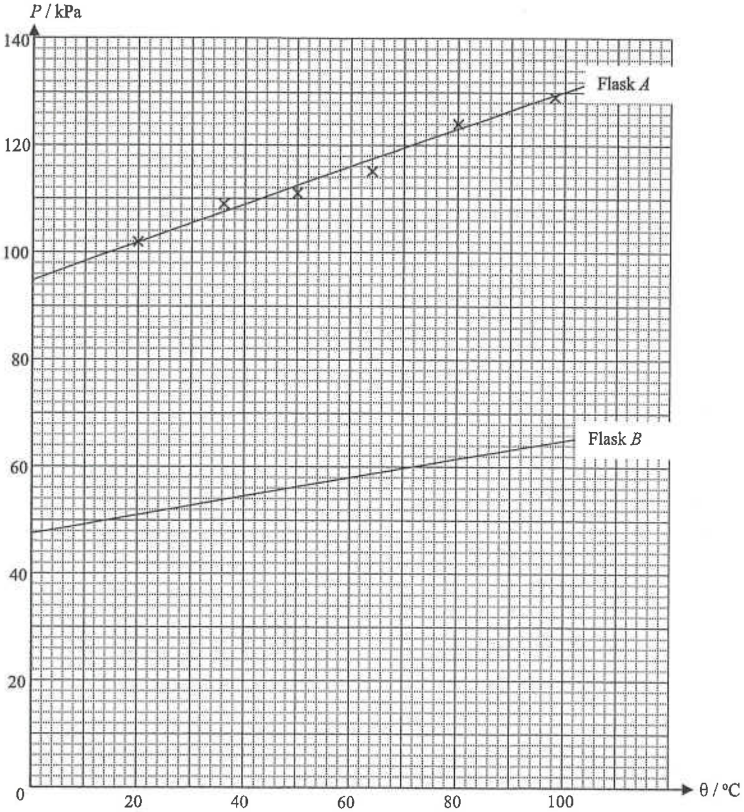
The student is attempting to verify Boyle's Law. [1]

(c) $P_1 V_1 = P_2 V_2$ [1]

$(100) \times (1.8 \times 10^{-4} + V) = (210)\,(V)$ [1]

$\therefore\ V = 1.64 \times 10^{-4}$ m^3 [1]

6. (a)



< Two labelled axes > [1]

< Correct scales > [1]

< Points correctly plotted > [1]

< A best fitted straight line drawn > [1]

(b) As the line does not pass through the origin, the pressure is not proportional to temperature. [1]

So David's conclusion is not correct. [1]

(c) Any **TWO** of the following : [2]

* Immerse the flask completely into the water. (**OR** Add some more water into the flask.)
* Stir the water throughout the experiment.
* Use a shorter rubber tubing. (**OR** Use a larger flask.)

(d) (i) $P_1 V_1 = P_2 V_2$ (For flask A, P = 95 kPa at 0°C) [1]

$(95)(V) = P_2(2V)$ $\therefore P_2 = 47.5$ kPa < from 46 to 49 is acceptable > [1]

(ii) < The pressure should be halved at the same temperature and the slope is also halved. > [1]

7. $\dfrac{P_1}{T_1} = \dfrac{P_2}{T_2}$ [1]

$\therefore \dfrac{200}{30+273} = \dfrac{P_2}{60+273}$ $\therefore P_2 = 220$ kPa [1]

8. (a) $L_1 = 4.7$ cm [1]

(b) By V-T relation : $V \propto L \propto T$ $\therefore \dfrac{L_1}{T_1} = \dfrac{L_2}{T_2}$

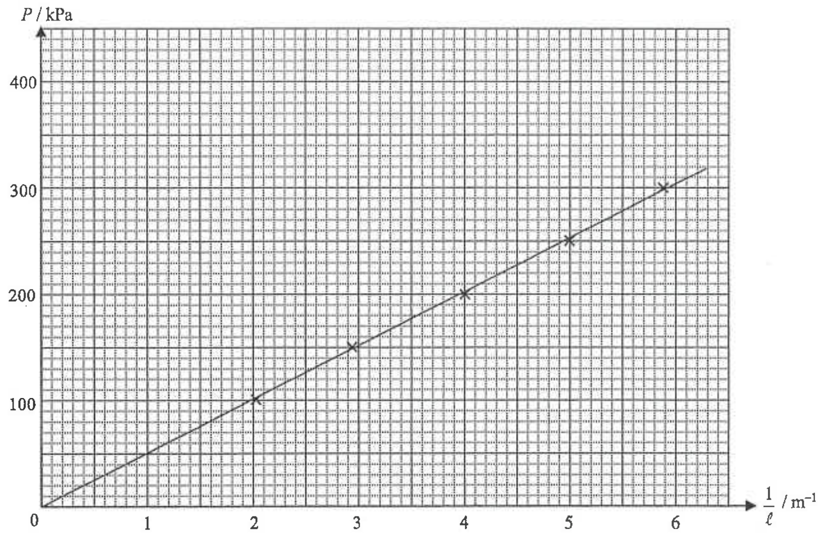
$\therefore \dfrac{4.7}{25+273} = \dfrac{L_2}{80+273}$ [1]

$\therefore L_2 = 5.57$ cm < accept 5.6 cm > [1]

Assume the pressure inside the air column is constant. [1]

9. (a)

Pressure P / kPa	100	150	200	250	300
Length of air column ℓ / m	0.49	0.34	0.25	0.20	0.17
$\dfrac{1}{\ell}$ / m^{-1}	2.04	2.94	4.00	5.00	5.88



< Correct labelled axes with units > [1]

< Appropriate scales > [1]

< Correct points plotted (at least 4 points) > [1]

< A straight line through the points > [1]

Conclusion : The pressure is inversely proportional to the volume. [1]

9. (b) Any **ONE** of the following : [1]

* Press the foot pump slowly.
* Do not take readings immediately after the foot pump is pressed.
* After pressing the pump, wait for a while to ensure that the temperature becomes steady.

10. By $PV = nRT$

$\therefore\ (1.01 \times 10^5)\,V = (1) \times (8.31) \times (0 + 273)$

$\therefore\ V = 0.0225\ \text{m}^3$ [1]

$M = \rho V = (1.43) \times (0.0225) = 0.032\ \text{kg}$ < accept 0.0321 or 0.0322 kg > [1]

11. (a) $PV = nRT$

$\therefore\ (10^5)\,V_1 = (0.2) \times (8.31) \times (301)$

$\therefore\ V_1 = 5.00 \times 10^{-3}\ \text{m}^3$ [1]

By V-T relation :

$\therefore\ \dfrac{V_2}{400} = \dfrac{5.00 \times 10^{-3}}{301}$

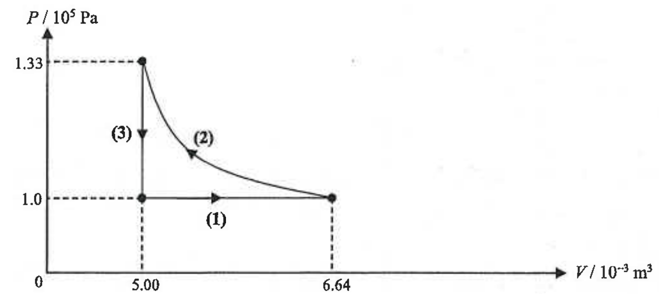
$\therefore\ V_2 = 6.64 \times 10^{-3}\ \text{m}^3$ [1]

(b) By Boyle's law :

$\therefore\ (1 \times 10^5) \times (6.64 \times 10^{-3}) = P \times (5.00 \times 10^{-3})$ [1]

$\therefore\ P = 1.33 \times 10^5\ \text{Pa}$ [1]

(c)



< Process (1) is horizontal > [1]

< Process (2) is a curve with constant temperature > [1]

< Process (3) is vertical > [1]

< Correct values indicated > [1]

12. (a) Remove the Bunsen burner to stop heating. [1]

Well stir the water with the stirrer to ensure uniform temperature. [1]

(b) (i) $\dfrac{65-20}{92-20} = \dfrac{L-64}{80-64}$ [1]

$\therefore\ L = 74\ \text{mm}$ [1]

(ii) $\dfrac{20-\theta}{92-20} = \dfrac{64-0}{80-64}$ [1]

$\therefore\ \theta = -268\ ^\circ\text{C}$ [1]

OR

$\dfrac{64}{20-\theta} = \dfrac{80}{92-\theta}$ [1]

$\therefore\ \theta = -268\ ^\circ\text{C}$ [1]

13. (a) $P_1 V_1 = P_2 V_2$

$(210) \times (1.0 \times 10^4) = (2) \times V_2$ [1]

$\therefore\ V_2 = 1.05 \times 10^6\ \text{cm}^3$ < accept $1.04 \times 10^6\ \text{cm}^3$ > [1]

