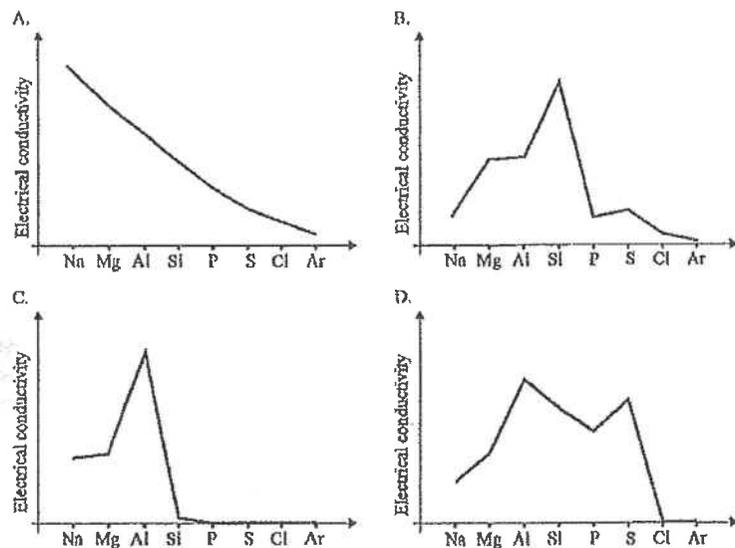


DSE14_30

Which of the following graphs (not drawn to scale) correctly shows the variation in electrical conductivity of the elements in the third period of the Periodic Table at room temperature?



DSE16_36

1st statement

$P_4O_{10}(s)$ can react with $NaOH(aq)$.

2nd statement

$P_4O_{10}(s)$ is an acidic oxide.

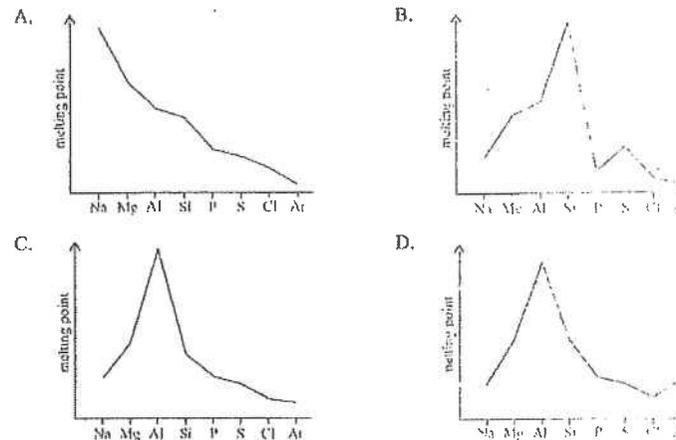
DSE17_22

Which of the following statements concerning burning coal under room conditions are correct?

- (1) Burning coal forms both acidic and non-acidic substances.
 - (2) Burning coal forms both gaseous and non-gaseous substances.
 - (3) Burning coal forms both poisonous and non-poisonous substances.
- A. (1) and (2) only B. (1) and (3) only
 C. (2) and (3) only D. (1), (2) and (3)

DSE17_25

Which of the following graphs (not drawn to scale) shows the variation in melting points of the elements in the third period of the Periodic Table?



DSE17_30

Which of the following statements concerning silicon dioxide solid is correct?

- A. There are single covalent bonds between silicon atoms and oxygen atoms.
- B. It is insoluble in sodium hydroxide solution.
- C. It has a simple molecular structure.
- D. It conducts electricity at room temperature.

DSE18_28

Which of the following statements is correct?

- A. The boiling point of argon is lower than that of neon.
- B. The boiling point of nitrogen is lower than that of oxygen.
- C. The melting point of silicon is lower than that of sodium.
- D. The melting point of aluminium is lower than that of magnesium.

DSE18_32

Which of the following processes can illustrate the characteristics of transition metals?

- (1) Mixing $AgNO_3(aq)$ and $NaCl(aq)$
 - (2) Mixing $FeSO_4(aq)$ and $Br_2(l)$
 - (3) Mixing $CuSO_4(s)$ and $H_2O(l)$
- A. (1) only B. (2) only
 C. (1) and (3) only D. (2) and (3) only

DSE19_33

Which of the following does NOT exhibit a characteristic of iron as a transition metal?