(b) (i) $V_o = \dfrac{1.05 \times 10^6}{60} = 1.75 \times 10^4\ \text{cm}^3$ < accept $1.73 \times 10^4\ \text{cm}^3$ > [1]

(ii) $\dfrac{P_1 V_1}{T_1} = \dfrac{P_2 V_2}{T_2}$

$\therefore\ \dfrac{(210) \times (1.0 \times 10^4)}{(24 + 273)} = \dfrac{(4.5)\,V_2}{(20 + 273)}$ [1]

$\therefore\ V_2 = 4.604 \times 10^5\ \text{cm}^3$ < accept $4.50 \times 10^5\ \text{cm}^3$ > [1]

Time $= \dfrac{4.604 \times 10^5}{1.75 \times 10^4} = 26.3$ min. < accept 26.0 min > [1]

14. (a) By $PV = nRT$ [1]

$\therefore\ (1.0 \times 10^5)(6.0 \times 10^{-5}) = n\,(8.31)\,(25 + 273)$ [1]

$\therefore\ n = 2.42 \times 10^{-3}\ \text{mol}$

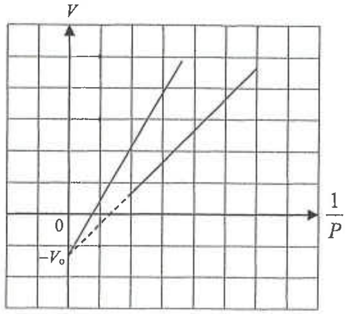
Number of molecules $= 2.42 \times 10^{-3} \times 6.02 \times 10^{23} = 1.46 \times 10^{21}$ [1]

(b) (i) Any **ONE** of the followings : [1]

* The process of pulling and pushing should be slow.
* Do not take readings immediately after moving the piston.

14. (b) (ii) V_0 represents the volume of gas inside the rubber tubing. [1]

(iii)



< same y-intercept > [1]

< greater slope > [1]

[By $P(V+V_0) = nRT$ $\therefore$ $V = nRT\frac{1}{P} - V_0$ $\therefore$ slope $= nRT$]

15. (a)

$pV = nRT$

$(100\times10^3)(0.52) = n(8.31)(273+15)$ 1M

$n = 21.727504$ (mol) ≈ 21.7 (mol) 1A

2

(b) (i) Since $pV = nRT \Rightarrow V = \dfrac{nRT}{p}$ / 1A

volume V of the balloon depends on both T and p,

the (fractional) decrease in pressure p (with height) is greater / faster than the (fractional) decrease in temperature T. 1A

2

(ii) (1) $\dfrac{pV}{T} = \text{constant}$

$\dfrac{(100)(0.52)}{(273+15)} = \dfrac{p(8)}{216}$ 1M

$p = 4.875$ kPa or 4875 Pa 1A

2

(2) $p = p_0e^{-kx}$

$4.875 = 100\,e^{-0.138x}$ 1M

$x = 21.89166726$ (km) ≈ 21.9 (km) 1A

2

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)

1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普通氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)

1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)

1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)

1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)

1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)

1. The universe seen in different scales (不同空間標度下的宇宙面貌)
2. Astronomy through history (天文學的發展史)
3. Orbital motions under gravity (重力下的軌道運動)
4. Stars and the universe (恆星和宇宙)

Elective 2 – Atomic World (原子世界)

1. Rutherford's atomic model (盧瑟福原子模型)
2. Photoelectric effect (光電效應)
3. Bohr's atomic model of hydrogen (玻爾的氫原子模型)
4. Particles or waves (粒子或波)
5. Probing into nano scale (窺探納米世界)

Elective 3 – Energy and Use of Energy (能量和能源的使用)

1. Electricity at home (家居用電)
2. Energy efficiency in building (建築的能源效率)
3. Energy efficiency in transportation (運輸業的能源效率)
4. Non-renewable energy sources (不可再生能源)
5. Renewable energy sources (可再生能源)

Elective 4 – Medical Physics (醫學物理學)

1. Making sense of the eye (眼的感官)
2. Making sense of the ear (耳的感官)
3. Medical imaging using non-ionizing radiation (非電離輻射醫學影像學)
4. Medical imaging using ionizing radiation (電離輻射醫學影像學)

The following list of formulae may be found useful :

Equation of state for an ideal gas	$pV = nRT$
Kinetic theory equation	$pV = \frac{1}{3}Nm\overline{c^2}$
Molecular kinetic energy	$E_k = \frac{3RT}{2N_A}$

Use the following data wherever necessary :

Molar gas constant	$R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$
Avogadro constant	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$

Part A : HKCE examination questions

1. **< HKCE 1986 Paper II - 19 >**

When observed through a microscope, smoke particles in a smoke cell are seen to be in continuous random motion. This is mainly due to
A. the motion of air molecules.
B. air currents.
C. the motion of atoms in the smoke particles.
D. heat radiation from the illuminating lamp of the smoke cell.

2. **< HKCE 1986 Paper II - 18 >**

When a constant mass of gas is compressed inside a vessel at constant temperature, the pressure of the gas increases. This is because
(1) the average distance between gas molecules decreases.
(2) the frequency of the gas molecules hitting the wall of the container increases.
(3) the average speed of the gas molecules increases.
A. (1) only
B. (2) only
C. (3) only
D. (1) & (2) only

3. **< HKCE 1988 Paper II - 9 >**

The pressure exerted by a gas in a container would increase if
(1) the average speed of the gas molecules were increased.
(2) the number of gas molecules were increased.
(3) the volume of the container were increased.
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

4. **< HKCE 1989 Paper II - 20 >**

When a constant mass of gas is heated at constant volume inside a vessel, the pressure of the gas increases. The main reasons include that
(1) the average speed of the gas molecules increases.
(2) the frequency of the gas molecules hitting the wall of the vessel increases.
(3) the average spacing between the gas molecules increases.
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

5. **< HKCE 1990 Paper II - 18 >**

Some gas is sealed inside a container of fixed volume. If the gas is heated, which of the following statements is/are true ?
(1) The pressure of the gas increases.
(2) The kinetic energy of the gas molecules increases.
(3) The density of the gas increases.
A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

6. **< HKCE 1991 Paper II - 19 >**

Which of the following statements concerning the Brownian motion of smoke particles in air is/are correct ?
(1) The Brownian motion is caused by collision between smoke particles.
(2) The air molecules are moving randomly in all directions.
(3) The mass of air molecules is almost the same as that of smoke particles.
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

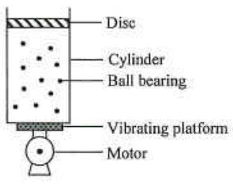
7. **< HKCE 1991 Paper II - 16 >**

Which of the following can increase the average kinetic energy of the molecules of a fixed mass of gas ?
(1) Heating the gas at constant volume
(2) Increasing the volume of the gas at constant pressure
(3) Reducing the volume of the gas at constant temperature
A. (1) only
B. (3) only
C. (1) & (2) only
D. (1), (2) & (3)

8. **< HKCE 1992 Paper II - 18 >**

If the volume of a fixed mass of gas is reduced at constant temperature, the pressure of the gas increases. Which of the following correctly account(s) for the increase in pressure ?
(1) The gas molecules hit the container wall more frequently.
(2) The average spacing between the gas molecules increases.
(3) The average speed of the gas molecules increases.
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

9. **< HKCE 1993 Paper II - 20 >**



The diagram shows a mechanical model of a gas. Which of the following processes can be used to demonstrate the variation of the pressure with the volume of a fixed mass of gas under constant temperature ?
A. Varying the weight of the disc.
B. Varying the power of the motor.
C. Varying the size of the ball bearings in the cylinder.
D. Varying the number of ball bearings in the cylinder.

10. **< HKCE 1993 Paper II - 17 >**

Energy is supplied to a fixed mass of gas which is kept at a constant volume. Which of the following statements is INCORRECT ?
A. The average speed of the gas molecules increases.
B. The average spacing between the gas molecules increases.
C. The gas molecules hit the container wall more frequently.
D. The temperature of the gas increases.

11. < HKCE 1995 Paper II - 23 >

A fixed mass of gas is heated at a constant pressure. Which of the following statements is/are correct ?

(1) The average speed of the gas molecules increases.
(2) The average spacing between the gas molecules increases.
(3) The number of gas molecules remains unchanged.

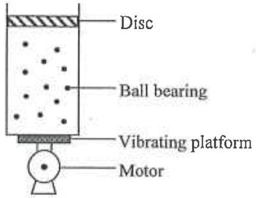
A. (3) only
B. (1) & (2) only
C. (1) & (3) only
D. (1), (2) & (3)

12. < HKCE 1996 Paper II - 23 >

Which of the following descriptions concerning the gas molecules is correct when a fixed mass of gas is compressed and also heated at the same time ?

	Average spacing between the gas molecules	Average speed of the gas molecule
A.	remains unchanged	increases
B.	decreases	increases
C.	decreases	decreases
D.	decreases	remains unchanged

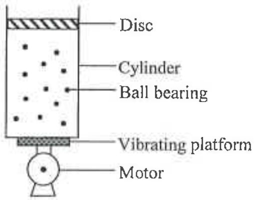
13. < HKCE 1997 Paper II - 21 >



The diagram shows a mechanical model of a gas. The weight of the disc and the power of the motor can give a measure of two different properties of the gas. What are these two properties ?

	Weight of the disc	Power of the motor
A.	Pressure	Volume
B.	Pressure	Temperature
C.	Volume	Temperature
D.	Temperature	Pressure

14. < HKCE 1998 Paper II - 24 >



The diagram shows a mechanical model of a gas. The ball bearings are set into motion by a motor-driven vibrating platform. Which of the following statements is/are correct if the operating voltage of the motor is increased ?

(1) The disc rises to a higher level.
(2) The average speed of the ball bearings increases.
(3) The average spacing between the ball bearings increases.

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1), (2) & (3)

15. < HKCE 1998 Paper II - 23 >

Which of the following can increase the average kinetic energy of the molecules of a fixed mass of gas ?

(1) increasing the volume of the gas at constant pressure
(2) increasing the pressure of the gas at constant volume
(3) increasing the pressure of the gas at constant temperature

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

16. < HKCE 1999 Paper II - 19 >

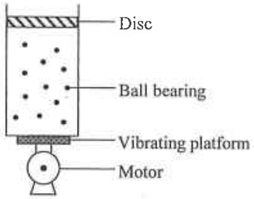


Figure (a)

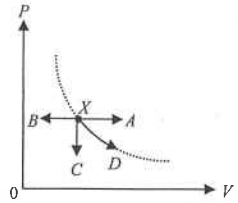


Figure (b)

Figure (a) shows a mechanical model of a gas and Figure (b) shows the P-V relation of a fixed mass of ideal gas at a certain temperature. If the operating voltage of the motor in the model is increased, which of the following denotes a corresponding transition in the P-V graph (point X represents the initial state of the gas) ?

A. $X \rightarrow A$
B. $X \rightarrow B$
C. $X \rightarrow C$
D. $X \rightarrow D$

17. < HKCE 2002 Paper II - 23 >

A column of gas is trapped inside a cylinder. The piston is now pushed slowly causing the gas to be compressed at a constant temperature. Which of the following statements about the gas molecules in the cylinder is/are correct ?

(1) The average speed of the gas molecules increases.
(2) Each gas molecule exerts a greater impact force on the walls of the cylinder in each collision.
(3) The gas molecules collide more frequently with the walls of the cylinder.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

Part B : HKAL examination questions

18. < HKAL 1980 Paper I - 5 >

Two gases X and Y are maintained at the same temperature. The molecular mass of X is 9 times that of Y. What is the ratio of the r.m.s. speed of molecules of gas Y to that of molecules of gas X ?

A. 3
B. $3\sqrt{2}$
C. 9
D. 18

19. < HKAL 1982 Paper I - 12 >

An ideal gas inside a container of volume V has a pressure P. If the mass of the gas is M, what is the r.m.s. speed of its molecules ?

A. $\sqrt{\dfrac{PV}{3M}}$

B. $\sqrt{\dfrac{PV}{M}}$

C. $\sqrt{\dfrac{3PV}{M}}$

D. $\sqrt{PVM}$

20. < HKAL 1983 Paper I - 32 >

A cylinder containing an ideal gas is fitted with a piston maintained at a constant temperature. The piston is moved very slowly until the volume of the cylinder becomes halved. Which of the following quantities would be doubled ?

(1) The average speed of the gas molecules in the cylinder.
(2) The average momentum of the gas molecules in the cylinder.
(3) The average force exerted by the gas molecules on the piston.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

21. < HKAL 1984 Paper I - 11 >

A fixed mass of gas at room temperature occupies a volume of V. The gas is heated and allowed to expand to a final volume of $2V$ with its pressure doubled. The average kinetic energy of the gas molecules is

A. halved.
B. unchanged.
C. doubled.
D. increased four times.

22. < HKAL 1985 Paper I - 11 >

A gas vessel of volume 1000 cm^3 contains 0.72 g of an ideal gas at a pressure of 100 kPa. What is the r.m.s. velocity of the gas molecules ?

A. 20 m s^{-1}
B. 110 m s^{-1}
C. 340 m s^{-1}
D. 650 m s^{-1}

23. < HKAL 1986 Paper I - 16 >

The density of a gas is 0.179 kg m^{-3} at the temperature of 0°C and pressure of 100 kPa. What would be the r.m.s. velocity of the gas molecules at a temperature of 91°C ?

A. 231 m s^{-1}.
B. 470 m s^{-1}.
C. 1290 m s^{-1}.
D. 1490 m s^{-1}.

24. < HKAL 1988 Paper I - 18 >

Which of the following is NOT an assumption of the kinetic model of ideal gases ?

A. Attractive forces between the gas molecules are negligible.
B. The duration of collision between gas molecule and the walls is negligible compared with the time between collisions.
C. The collisions of gas molecules with the walls of the container cause no change in the average kinetic energy of molecules.
D. The gas molecules suffer negligible change of momentum on collision with the walls of the container.

25. < HKAL 1988 Paper I - 17 >

An ideal gas is at an absolute temperature T. If m is the mass of a gas molecule, then the r.m.s. speed of the molecules is

A. $\sqrt{\dfrac{3RT}{m}}$

B. $\sqrt{\dfrac{RT}{mN_A}}$

C. $\sqrt{\dfrac{3RT}{mN_A}}$

D. $\sqrt{\dfrac{RTN_A}{m}}$

26. < HKAL 1988 Paper I - 12 >

Smoke particles in air are observed to have Brownian motion observed by microscope. The Brownian motion of the smoke particles is mainly caused by

A. the interaction between oxygen and the nitrogen molecules.
B. collisions between air molecules.
C. collisions between smoke particles.
D. collisions between air molecules and smoke particles.

27. < HKAL 1988 Paper I - 15 >

An ideal gas is contained in a cylinder. The piston is slowly pushed into the cylinder so that the temperature remains unchanged. Which of the following statements is NOT correct ?

A. The mass of the gas remains the same.
B. The pressure of the gas increases.
C. The number of the molecules per unit volume increases.
D. The average speed of gas molecules increases.

28. < HKAL 1989 Paper I - 17 >

Two identical vessels contain two different gases A and B, which are treated as ideal gases. If the ratio of their molar masses and absolute temperatures are 8 : 1 and 2 : 1 respectively, what is the ratio of their r.m.s. molecular speeds ?

A. 1 : 4
B. 1 : 2
C. 1 : 1
D. 2 : 1

29. < HKAL 1990 Paper I - 13 >

Container X contains hydrogen gas while container Y contains oxygen gas. If both of the hydrogen molecules in X and the oxygen molecules in Y have the same r.m.s. speed, which of the following deduction must be correct ?

A. The gas in X has a higher temperature than Y.
B. The gas in X has a higher pressure than Y.
C. The gas in X has a lower temperature than Y.
D. The gas in X has a lower pressure than Y.

30. < HKAL 1991 Paper I - 10 >

A container holds an ideal gas on the Earth. If the container is brought to the surface of the Moon with the same temperature and the same volume, which of the following properties of the gas molecules is/are the same ?

(1) The average momentum change when a molecule of the gas rebounds from a wall of the container
(2) The average kinetic energy of a molecule of the gas
(3) The weight of a molecule of the gas

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

31. **< HKAL 1991 Paper I - 17 >**

A fixed mass of ideal gas at room temperature and atmospheric pressure occupies a volume of $0.2\ m^3$. The gas is heated and allowed to expand to a final volume of $0.4\ m^3$ with its pressure doubled. The root mean square speed of the gas molecules is
A. reduced to one quarter of its original value.
B. halved.
C. unchanged.
D. doubled.