- A. Iron corrodes readily.
- B. Iron can be used as a catalyst.
- C. Iron can form two chlorides.
- D. Iron(II) sulphate solution is green.

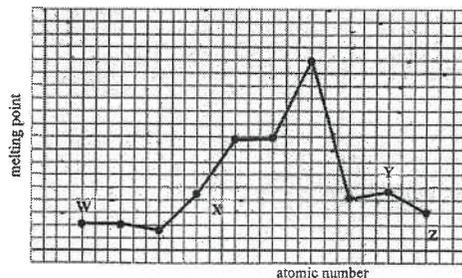
DSE20_28

28. Which of the following statements concerning the oxides of elements in the third period of the Periodic Table is correct?

- A. $\text{SiO}_2(\text{s})$ dissolves in water to form a neutral solution.
- B. $\text{P}_4\text{O}_{10}(\text{s})$ dissolves in water to form an acidic solution.
- C. $\text{Al}_2\text{O}_3(\text{s})$ dissolves in water to form an alkaline solution.
- D. $\text{Cl}_2\text{O}(\text{g})$ dissolves in water to form $\text{Cl}_2(\text{aq})$ and $\text{O}_2(\text{g})$ only.

DSE20_30

30. The sketch below shows the melting points of ten consecutive elements in the second and third periods of the Periodic Table, arranged in the order of increasing atomic numbers. Sodium is one of these ten elements. Which of W, X, Y or Z may represent sodium?



- A. W
- B. X
- C. Y
- D. Z

DSE21_28

28. Which of the following statements correctly describes the property of an amphoteric oxide?

- A. It can react as an acid or as a base.
- B. It can react with water to form an acid and an alkali.
- C. It can be simultaneously oxidised and reduced in a reaction.
- D. It can react with water to form an oxidising agent and a reducing agent.

DSE21_33

33. Which of the following statements concerning the elements in the third period of the Periodic Table going from Na to Cl is / are correct?

- (1) The bond type of the elements changes from metallic bonding to covalent bonding.
- (2) The oxide of the elements changes from acidic to basic.
- (3) The electrical conductivity of the elements keeps decreasing.

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

Structural Questions

AL96 (I)_04a

BaO is a basic oxide, while CO_2 is an acidic oxide.

- (i) State all observations when dilute $\text{HCl}(\text{aq})$ is added to $\text{BaO}(\text{s})$. (1.5 marks)
- (ii) State all observations when CO_2 is bubbled, until in excess, into the following solutions.
 - (1) dilute $\text{HCl}(\text{aq})$
 - (2) $\text{Ca}(\text{OH})_2(\text{aq})$(2.5 marks)

AL96 (II)_06c (modified) [Similar to DSE14_11]

State THREE characteristic properties of transition elements, apart from complex ion formation. In each case, illustrate your answer with an example involving copper or vanadium.

(3 marks)

AL98 (I)_03b

Sketch the trends for the properties mentioned in (i) and (ii) below, and account for the trend in each case.

- (i) Melting point of the alkali metals, Li, Na and K (2 marks)
- (ii) Boiling point of the Period 3 elements, Na, Mg and Al (2 marks)

AL99 (I)_03 [Similar to DSE17_14]

When $\text{KMnO}_4(\text{aq})$ is added dropwise to acidified $\text{Na}_2\text{C}_2\text{O}_4(\text{aq})$, decolorization is slow at the beginning and then becomes faster.

- (a) Write the balanced equation for the reaction involved. (1 mark)
- (b) Explain why the rate of decolorization increases. (2 marks)

AL99 (I)_03

Describe how to detect the presence of water of crystallization in an inorganic salt.

(1 mark)

AL02 (I)_03

Account for the following observation:

When hydrated copper(II) hydroxide solid is shaken with deionized water, the liquid portion of the mixture is very pale blue. On the addition of an aqueous solution of ammonium chloride, the liquid portion shows no significant change in color. However, if instead, aqueous ammonia is added, an intense blue color is observed.

(3 marks)

AL02(I)_03

CO₂ and SiO₂ are oxides of Group IV elements. Account for the fact that CO₂ is a gas while SiO₂ is a high melting solid under room temperature and atmospheric pressure.