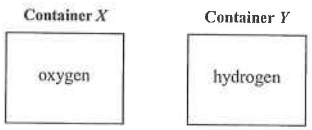
32. **< HKAL 1991 Paper I - 19 >**

Smoke particles in air inside a smoke cell are seen to undergo Brownian motion by viewing through microscope. Which of the following statements concerning Brownian motion is/are correct ?
(1) The motion is caused by collisions between air molecules and smoke particles.
(2) The experiment makes it possible to see the motion of the air molecules.
(3) The motion is irregular because air is a mixture of gases, and the molecules have different masses.
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

33. **< HKAL 1992 Paper I - 14 >**

The molar mass of oxygen gas and hydrogen gas are 32 g and 2 g respectively. What is the ratio of the r.m.s. speed of oxygen molecules to that of hydrogen molecules at room temperature ?
A. $\frac{1}{16}$
B. $\frac{1}{4}$
C. 1
D. 4

34. **< HKAL 1993 Paper I - 18 >**



Two identical gas vessels X and Y contain oxygen and hydrogen respectively. Both gases are at room temperature and atmospheric pressure. Which of the following statements is/are true concerning the two gases in both containers ?
(1) The number of gas molecules is the same.
(2) The r.m.s. speed of gas molecules is the same.
(3) The frequency of collision of gas molecules with the walls of container is the same.
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

35. **< HKAL 1995 Paper IIA 21 >**

The r.m.s. speed of the molecules of a certain gas is $341\ m\ s^{-1}$ at 25°C. Find the molar mass of this gas.
A. 21.8 g
B. 33.8 g
C. 42.6 g
D. 63.9 g

36. **< HKAL 1997 Paper IIA - 35 >**

Two identical vessels contain two different ideal gases A and B. If the ratio of their absolute temperatures and the ratio of their root-mean-square speed of the molecules are respectively 2 : 1 and 3 : 1, what is the ratio of their molar mass ?
A. 2 : 3
B. 2 : 9
C. 1 : 6
D. 9 : 2

37. **< HKAL 2000 Paper IIA - 39 >**

Which of the following statements concerning a real gas are correct ?
(1) The collisions between gas molecules and the walls of a container are not perfectly elastic.
(2) The size of the gas molecules cannot be neglected.
(3) Intermolecular attraction forces between gas molecules cannot be neglected.
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

38. **< HKAL 2001 Paper IIA - 32 >**

Which of the following is NOT a basic assumption of the kinetic theory of an ideal gas ?
A. All gas molecules are in random motion.
B. All gas molecules move with the same speed at a certain temperature.
C. All gas molecules are point particles that have no physical size.
D. All collisions between gas molecules and the walls of the container are perfectly elastic.

39. **< HKAL 2002 Paper IIA - 40 >**

The r.m.s. speed of the molecules in a fixed mass of an ideal gas is c at 80°C. If the temperature is increased to 160°C, what would be the r.m.s. speed of the gas molecules ?
A. 2 c.
B. 1.4 c.
C. 1.2 c.
D. 1.1 c.

40. **< HKAL 2005 Paper IIA - 20 >**

Two gas vessels contain hydrogen and oxygen gas respectively. They have the same temperature and pressure. If both gases are assumed to be ideal, which of the following physical quantities must be the same for the two gases ?
A. The r.m.s. speed of the gas molecules
B. The volume of the gas
C. The mass per unit volume of the gas
D. The number of gas molecules per unit volume

41. **< HKAL 2006 Paper IIA - 22 >**

The following is the kinetic equation for ideal gas :

$$P = \frac{1}{3}\frac{N\,m}{V}\overline{c^2}.$$

In the above equation, the product $N\,m$ represent
A. the total mass of the gas.
B. the mass of one mole of the gas.
C. the number of molecules in unit volume of the gas.
D. the number of molecules in one mole of the gas.

42. **< HKAL 2008 Paper IIA - 23 >**

An ideal gas is contained in a gas vessel at a certain temperature. The gas is heated until its pressure reaches 1.2 times its initial value. Calculate the percentage increase in the average kinetic energy of the gas molecules.
A. 10%
B. 20%
C. 44%
D. It cannot be determined since the number of moles of gas molecules is not known.

43. **< HKAL 2011 Paper IIA - 41 >**

Which of the following is NOT an essential assumption of the kinetic model of ideal gas ?
A. The number of molecules in the container is large.
B. The volume occupied by the molecules is negligible compared with the container's volume.
C. There is no collision between the molecules.
D. There are no intermolecular forces of attraction between two molecules at any separation.

44. **< HKAL 2011 Paper IIA - 42 >**

Two different ideal gases are contained in two identical vessels. Both vessels are at the same temperature. Which of the following physical quantities about the two gases in their vessels must be the same ?
(1) the pressure of the gas
(2) the number of molecules per unit volume
(3) the average kinetic energy of molecules
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

45. **< HKAL 2012 Paper IIA - 36 >**

Two vessels X and Y contain equal mass of an ideal gas. The pressure of the gas in X is equal to that in Y, while the temperature of the gas in X is higher than that in Y. Which of the following statements is/are correct ?
(1) The average separation of the gas molecules in X is greater than that in Y.
(2) Every gas molecule in X has greater kinetic energy than that in Y.
(3) The collision frequency of the molecules on each wall of the vessel in X is greater than that in Y.
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

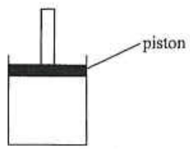
Part C : HKDSE examination questions

46. **< HKDSE Sample Paper IA - 4 >**

Two vessels contain hydrogen and oxygen gas respectively. Both gases have the same pressure and temperature and are assumed to be ideal. Which of the following physical quantities must be the same for the two gases ?
A. The volume of the gas
B. The mass per unit volume of the gas
C. The r.m.s. speed of the gas molecules
D. The number of gas molecules per unit volume

47. **< HKDSE Practice Paper IA - 5 >**

A fixed mass of an ideal gas is contained in a cylinder fitted with a frictionless piston as shown in the figure. If the gas is cooled under constant pressure,

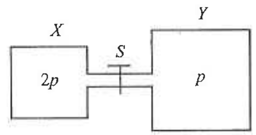


(1) the average separation of the gas molecules will decrease.
(2) the r.m.s. speed of the gas molecules will decrease.
(3) the number of collisions per second of the gas molecules on the piston will decrease.
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

48. **< HKDSE 2013 Paper IA - 3 >**

In which of the following situations would the r.m.s. speed of the molecules of a fixed mass of an ideal gas increase ?
(1) The gas is heated under constant volume.
(2) The gas expands under constant pressure.
(3) The gas is compressed under constant temperature.
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

49. **< HKDSE 2013 Paper IA - 4 >**



Vessel X of volume V and vessel Y of volume $2V$ are connected by a short narrow tube as shown. Initially, tap S is closed and the same kind of ideal gas at the same temperature is contained in X and Y at pressure $2p$ and p respectively. The tap S is then opened and equilibrium state is finally reached with the temperature unchanged. Which statement is **INCORRECT** ?
A. Before S is opened, both vessels contain the same number of gas molecules.
B. Before S is opened, the average kinetic energy of the gas molecules in both vessels is the same.
C. When S is opened, a net flow of gas from X to Y occurs.
D. When equilibrium is reached, the gas pressure becomes $\frac{3}{2}p$.

50. **< HKDSE 2016 Paper IA - 3 >**

When an ideal gas is heated from 25°C to 50°C, the average kinetic energy of the gas molecules will
A. double.
B. increase by 41%.
C. increase by 8.4%.
D. increase by 4.1%.

51.<HKDSE 2020 Paper IA-3>

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. A	11. D	21. D	31. D	41. A	51.A
2. B	12. B	22. D	32. A	42. B	
3. C	13. B	23. D	33. B	43. C	
4. C	14. D	24. D	34. A	44. B	
5. C	15. C	25. C	35. D	45. A	
6. B	16. A	26. D	36. B	46. D	
7. C	17. B	27. D	37. C	47. A	
8. A	18. A	28. B	38. B	48. C	
9. A	19. C	29. C	39. D	49. D	
10. B	20. B	30. C	40. D	50. C	

M.C. Solution

1. A

The motion of air molecules causes the hitting of air molecules onto the large smoke particles, thus the smoke particles perform zig-zag motion.
This is called Brownian motion.

2. B

× (1) Although the average distance between gas molecules is decreased due to the decrease of volume, it cannot explain why the pressure is increased.

✓ (2) When volume of container is decreased, distance between two walls is decreased, thus the gas molecules bombard the walls more frequently, therefore pressure is increased.

× (3) Since there is no change in temperature, thus the speed of molecules remains unchanged.

3. C

✓ (1) If the average speed of gas molecules is increased, the bombardment with the walls of container would become more violently and more frequently, thus pressure is increased.

✓ (2) If the number of gas molecules is increased, the bombardment with the walls of container would become more frequently, thus pressure is increased.

× (3) If the volume is increased, the bombardment with the walls of container would become less frequently, thus pressure is decreased.

4. C

✓ (1) When temperature is increased, the kinetic energy and the average speed of gas molecules must increase.

✓ (2) When the average speed of gas molecules increases, the molecules hit the wall more frequently.

× (3) Since the volume is constant, average spacing of gas molecules remains unchanged.

5. C

✓ (1) When the gas is heated, average speed of gas molecules must increase. Gas molecules hit the walls of container more violently and more frequently. Thus pressure increases.

✓ (2) When a gas is heated, its temperature must increase, thus its kinetic energy is increased.

× (3) Since the volume is fixed, its density must also be unchanged.

6. B

× (1) Smoke particles undergo Brownian motion as air molecules bombard the smoke particles but not the collision between smoke particles themselves.

✓ (2) Air molecules move randomly to give collision with smoke particles and causes Brownian motion

× (3) The mass of smoke particles is much larger than the mass of each air molecule.

7. C

✓ (1) When a gas is heated, its temperature must increase, thus the kinetic energy must increase.

✓ (2) At constant pressure, the volume of gas can be increased by increasing the temperature only.

× (3) If temperature is constant, the kinetic energy of molecules must be constant.

8. A

✓ (1) When the volume is decreased, distance between two walls of container is decreased, thus the gas molecules hit the walls more frequently, therefore pressure is increased.

× (2) The average spacing should be decreased when volume is decreased.

× (3) The average speed should be unchanged when temperature is constant.

9. A

✓ A. Varying the weight of disc means varying the pressure of gas.

× B. Varying the power of the motor means varying the temperature.

× C. Varying the size of ball bearings means varying the mass of the gas molecules.

× D. Varying the number of ball bearings means varying the number of gas molecules.

10. B

✓ A. When energy is supplied to a gas, its temperature must increase, thus the kinetic energy of gas molecules must increase, thus the average speed is increased.

× B. Since the gas is kept at constant volume, the average spacing does not change.

✓ C. Since the average speed is increased, the gas molecules hit the wall more frequently and more violently.

✓ D. When energy is supplied, its temperature must increase.

11. D

✓ (1) Under heating, the temperature of the gas must increase, and thus the average speed is increased.

✓ (2) When heating under constant pressure, the volume of container must increase, thus the average spacing of molecules must also increase.

✓ (3) For a fixed mass of gas, the number of gas molecules must also be unchanged.

12. B

① When a gas is compressed, its volume is decreased, thus the average spacing is decreased.

② When a gas is heated, its kinetic energy increases, thus the kinetic energy of the gas molecules increases.

13. B

Weight of the disc : simulates the pressure of the gas

Power of the motor : simulates the temperature of the gas

14. D

✓ (1) When the operating voltage is increased, the average speed of ball bearings is increased. The ball bearing thus hit the disc more violently to increase the volume.

✓ (2) When the operating voltage is increased, the average speed of ball bearings is increased.

✓ (3) When the volume is increased, the average spacing between ball bearings is increased.

15. C

✓ (1) At constant pressure, the volume of a gas can be increased by increasing the temperature only.

✓ (2) At constant volume, the pressure of a gas can be increased by increasing the temperature only.

× (3) At constant temperature, the kinetic energy of gas molecules must remain unchanged.

16. A

When the operating voltage of the motor is increased, it simulates the increase of temperature.

Since the disc remains unchanged, it represents no change of pressure.

As temperature is increased but pressure is unchanged, the volume must increase.

Thus the change should be from X to A.

17. B

× (1) The average speed of the gas molecules does not change as the temperature is constant.

× (2) Since the average speed is unchanged, the impact force of each molecule is unchanged.

✓ (3) As the volume decreases, the distance between the piston and the walls of container decreases, the gas molecules will collide more frequently with the walls of the container.

18. A

For same temperature, molecules have the same kinetic energy E_K.

$E_K = \frac{1}{2}mc^2$ $\therefore$ $c \propto \frac{1}{\sqrt{m}}$ $\therefore$ $\frac{c_Y}{c_X} = \sqrt{\frac{m_X}{m_Y}} = \sqrt{\frac{9}{1}} = 3$

19. C

As $PV = \frac{1}{3}Nmc^2$ $\therefore$ $PV = \frac{1}{3}Mc^2$

$\therefore$ $c = \sqrt{\frac{3PV}{M}}$

20. B

× (1) As T kept constant $\therefore$ r.m.s. speed c is no change $\therefore$ average speed is no change

× (2) average speed : no change $\Rightarrow$ average momentum : no change (By $p = mc$)

✓ (3) $V \to \frac{1}{2}V \Rightarrow P \to 2P$ (By PV = constant) $\Rightarrow F \to 2F$ (By $F = PA$)

21. D

$PV = nRT$

As $P \to 2P$ and $V \to 2V$ $\therefore$ $T \to 4T$

Since average kinetic energy : $E_K \propto T$ $\therefore$ E_K increases 4 times

22. D

$PV = \frac{1}{3}Nmc^2 = \frac{1}{3}Mc^2$ (M is the mass of the gas)

$\therefore$ $(100\times10^3)(1000\times10^{-6}) = \frac{1}{3}(0.72\times10^{-3})c^2$ $\therefore$ $c = 650$ m s^{-1}

23. D

At 0°C, $PV = \frac{1}{3}Nmc^2$ $\therefore$ $P = \frac{1}{3}\rho c^2$

$\therefore$ $(1\times10^5) = \frac{1}{3}(0.179)c^2$ $\therefore$ $c = 1290$ m s^{-1}

At 91°C, $c = \sqrt{\frac{3RT}{M_m}}$ $\therefore$ $c \propto \sqrt{T}$ $\therefore$ $\frac{c_1}{c_2} = \sqrt{\frac{T_1}{T_2}}$

$\therefore$ $\frac{1290}{c_2} = \sqrt{\frac{0+273}{91+273}}$ $\therefore$ $c_2 = 1490$ m s^{-1}

24. D

Perfectly elastic collision $\Rightarrow$ change of momentum $= mc - (-mc) = 2mc$

$\therefore$ Momentum of molecules must change during collision $\therefore$ D is incorrect.

25. C

$PV = \frac{1}{3}Nmc^2$ and $PV = nRT$ $\therefore$ $nRT = \frac{1}{3}Nmc^2$

$\therefore$ $\frac{N}{N_A}RT = \frac{1}{3}Nmc^2$ $\therefore$ $c = \sqrt{\frac{3RT}{mN_A}}$

26. D

Smoke particles perform Brownian motion is due to the collision between air molecules and smoke particles.

27. D

✓ A. The mass of the gas inside the cylinder must be unchanged since the gas is enclosed by the cylinder.

✓ B. By Boyle's Law, the decrease of volume gives the increase of pressure.

✓ C. As the volume decreases, more gas molecules is contained in a unit volume, thus the number of the molecules per unit volume increases.

× D. As the temperature is unchanged, the average speed should also be unchanged.

28. B

$$c = \sqrt{\frac{3RT}{M_m}} \propto \sqrt{\frac{T}{M_m}}$$

$$\therefore \frac{c_A}{c_B} = \sqrt{\frac{T_A}{T_B}} \cdot \sqrt{\frac{M_B}{M_A}} = \sqrt{\frac{2}{1}} \cdot \sqrt{\frac{1}{8}} = \frac{1}{2}$$

29. C

By $c = \sqrt{\frac{3RT}{M_m}}$ $\therefore$ for same $c \Rightarrow M_m \propto T$

$$\therefore M_{H_2} < M_{O_2} \Rightarrow M_X < M_Y \Rightarrow T_X < T_Y$$

30. C

✓ (1) At the moon, the mass of molecule remains unchanged, thus the momentum change should be the same.

✓ (2) At the moon, the mass of molecule remains unchanged, thus the kinetic energy should be the same.

× (3) At the moon, the gravity g is smaller, thus the weight mg would be smaller and not the same.

31. D

$$PV = \frac{1}{3}Nmc^2 \quad \therefore PV = \frac{1}{3}Mc^2 \quad \therefore c = \sqrt{\frac{3PV}{M}} \propto \sqrt{PV}$$

$$\therefore \frac{c'}{c} = \sqrt{\frac{P'}{P} \cdot \frac{V'}{V}} = \sqrt{(2)\times\left(\frac{0.4}{0.2}\right)} = 2 \qquad \therefore c' = 2c.$$

32. A

✓ (1) When thousands of air molecules collide with a smoke particle, the random resultant force makes the smoke particles move in zig-zag path, and this is the Brownian motion

× (2) Air molecules are invisible even under microscope.

× (3) The irregular motion of smoke particles is due to the collisions of air molecules on the smoke particles ; the irregular motion would still occur even for the same type of gas or for mixture.

33. B

$$c = \sqrt{\frac{3RT}{M_m}} \propto \frac{1}{\sqrt{M_m}}$$

$$\therefore \frac{c_{O_2}}{c_{H_2}} = \sqrt{\frac{M_{H_2}}{M_{O_2}}} = \sqrt{\frac{2}{32}} = \frac{1}{4}$$

34. A

✓ (1) Same $V, T, P \Rightarrow$ same n and same N (by $PV = nRT$)

× (2) Different molar mass $M_m \Rightarrow$ different c (by $c = \sqrt{\frac{3RT}{M_m}}$)

× (3) Different $c \Rightarrow$ different frequency f (for same volume V and same number N)

35. D

$$c = \sqrt{\frac{3RT}{M_m}}$$

$$\therefore (341) = \sqrt{\frac{3(8.31)(25+273)}{M_m}}$$

$$\therefore M_m = 0.0639 \text{ kg} = 63.9 \text{ g}$$

36. B

As $c = \sqrt{\frac{3RT}{M_m}}$

$$\therefore M_m = \frac{3RT}{c^2} \propto \frac{T}{c^2}$$

$$\therefore \frac{M_A}{M_B} = \frac{T_A}{T_B} \cdot \left(\frac{c_B}{c_A}\right)^2 = (\frac{2}{1})\left(\frac{1}{3}\right)^2 = \frac{2}{9}$$

37. C

× (1) Otherwise, the molecules stop moving after a certain time period.