(2 marks)

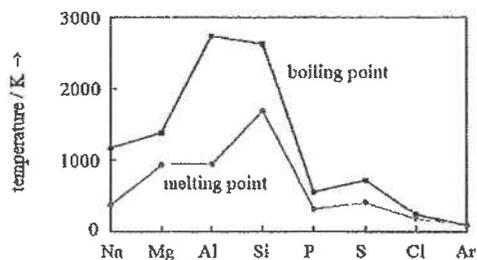
ASL02(I)_04

Sketch the variations of their boiling points and account for the variations.
Na, Mg and Al

(3 marks)

AL02(II)_02 [Similar to DSE19_14]

The graph below shows the variations of melting points and boiling points of the Period 3 elements.



Explain why

(a) silicon, a metalloid, has a very high melting point;

(2 marks)

(b) the boiling points of the metals are in the order:
Al > Mg > Na

(3 marks)

(c) there is generally a larger difference between the melting point and the boiling point for metals than for non-metals;

(2 marks)

(d) the melting point of sulphur is the highest among the non-metals.

(2 marks)

AL05(I)_01 [Similar to DSE16_14]

(a) Sketch the variation in electrical conductivity of the Period 3 elements from sodium to argon at room temperature and atmospheric pressure.

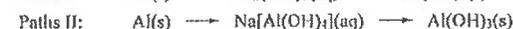
(2 marks)

(b) Explain the variation in (a).

(3 marks)

AL05(II)_04

Aluminium hydroxide is an active ingredient of antacid. Two paths for the production of aluminium hydroxide using Al(s), H₂SO₄(aq) and NaOH(aq) as reactants are outlined below:



(a) Use chemical equations to describe the reactions in Path I and in Path II.

(4 marks)

(b) Work out the number of moles of H₂SO₄ and NaOH required for producing 2 mol of Al(OH)₃ via Path I and via Path II.

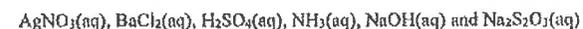
(1 mark)

(c) Suggest, with explanation, whether Path I or Path II is recommended for the production of aluminium hydroxide.

(2 marks)

AL05(II)_01

Each of six reagent bottles labeled A, B, C, D, E and F contained one of the following solutions:



In an attempt to identify the contents of the bottles, a series of tests were conducted by mixing two of the solutions. The table below lists the observations in these tests.

Solutions being mixed	Observations
A and C	A brown precipitate is formed
A and E	A white precipitate is formed
A and F	A brown precipitate is initially formed, and the precipitate dissolves when F is in excess.
B and C	Only heat is liberated
B and D	A pale yellow precipitate is formed slowly
B and E	A white precipitate is formed

Identify, with explanation, the contents of the six reagent bottles based on the above information.

(6 marks)

AL06(I)_03 (modified)

The table below lists the melting points of three oxides of the Period 3 elements:

Oxide	Na ₂ O	Al ₂ O ₃	SO ₂
Melting point / °C	920	2040	-75

Account for the large difference in the melting points of the three oxides.

(3 marks)

AL06(I)_03

Write chemical equations for the following reactions:

- (a) The reaction of S(s) with concentrated HNO_3 to give $\text{SO}_4^{2-}(\text{aq})$ and $\text{NO}_2(\text{g})$. (1 mark)
- (b) The reaction of $\text{Mn}^{2+}(\text{aq})$ with $\text{O}_2(\text{g})$ under alkaline conditions to give $\text{Mn}(\text{OH})_2(\text{s})$. (1 mark)
- (c) The disproportionation of $\text{MnO}_4^{2-}(\text{aq})$ in water to give $\text{MnO}_4^{-}(\text{aq})$ and $\text{MnO}_2(\text{s})$. (1 mark)

ASL06(II)_11 [Similar to DSE13_13]

The symbols p, q, r, s, t, u, v and w represent eight consecutive elements in the second and third periods of the Periodic Table. The table below lists their boiling points:

Element	p	q	r	s	t	u	v	w
Boiling point / K	4203	5103	77	90	85	27	1163	1383

- (a) Deduce from the above information which elements q and r represent respectively. (4 marks)
- (b) Explain why the boiling point of t is higher than that of u. (2 marks)
- (c) Explain why the boiling point of v is lower than that of w. (2 marks)

AL07(I)_03

A mixture of $\text{Fe}^{3+}(\text{aq})$ and $\text{Cu}^{2+}(\text{aq})$ is separated by paper chromatography using a mixture of propanone and 6 M $\text{HCl}(\text{aq})$ as the mobile phase. Suggest how you would identify chemically the $\text{Fe}^{3+}(\text{aq})$ and $\text{Cu}^{2+}(\text{aq})$ on the chromatographic paper.

(3 marks)

ASL07(II)_02 [Similar to DSE15_10]

Account for the difference in hydrolytic behavior of the following oxides of the Period 3 elements:
 Na_2O , SiO_2 and SO_2

(3 marks)

ASL07(II)_03

Aluminium is commonly extracted from bauxite, which contains mainly hydrated aluminium oxide with compounds of iron and silicon as impurities. The extraction consists of two stages: (1) removal of impurities from bauxite to give aluminium oxide, and (2) electrolysis of molten aluminium oxide.

- (a) In Stage (1), bauxite is treated firstly with sodium hydroxide solution and subsequently with carbon dioxide to convert it to aluminium hydroxide. The aluminium hydroxide is then strongly heated to give aluminium oxide.

Outline the chemistry involved in obtaining aluminium oxide in Stage (1) and write chemical equations for the reactions involving the aluminium-containing species.

(5 marks)

- (b) In Stage (2), an electrolytic bath consisting of a molten mixture of aluminium oxide and cryolite, Na_3AlF_6 , is used.

Suggest why cryolite is used in the electrolysis.

(2 marks)

- (c) Knowing that aluminium is highly abundant in the earth's crust, a student remarked, 'Recycling of used aluminium objects is economically unsound.'

Do you agree with the student? Explain.

(1 mark)

AL08(II)_02

The following four substances all exist in the form of white powder:

Baking soda (NaHCO_3), cornstarch, finely ground sugar, and plaster of Paris ($\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$)

Suggest how you would do experiments at home to distinguish the four substances from one another.

(You are *not* allowed to taste the substances.)

(4 marks)

ASL09(I)_09 [Similar to DSE16_14, DSE19_14]

Write an essay to discuss the variation in physical properties of elements in period 3 of the Periodic Table.

(6 marks)

AL10 (I)_03 [Similar to DSE12PP_13]

State the expected observation in each of the following experiments, and account for the observation with the aid of chemical equation(s).

Adding $\text{NH}_3(\text{aq})$ dropwise to $\text{CuSO}_4(\text{aq})$ until in excess.

(3 marks)

ASL10 (II)_05 [Similar to DSE18_14]

Account for the following:

(a) The boiling point of neon is lower than that of argon.

(2 marks)

(b) $\text{Al}_2\text{O}_3(\text{s})$ is soluble in both aqueous acids and aqueous alkalis.

(2 marks)

ASL11(I)_04

Although both K and Br are Period 4 elements, KOH and HOBr exhibit different acid-base behavior.

(2 marks)

AL11(I)_07

For each of the following pairs of species, suggest a chemical test to distinguish between them and write the chemical equation(s) of the reaction(s) involved.

(a) $\text{Ba}^{2+}(\text{aq})$ and $\text{Pb}^{2+}(\text{aq})$

(2 marks)

(b) $\text{Cl}^-(\text{aq})$ and $\text{Br}^-(\text{aq})$

(2 marks)

AL11 (II)_06

State the expected observation(s) in each of the following experiment, and write the chemical equation(s) of the reaction(s) involved.

$\text{NaOH}(\text{aq})$ is added dropwise to $\text{Al}(\text{NO}_3)_3(\text{aq})$ until in excess.

(3 marks)

AL12(I)_01 [Similar to DSE15_10, DSE17_14]

Apart from complex formation, state TWO properties of iron that characterize it as a transition metal.

(2 marks)

ASL12(I)_11 [Similar to DSE16_14]

Write an essay on the classification of elements according to bonding and structure, and comment on the electrical conductivity property of each class.

(10 marks)

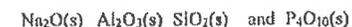
ASL12(II)_05 [Similar to DSE19_14]

Sketch the variation of the melting point of the following elements: Na, Mg, Si, S and Cl. Account for the variation.

(5 marks)

ASL13(II)_02 [Similar to DSE12PP_09, DSE18_14]

For the following oxides, comment on their behavior with water. Explain your answer.



(4 marks)

AL13(II)_02

Suggest why transition metal compounds are usually colored.

(2 marks)

DSE11SP_14

Compare the acid base properties of sodium oxide (Na_2O) and sulphur dioxide (SO_2) with reference to how they interact with water molecules.