✓ (2) Gas molecules of real gas have size that is not negligible.

✓ (3) Intermolecular attraction forces of real gas are significant.

38. B

× A. Molecules of ideal gas are assumed to move in random motion.

✓ B. Speed of molecules should have a distribution, with an average value of speed.

× C. Molecules of ideal gas are assumed to have no volume.

× D. Molecules of ideal gas are assumed to have perfectly elastic collision.

39. D

As $c \propto \sqrt{T}$

$\therefore \frac{c_2}{c_1} = \sqrt{\frac{T_2}{T_1}}$

$\therefore \frac{c_2}{(c)} = \sqrt{\frac{160+273}{80+273}} = 1.1 \qquad \therefore c_2 = 1.1\,c$

40. D

By $PV = nRT$

Since P and T are the same, the ratio $\frac{n}{V}$ is the same for the two gases.

As the number of gas molecules N is proportional to the number of mole n,

they have the same number per volume $\frac{N}{V}$.

41. A

N represents the total number of molecules ; m represents the mass of each molecule.

Nm thus represents the total mass of all the gas molecules.

42. B

As the volume is unchanged in a closed vessel, $P \propto T$.

When pressure reaches 1.2 times, the absolute temperature also reaches 1.2 times.

As the average kinetic energy is proportional to the absolute temperature, i.e. $KE \propto T$.

When the absolute temperature reaches 1.2 times, the average kinetic energy of the gas molecules also reaches 1.2 times.

Thus the percentage increase is 20%.

43. C

✓ A. Large number of molecules in the container is assumed.

✓ B. Ideal gas molecules have negligible size.

× C. Molecules may collide with each when they move.

✓ D. Ideal gas molecules do not have intermolecular forces.

44. B

× (1) Since the two vessels are identical, their volumes are the same.
Since the two vessels are in thermal equilibrium, their temperatures are the same.
However, their pressure and number of mole may not be the same.

× (2) Since the number of mole may not be the same, the number of molecules may also not be the same.

✓ (3) Since their temperatures are the same, their average molecular kinetic energy must be the same.

45. A

✓ (1) As they have equal mass, their number of mole n must be the same.
By $PV = nRT$, as their pressures P are the same, since X has higher temperature,
the volume of vessel X is greater, thus the molecules in X has greater average separation.

× (2) Although the average kinetic energy of gas molecules in X is greater,
but still there are some gas molecules in X that may have kinetic energy less than that of Y,
as the molecules have a range of speed or range of kinetic energy.

× (3) Since the temperature of X is higher, the average speed of gas molecules in X is greater.
Thus, the gas molecules in X hit the wall more vigorously with greater momentum.
To have the same pressure, the collision of gas molecules in X must be less frequently.
Thus the collision frequency in X should be smaller than that in Y.

46. D

By $PV = nRT$

$\therefore \frac{n}{V} = \frac{P}{RT}$

Since P and T are the same, the ratio $\frac{n}{V}$ is the same for the two gases.

As the number of gas molecules N is proportional to the number of mole n,

they have the same number of gas molecules per unit volume $\frac{N}{V}$.

47. A

✓ (1) Under constant pressure, as temperature decreases, volume decreases.
Thus the average separation will decrease as it depends on the volume of the gas.

✓ (2) As the gas is cooled, the temperature decreases, thus KE decreases and r.m.s. speed decreases.

× (3) As the r.m.s. speed decreases, the gas molecules hit the walls less violently.
Thus the gas molecules must hit the walls more frequently so that the pressure is the same.
Therefore, the number of collisions per second of the gas molecules should increase.

48. C

✓ (1) As the gas is heated, its temperature must increase, thus r.m.s. speed would increase.

✓ (2) At constant pressure, the gas expands only when temperature increases, thus r.m.s. speed must increase.

× (3) Under constant temperature, average kinetic energy and r.m.s. speed remain unchanged.

49. D

✓ A. By $PV = nRT$, for X : $(2p)(V) = nRT$ and for Y : $(p)(2V) = nRT$
the number of mole n in both vessels are the same, thus they contain the same number of molecules.

✓ B. Since average kinetic energy depends on temperature only, same temperature has same average KE.

✓ C. Since pressure of X is greater, there is a net flow of gas from X to Y.

× D. At equilibrium, $(2p)(V) + (p)(2V) = p'(V + 2V) \qquad \therefore p' = \frac{4}{3}p$.

50. C

By $E_K = \frac{3}{2}\cdot\frac{R}{N_A}\cdot T$ $\therefore E_K \propto T$

$\therefore \frac{E_2}{E_1} = \frac{T_2}{T_1} = \frac{(50+273)}{(25+273)} = 1.084 = 108.4\%$

$\therefore$ Kinetic energy increases by 8.4%.

The following list of formulae may be found useful :

Equation of state for an ideal gas	$pV = nRT$
Kinetic theory equation	$pV = \frac{1}{3}Nm\overline{c^2}$
Molecular kinetic energy	$E_k = \frac{3RT}{2N_A}$

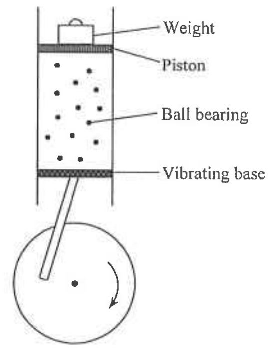
Use the following data wherever necessary :

Molar gas constant	$R = 8.31\ \mathrm{J\ K^{-1}\ mol^{-1}}$
Avogadro constant	$N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$

Part A : HKCE examination questions

1. **< HKCE 1979 Paper I - 4 >**

(a) The below figure shows a mechanical model for the kinetic theory of a gas.



As the ball bearings are in motion, the mean separation between the piston and the base is h.

(i) State how the value of h may be affected by increasing the frequency of vibration of the base. (1 mark)

____

(ii) State how the value of h may be affected by adding weights to the piston. (1 mark)

____

(iii) State how the value of h may be affected by reducing the number of ball bearings. (1 mark)

____

(b) Explain in terms of the kinetic theory of matter, why at constant volume, the increase in the temperature of a gas causes an increase of its pressure. (3 marks)

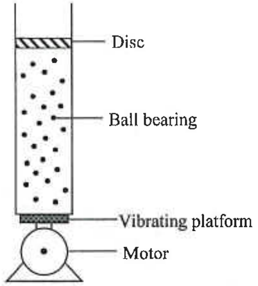
____

____

____

2. < HKCE 1988 Paper I - 4 >

The below figure shows a mechanical model of a gas. A large number of ball bearings are set in motion by a vibrating platform. The ball bearings represent gas molecules.



(a) Which property of the gas would be represented in this model by (2 marks)

(i) the weight of the disc; and

(ii) the voltage of the d.c. supply ?

(b) For a fixed amount of gas, when temperature is kept constant, its pressure increases as the volume decreases.

(i) Describe how this behaviour of gas can be demonstrated using the model. (2 marks)

(ii) Describe the change in the average speed of the ball bearings and the frequency of bombardment on the walls in this demonstration. (4 marks)

(c) In a real situation, gas molecules could keep on moving by themselves without an external energy supply but in this model energy has to be supplied to the ball bearings continuously by the vibrating platform. Briefly explain this difference. (3 marks)

(d) A large polystyrene ball is now placed into the cylinder. Briefly describe and explain the motion of the polystyrene ball. (3 marks)

3. < HKCE 1989 Paper I - 4 >

Based on the kinetic theory of gases, explain briefly why the pressure increases as the temperature does. (3 marks)

4. < HKCE 1990 Paper I - 4 >

Describe the arrangement and motion of the molecules of the substance in the (4 marks)

(i) solid state, and

(ii) liquid state.

5. < HKCE 1994 Paper I - 4 >

Explain, in terms of the kinetic theory of gases, the increase in the pressure of the gas when the volume decreases at a constant temperature. (3 marks)

6. < HKCE 1999 Paper I - 9 >

Based on the kinetic theory, explain why the pressure of a gas increases with temperature at a constant volume. (3 marks)

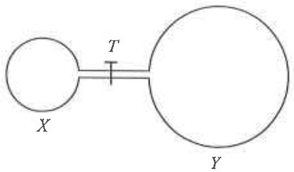
7. < HKCE 2001 Paper I - 2 >

Based on the kinetic theory, explain why the gas pressure inside a metal can increases with temperature at a constant volume. (3 marks)

Part B : HKAL examination questions

8. < HKAL 2001 Paper I - 10 >

Two containers X and Y with volumes 100 cm^3 and 500 cm^3 respectively are connected by a tube of negligible volume as shown in the figure below. Container X contains an ideal gas at a pressure of 12×10^5 Pa while there is a vacuum in container Y. The temperature of the two containers is maintained at 0°C by two separate water baths with melting ice. The tap T for controlling gas flow is closed initially



Given that the mass of one molecule of the ideal gas is 4.52×10^{-26} kg.