(4 marks)

DSE12PP_09 [Similar to ASL13(II)_02]

(a) Using the following notations to complete the table below so as to provide information about the structure and acid-base property of the oxides of Period 3 elements.

IC: ionic crystal CN: covalent network SM: simple molecular structure
AC: acidic BA: basic AM: amphoteric

	MgO	Al_2O_3	SiO_2	P_4O_{10}	SO_2
Structure					
Acid-base property					

(2 marks)

(b) By considering the trend of acid-base property and that of bonding of these oxides, state the relationship between the two trends.

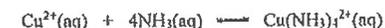
(1 mark)

(c) Outline chemical tests to show how these oxides can be classified into acidic, basic and amphoteric.

(4 marks + 1 mark)

DSE12PP_13 [Similar to AL10(I)_03]

In an experiment, excess aqueous ammonia is added to an aqueous solution of copper(II) sulphate. The following equilibrium is established and the resulting solution is deep blue in color.



(c) When $\text{H}_2\text{SO}_4(\text{aq})$ is added slowly to the equilibrium mixture until in excess, a blue precipitate is formed and the precipitate subsequently dissolves in the excess acid forming a blue solution. Account for these observations with the help of relevant chemical equation(s).

(5 marks)

DSE12_16

Consider the following oxides:

Na₂O MgO Al₂O₃ SiO₂ P₄O₁₀ SO₂ Cl₂O

- (a) Which of the oxides listed above can conduct electricity in molten state? (1 mark)
- (b) Explain why SiO₂ has the highest melting point among the covalent oxides listed above. (2 marks)
- (c) Write a chemical equations for the reaction between Al₂O₃(s) and NaOH(aq). (1 mark)

DSE13_13 [Similar to ASL06(II)_11]

Lithium, beryllium, carbon (graphite) and nitrogen are elements of the second period of the Periodic Table. Arrange them in increasing order of melting point, and explain the order in terms of structure and bonding.

(4 marks + 1 mark)

DSE14_11 [Similar to AL09(II)06c]

Vanadium is a transition metal, its chemical symbol is V. The formulae and the colors of three aqueous vanadium-containing ions are shown below:

Formula	VO ²⁺ (aq)	V ³⁺ (aq)	V ²⁺ (aq)
Color	Blue	Green	violet

- (a) Based on the given information, suggest TWO properties of vanadium to characterize it as a transition metal. (1 mark)

DSE15_10 [Similar to ASL07(II)_02, AL12(I)_01]

- (a) For each of the oxides below, draw its electron diagram (showing electrons in the outermost shells only), and state its behavior in water.

(i) Na₂O

(2 marks)

(ii) Cl₂O

(2 marks)

- (b) Using iron as an example, illustrate TWO characteristics of transition metals.

(2 marks)

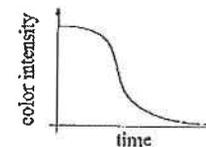
DSE16_14 [Similar to AL05(I)_01, ASL09(I)_09, ASL12(I)_11]

Arrange sodium, aluminium, silicon and sulphur in decreasing order of electrical conductivity at room conditions, and explain your answer in terms of bonding and structure.

(4 marks + 1 mark)

DSE17_14 [Similar to AL99(I)_03, AL12(I)_01]

At 60°C, MnO₄⁻(aq) reacts with C₂O₄²⁻(aq) in an acidic medium to give Mn²⁺(aq), CO₂(g) and H₂O(l). The graph below shows the variation of the color intensity of the reaction mixture with time.



Based on the information above, write the chemical equation for the reaction and illustrate THREE characteristics of transition metals exhibited by manganese.

(5 marks + 1 mark)

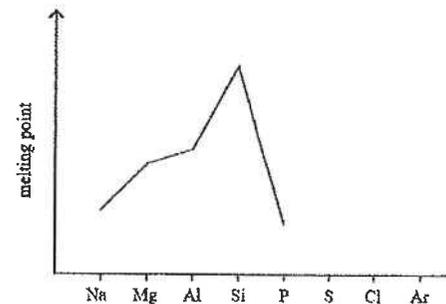
DSE18_14 [Similar to ASL10 (II)_05, ASL13(II)_02]

Using Na₂O, Al₂O₃ and SO₂ as examples, illustrate the acid-base behavior of the oxides of the third period elements with the aid of relevant reactions.