(a) Calculate the number of moles of gas in the container X. (2 marks)

(b) Calculate the root-mean-square speed of the gas molecules in X. (2 marks)

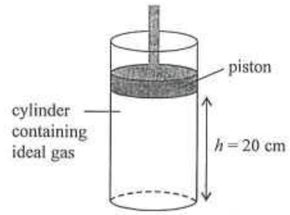
(c) Now the tap is open and the gas in X flows to Y. Finally, equilibrium state is achieved.

(i) What is the root-mean-square speed of the gas molecules in Y ? (1 mark)

(ii) What is the common pressure in the two vessels ? (2 marks)

(iii) What is the number of mole of gas in the vessel Y ? (2 marks)

9. < HKAL 2006 Paper I - 5 >



In the above Figure, an ideal gas is contained in a cylinder fitted with a piston which can move smoothly. The gas has a volume of 300 cm^3 at an atmospheric pressure of 100 kPa and a temperature of 300 K. The piston is at a height of 20 cm from the bottom of the cylinder. Given that the molar mass of the ideal gas is 4 g mol^{-1}.

(a) (i) Find the number of moles of the ideal gas in the cylinder. (2 marks)

(ii) Calculate the r.m.s. speed of the gas molecules. (2 marks)

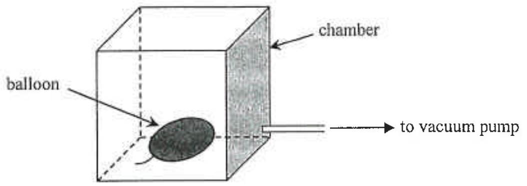
(b) The ideal gas in the cylinder is now heated to a temperature of 90°C while keeping the pressure at 100 kPa.

(i) Find the equilibrium position of the piston, i.e. its height from the bottom of the cylinder. (2 marks)

(ii) If the piston is pushed slowly back to the original position by keeping constant temperature, calculate the new pressure of the gas. (2 marks)

Part C : HKDSE examination questions

10. **< HKDSE Sample Paper IB - 1 >**

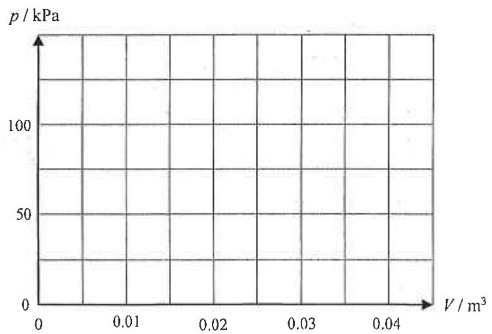


A balloon containing 0.01 m^3 of gas at a pressure of 100 kPa is placed inside a chamber. Air is slowly pumped out from the chamber while the temperature remains unchanged.

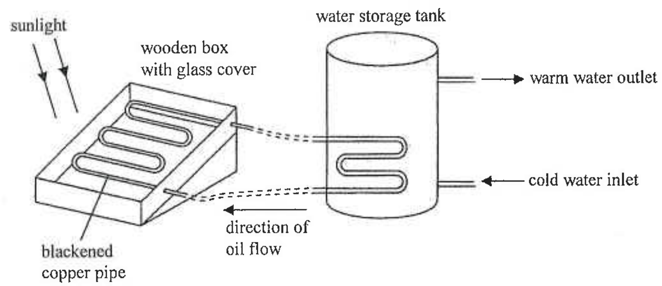
(a) Explain, in terms of molecular motion, how the gas inside the balloon exerts a pressure on its inner surface. (2 marks)

(b) Find the final pressure inside the balloon when its volume is doubled. (2 marks)

(c) Sketch a graph to show the relationship between the pressure p inside the balloon and the volume V of the balloon. (2 marks)



11. **< HKDSE Practice Paper IB - 1 >**



The Figure above shows a solar water heating system. The heater is made from a glass-covered wooden box and the copper pipe inside is painted black. The heater is put on an inclined plane. Oil circulates between the heater and the water storage tank via the copper pipe.

(a) (i) Explain why the copper pipe inside the box is painted black. (1 mark)

(ii) Explain why the wooden box is covered by a sheet of glass. (1 mark)

(iii) Explain why the oil circulates in the system in the direction as indicated in the above Figure. (2 marks)

(b) When the oil flows through the pipe in the heater at a rate of 0.3 kg per minute, the temperature of the oil rises from 25°C to 37°C. Determine the power absorbed by the oil.

Given : specific heat capacity of oil = 2500 J kg^{-1} $°C^{-1}$ (3 marks)

(c) If the wooden box is sealed and made air-tight, how would the air pressure inside change when temperature increases ? Explain briefly in terms of kinetic theory. No mathematical derivation is required. (3 marks)

12. < HKDSE 2012 Paper IB - 2 >

A gas bubble rises from the bottom of a lake to the water surface. Its radius increases from 0.8 cm to 1.0 cm.

(a) If the gas pressure in the bubble at the water surface is 1.01×10^5 Pa, find the gas pressure in the bubble when it is at the bottom of the lake. Assume that the temperature of the gas in the bubble remains constant. (2 marks)

(b) Use kinetic theory to explain the change in gas pressure in the bubble as its volume increases. (2 marks)

13. < HKDSE 2014 Paper IB - 2 >

The Figure below shows a basketball connected to an air pump via a short rubber tubing. By pushing the piston inward, the pump can compress 120 cm^3 of air inside its barrel at atmospheric pressure and room temperature into the basketball for each stroke.

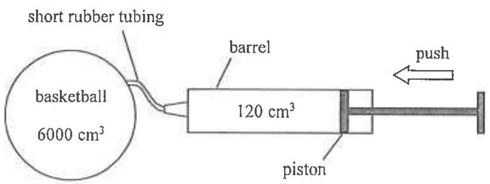


Diagram NOT drawn to scale

Initially the volume of air inside the basketball is 6000 cm^3 and is at equilibrium with the atmospheric pressure 100 kPa. The basketball has to be pumped to a pressure of 156 kPa for an official match. Throughout the pumping process, the temperature of the basketball and the surrounding is assumed to be maintained at room temperature which is constant.

(a) (i) Show that 3360 cm^3 of air, originally at atmospheric pressure, is required to be pumped into the basketball until its pressure is suitable for an official match. Assume that the volume of the basketball remains unchanged at 6000 cm^3. (3 marks)

(ii) Hence estimate the minimum number of strokes needed to pump the basketball to the required pressure. (1 mark)

(b) Use kinetic theory of an ideal gas to explain the increase of pressure inside the basketball when air is pumped into it. (2 marks)

14. < HKDSE 2017 Paper IB - 3 >

The average kinetic energy of one monatomic gas molecule at temperature T is given by

$$E_K = \frac{3}{2}\left(\frac{R}{N_A}\right)T$$

where R is the universal gas constant and N_A is the Avogadro constant.

A monatomic gas is heated from 300 K to 350 K under fixed volume.

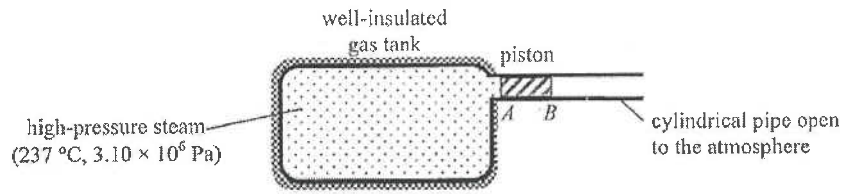
(a) Estimate the ratio of the root-mean-square speed ($c_{r.m.s.}$) of the gas molecules at the two temperatures $\left(\frac{c_{r.m.s.} \text{ at } 350\text{ K}}{c_{r.m.s.} \text{ at } 300\text{ K}}\right)$. (2 marks)

(b) Thus, using kinetic theory, explain why the gas pressure would increase. (2 marks)

15. < HKDSE 2020 Paper 1B -2>

Figure 2.1 shows a large gas tank connected with a cylindrical pipe open to the atmosphere. The pipe is fitted with a smooth piston AB. This well-insulated gas tank is filled with high-pressure steam at a temperature of 237 °C under a pressure of 3.10×10^6 Pa while the movable piston is held stationary by a force F_p.
Given: atmospheric pressure = 1.0×10^5 Pa

Figure 2.1



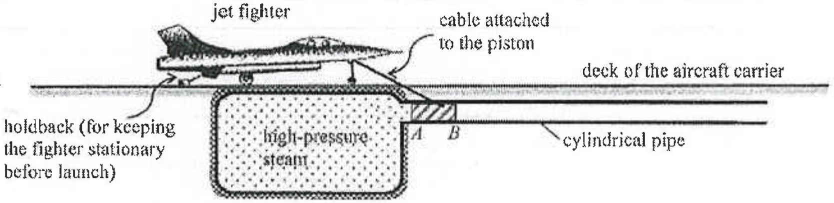
(a) (i) On Figure 2.1 indicate the force F_p. (1 mark)

*(ii) By considering the force acting on the piston due to the difference in pressure, find the value of F_p. The piston has a cross-sectional area of 0.67 m^2. (2 marks)

*(iii) Estimate the volume of the gas tank which contains 570 kg steam. You may treat the steam as an ideal gas. Given: mass of one mole of steam = 0.018 kg. (3 marks)

(b) This set-up can be used as a 'steam catapult' to launch jet fighters from an aircraft carrier. A jet fighter in position to be launched is connected to the piston via an inextensible cable as shown in Figure 2.2. When the holdback behind the jet fighter is released, the high-pressure steam in the gas tank expands and pushes the piston which in turn helps to accelerate the jet fighter.

gure 2.2



In a trial run of the catapult, a jet fighter (with its engine shut down) acquires a final speed of 54 m s^{-1} in 1.5 s after running a distance horizontally on the deck. The mass of the jet fighter is 2.6×10^4 kg.