(5 marks + 1 mark)

DSE19_14 [Similar to AL02(II)_02, ASL09(I)_09, ASL12(II)_05]

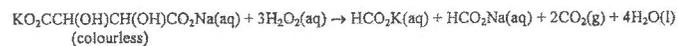
The following graph shows an incomplete sketch of the variation in melting points of the elements in the third period of the Periodic Table.



- (a) Complete the sketch on the graph above. (1 mark)
- (b) Explain why the melting point of Mg is higher than that of Na. (1 mark)
- (c) Explain why the melting point of Si is higher than that of P. (2 marks)

DSE20_12

12. An experiment was performed to study the following reaction :



When 10 cm³ of 0.25 M K₂C₂O₄·C₂H₂(OH)₂ and 3 cm³ of 6% H₂O₂(aq) were mixed at 60°C, it was found that only a few gas bubbles evolved. Then a small amount of pink CoCl₂(aq) solution was added to the mixture. Gas bubbles formed vigorously and the mixture turned to green due to the formation of a cobalt(III) compound. When no more gas evolved, the green mixture turned back to pink.

There is a view saying that cobalt illustrates THREE characteristics of transition metals according to the observation of this experiment. Suggest reasons to support this view.

Marking Scheme

MCQ

CE08_22	A (33%)	CE10_31	A (60%)	DSE12PP_30	A	DSE12PP_35	B
DSE12_31	A (81%)	DSE13_26	C (72%)	DSE13_36	C (62%)	DSE14_36	C (66%)
DSE15_25	B (49%)	DSE15_35	B (69%)	DSE16_30	D (68%)	DSE14_30	C (77%)
DSE16_36	A (65%)	DSE17_22	D (50%)	DSE17_25	B (75%)	DSE17_30	A (37%)
DSE18_28	B (69%)	DSE18_32	D (45%)	DSE19_33	A		
DSE20_28	B	DSE20_30	B				

DSE21_12

12. (a) Silicon dioxide is an acidic oxide. However, the pH of a mixture of silicon dioxide and distilled water is 7.
- Suggest why silicon dioxide is classified as an acidic oxide.
 - Explain why the pH of the mixture is 7.
- (b) Phosphorus(V) oxide is an acidic oxide. With the aid of a chemical equation, explain why the pH of a mixture of phosphorus(V) oxide and distilled water is smaller than 7.
- (c) Refer to the following reaction :



State how this reaction can demonstrate that copper exhibits TWO characteristics of transition metals.

Structural Questions

AL96 (I)_04a

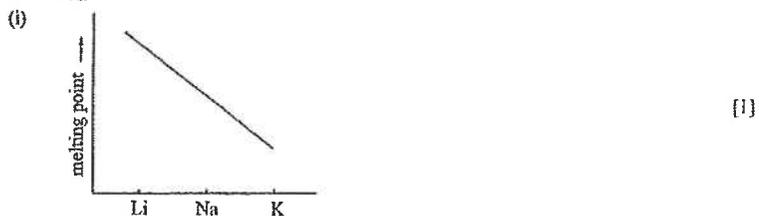
- (i) **BaO dissolves forming colorless solution.** [1]
Heat evolves [½]
- (ii) (1) No change / solution remains colorless. [1]
 (2) White precipitate / solution turns milky. [½]
 Precipitate redissolves / solution turns clear again. [1]

AL96 (II)_06c (modified)

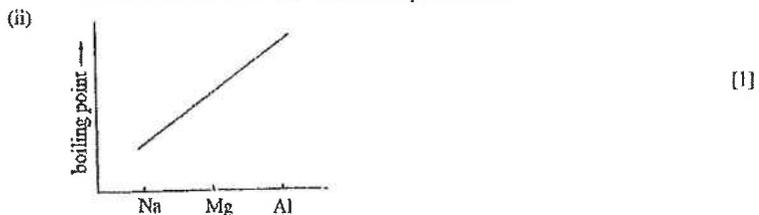
Any THREE of the following:

- Exhibition of variable oxidation states, e.g. Cu^+ & Cu^{2+} / V^{2+} , V^{3+} , VO^{2+} , VO_2^+
- Formation of colored compounds, e.g. $\text{Cu}^{2+}(\text{aq})$ is blue, $\text{VO}_2^+(\text{aq})$ is yellow
- Exhibition of catalytic properties, e.g. V_2O_5 in contact process, CuO in syngas formation.
- Exhibition of paramagnetic properties, e.g. Cu^{2+} / V^{2+} are paramagnetic

AL98 (I)_03b



Atomic size: $\text{Li} < \text{Na} < \text{K}$ [½]
 \therefore Attraction of nucleus on the delocalized electron / strength of metallic bond decreases in the order: $\text{Li} > \text{Na} > \text{K}$, hence m.p. decreases. [½]



The atomic radius decreases and the no. of electron involved in metallic bond increases in the order: $\text{Na}, \text{Mg}, \text{Al}$ [½]
 \therefore Attraction of nucleus on the delocalized electron in the same order. [½]

AL99 (I)_03

- (a) $2\text{MnO}_4^- + 5\text{C}_2\text{O}_4^{2-} + 16\text{H}^+ \longrightarrow 2\text{Mn}^{2+} + 10\text{CO}_2 + 8\text{H}_2\text{O}$ [1]
- (b) Mn^{2+} acts as a catalyst for the reaction [1]
 At the beginning, when $[\text{Mn}^{2+}]$ is low, rate of reaction is slow [½]
 When $[\text{Mn}^{2+}]$ builds up gradually, the reaction occurs much faster [½]

AL99 (I)_03

Heat the sample [½]
 Water vapor will turn anhydrous CoCl_2 from blue to pink / anhydrous CuSO_4 from white to blue. [½]
 (0 mark if heating is not mentioned.)

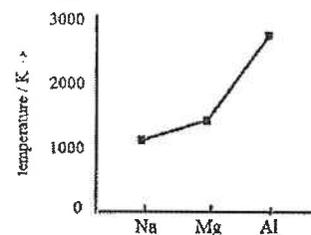
AL02 (I)_03

Hydrated $\text{Cu}(\text{OH})_2$ has a very low solubility in water / concentration of $\text{Cu}^{2+}(\text{aq})$ in the liquid portion is very low. \therefore It has a very pale blue color. [1]
 The extent of hydrolysis of $\text{NH}_4^+(\text{aq})$ is very small. $[\text{NH}_3(\text{aq})]$ in $\text{NH}_4\text{Cl}(\text{aq})$ is very low. Thus, the concentration of $[\text{Cu}(\text{NH}_3)_4]^{2+}(\text{aq})$ is low. [1]
 $\text{NH}_3(\text{aq})$ reacts with $\text{Cu}(\text{OH})_2(\text{s})$ to give a complex ion $[\text{Cu}(\text{NH}_3)_4]^{2+}(\text{aq})$ which has a deep blue color. [1]
 $\text{Cu}(\text{OH})_2(\text{s}) + 4\text{NH}_3(\text{aq}) \rightleftharpoons [\text{Cu}(\text{NH}_3)_4]^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq})$ [1]

AL02(I)_03

CO_2 exists as simple molecules and the intermolecular attraction is van der Waals' forces. [1]
 SiO_2 has a giant covalent network structure. [1]
 Attraction between CO_2 molecules is weak, but attraction between Si and O atoms in $\text{SiO}_2(\text{s})$ is strong. [1]

ASL02(I)_04

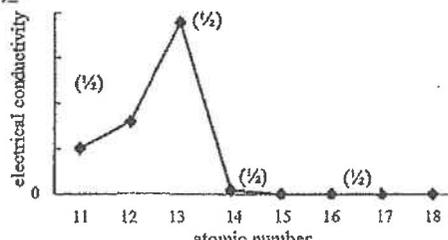


Strength of metallic bond increases with number of electrons taking part in metallic bond per atom and decreases with increasing in size of atom. [1]
 For Na, Mg and Al, [1]
 No. of valence electron: $\text{Al} > \text{Mg} > \text{Na}$ [½]
 Size of atom: $\text{Al} < \text{Mg} < \text{Na}$ [½]
 Hence, boiling point increases in the order $\text{Al} > \text{Mg} > \text{Na}$

AL02(II)_02

- (a) Silicon has a giant covalent network structure. [1]
Melting of Si involves breaking down of the network structure, a large number of covalent bonds. Hence, a large amount of energy is required. [1]
- (b) Strength of metallic bond increases with number of electrons taking part in metallic bond per atom and decreases with increasing in size of atom. [1]
For Na, Mg and Al, [1]
No of valence electron : Al > Mg > Na [1/2]
Size of atom: Al < Mg < Na [1/2]
Hence, boiling point increases in the order Al > Mg > Na
- (c) For metals, metallic bonding persists in the liquid state and this strong bonding has to be overcome during vaporization. [1]
Non-metals (P, S, Cl, Ar) exist as simple molecules. The molecules are held by weak van der Waals' forces. Only a small amount of energy is needed for the elements in liquid state to undergo vaporization. [1]
- (d) Sulphur exists as S₈, phosphorus as P₄, chlorine as Cl₂ and argon as Ar. [1]
Strength of van der Waals' forces depends on the number of electrons per molecule / relative molecular mass / polarizability of molecules. [1]
S₈ has the larger molecular size. Hence, melting point of sulphur is the highest.