(i) Find the work done by the net force on the jet fighter during launch. (2 marks)

(ii) Calculate the average acceleration of the jet fighter during launch.

*(iii) State whether the acceleration of the jet fighter is increasing, decreasing or uniform during launch. Explain your answer. (3 marks)

Question Solution

1. (a) (i) h increases [1]

(ii) h decreases [1]

(iii) h decreases [1]

(b) When temperature increases, the gas molecules have greater K.E. and move faster. [1]
They bombard the container wall more violently [1]
and more frequently. This causes an increase in pressure. [1]

2. (a) (i) Pressure [1]

(ii) Temperature [1]

(b) (i) Add weight on the disc to decrease the volume [2]

(ii) No change in the average speed of ball bearings. [2]
Frequency of bombardment on the walls increases [2]

(c) In real situation, elastic collision between gas molecules and the wall occurs [1]
and thus no energy is lost due to collision. [1]
In this model, the collision is not elastic and kinetic energy is lost during collisions. [1]

(d) The polystyrene ball moves with a zig-zag path (or Brownian motion) [1]
since the polystyrene ball is being hit by the ball bearings [1]
with a random resultant force. [1]

3. When the temperature of a fixed volume of gas is increased, the molecules move faster. [1]
Thus they hit the container wall more frequently [1]
and more vigorously. [1]
This increases the pressure.

4. (i) Molecules are arranged in regular structure **OR** Molecules are closely packed [1]
Molecules can only vibrate about their mean position. [1]

(ii) Molecules are not arranged in regular structure **OR** Molecules are loosely packed [1]
Molecules can move freely. [1]

5. If the volume of the gas is decreased at constant temperature,
distance travelled by the gas molecules between two walls decreases. [1]
Thus the molecules hit the container wall more frequently. [2]
So the pressure of the gas increases.

6. As temperature increases, the speed of the gas molecules increases. [1]
The gas molecules hit the wall of the container more violently and more frequently. [2]
So pressure increases.

7. As temperature increases, the speed of the gas molecules increases. [1]
The gas molecules hit the wall of the container more violently [1]
and more frequently. So pressure increases. [1]

8. (a) $P V = n R T$

$\therefore\ (12 \times 10^5)(100 \times 10^{-6}) = n(8.31)(0 + 273)$ [1]

$\therefore\ n = 0.0529$ mol < accept answer without unit > [1]

(b) $P V = \frac{1}{3} N m c^2 = \frac{1}{3}(n N_A) m c^2$

$\therefore\ (12 \times 10^5)(100 \times 10^{-6}) = \frac{1}{3}(0.0529 \times 6.02 \times 10^{23})(4.52 \times 10^{-26}) c^2$ [1]

$\therefore\ c = 500$ m s^{-1} [1]

OR

By $c = \sqrt{\dfrac{3RT}{M_m}} = \sqrt{\dfrac{3(8.31)(0+273)}{(4.52\times10^{-26})(6.02\times10^{23})}}$ [1]

$\therefore\ c = 500$ m s^{-1} [1]

(c) (i) As r.m.s. speed depends on temperature, and the temperature of gas in vessel Y is also at 0°C.
$\therefore\ c = 500$ m s^{-1} [1]

(ii) Boyle's Law :
$P_1 V_1 = P_2 V_2$
$\therefore\ (12 \times 10^5)(100) = P(100 + 500)$ [1]
$\therefore\ P = 2 \times 10^5$ Pa [1]

(iii) $P V = n R T$
$\therefore\ (2 \times 10^5)(500 \times 10^{-6}) = n(8.31)(0 + 273)$ [1]
$\therefore\ n = 0.0441$ mol [1]

9. (a) (i) $PV = nRT$

$\therefore$ $(100 \times 10^3)(300 \times 10^{-6}) = n(8.31)(300)$ [1]

$\therefore$ $n = 0.012$ mol [1]

(ii) $PV = \frac{1}{3}Nmc^2 = \frac{1}{3}Mc^2 = \frac{1}{3}nM_m c^2$

$\therefore$ $(100 \times 10^3)(300 \times 10^{-6}) = \frac{1}{3}(0.012 \times 4 \times 10^{-3})c^2$ [1]

$\therefore$ $c = 1370$ m s^{-1} [1]

(b) (i) $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ [1]

$\therefore$ $\frac{(20)}{(300)} = \frac{h}{(90+273)}$ $\therefore$ $h = 24.2$ cm [1]

(ii) Since the process is slow, the temperature is constant.

$P_1V_1 = P_2V_2$ [1]

$\therefore$ $(100)(24.2) = P_2(20)$ $\therefore$ $P_2 = 121$ kPa [1]

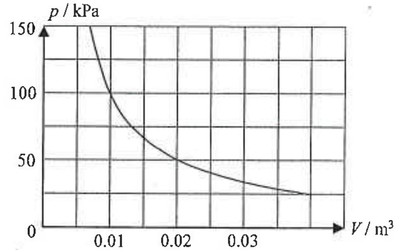
10. (a) The gas molecules collide with the surface of the balloon and rebound, [1]

it results in momentum change and thus gives pressure to the surface of the balloon. [1]

(b) $p_1V_1 = p_2V_2$ [1]

$(100)(0.01) = p_2(0.02)$ $\therefore$ $p_2 = 50$ kPa [1]

(c)



< a curve > [1]

< the curve passing the 0.01 and 0.02 points > [1]

11. (a) (i) A black surface is a good absorber of radiation. [1]

(ii) A cover can reduce heat loss due to convection of air. [1]

OR

A cover can trap heat by greenhouse effect. [1]

(iii) The oil in the copper pipe inside the box is heated, becomes less dense and rises. [1]

The cooler and denser oil from the pipe in the storage tank will move downwards to replace the heated oil. [1]

11. (b) $Pt = mc\Delta T$ [1]

$P(60) = (0.3)(2500)(37-25)$ [1]

$P = 150$ W [1]

(c) The pressure increases when temperature increases. [1]

As temperature increases, the average speed of the gas molecules increases. [1]

The air molecules will then hit the wall of the box more violently and more frequently. [1]

12. (a) $P_1V_1 = P_2V_2$ [1]

$P_1[\frac{4}{3}\pi \times (0.8)^3] = (1.01 \times 10^5)[\frac{4}{3}\pi \times (1.0)^3]$

$P_1 = 1.97 \times 10^5$ Pa [1]

(b) Volume increases as the bubble rises but the average speed of the gas molecules remains unchanged, [1]

therefore the frequency of collision on the bubble's inner surface decreases, thus the gas pressure decreases. [1]

13. (a) (i) By Boyle's Law,

$P_1V_1 = P_2V_2$ [1]

$(100)(6000 + V_o) = (156)(6000)$ [1]

$\therefore$ $V_o = 3360$ cm^3 [1]

(ii) $N = \frac{3360}{120} = 28$ [1]

(b) As volume and temperature of the gas remain unchanged, [1]

the increase of pressure is due to the increase of number of air molecules hitting the wall per unit time. [1]

OR

As the number of air molecules increases, [1]

the frequency of collision of molecules with the walls increases, thus pressure increases. [1]

14. (a) $E_K = \frac{3}{2}\left(\frac{R}{N_A}\right)T = \frac{1}{2}mc^2$ $\therefore$ $c \propto \sqrt{T}$ [1]

$\therefore$ $\left(\frac{c_{r.m.s.} \text{ at } 350\text{ K}}{c_{r.m.s.} \text{ at } 300\text{ K}}\right) = \sqrt{\frac{350}{300}} = 1.08$ [1]

(b) As the temperature increases, the speed of the gas molecules increases. [1]

Gas molecules hit the walls of the container more violently and more frequently. [1]

Thus, the pressure increases.