AL05(I)_01

- (a)  [2]
- (b) Explanation: [1]
Na, Mg and Al are good electrical conductors. [1]
For Na, Mg and Al, the number of valence electrons available for delocalization increases with atomic number. ∴ electrical conductivity increases. [1]
Si is a semi-conductor. [1]
P, S, Cl and Ar exist in simple molecular structures. They do not possess delocalized electrons for electrical conductivity and are insulators. [1]

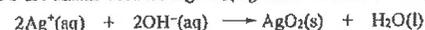
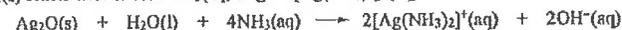
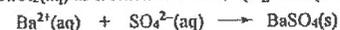
AL05(II)_04

- (a) Path I: $2\text{Al}(s) + 6\text{H}^+(\text{aq}) \longrightarrow 2\text{Al}^{3+}(\text{aq}) + 3\text{H}_2(\text{g})$ [1]
 $\text{Al}^{3+}(\text{aq}) + 3\text{OH}^-(\text{aq}) \longrightarrow \text{Al}(\text{OH})_3(\text{s})$ [1]
Path II: $2\text{Al}(s) + 2\text{OH}^-(\text{aq}) + 6\text{H}_2\text{O}(\text{l}) \longrightarrow 2\text{Al}(\text{OH})_4^-(\text{aq}) + 3\text{H}_2(\text{g})$ [1]
 $\text{Al}(\text{OH})_4^-(\text{aq}) + \text{H}^+(\text{aq}) \longrightarrow \text{Al}(\text{OH})_3(\text{s}) + \text{H}_2\text{O}(\text{l})$ [1]

- (b) Path I: Production of 2 mol of Al(OH)₃ requires 3 mol of H₂SO₄ and 6 mol of NaOH [1/2]
Path II: Production of 2 mol of Al(OH)₃ requires 1 mol of H₂SO₄ and 2 mol of NaOH [1/2]
- (c) Path II is better because less reactants are used [1]
and less heat is produced. [1]

AL05(II)_01

The six solutions are:

A: AgNO₃(aq) B: H₂SO₄(aq) C: NaOH(aq)D: Na₂S₂O₃(aq) E: BaCl₂(aq) F: NH₃(aq)A is AgNO₃(aq) [1]C is NaOH(aq) while F is NH₃(aq) [1]C and F are alkalis because AgNO₃(aq) reacts with alkalis to give brown Ag₂O(s) [1]Ag₂O(s) reacts with excess NH₃(aq) to give [Ag(NH₃)₂]⁺(aq)B is H₂SO₄(aq) as it undergoes neutralization with C. (heat is evolved)E is BaCl₂(aq) as it reacts with SO₄²⁻(aq) ions (in B) to give a white precipitate. [1]E also reacts with AgNO₃(aq) to give a white precipitate AgCl(s) [1]D is Na₂S₂O₃(aq) because it reacts with acid (B) to give a pale yellow precipitate. [1]

AL06(I)_03 (modified)

Na₂O(s) and Al₂O₃(s) are ionic compounds. SO₂(g) is a covalent compound and it exists as simple molecules. [1]The attraction between SO₂ molecules is weak van der Waals' forces. ∴ SO₂(g) has a very low melting point. [1]The charge : radius ratio of Al³⁺ is greater than that of Na⁺. Al₂O₃(s) has a stronger ionic bond than that in Na₂O(s). ∴ m.p. of Al₂O₃(s) > m.p. of Na₂O(s) [1]

AL06(I)_03

- (a) $\text{S}(\text{s}) + 6\text{HNO}_3(\text{aq}) \longrightarrow \text{H}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(\text{l}) + 6\text{NO}_2(\text{g})$ [1]
- (b) $4\text{Mn}^{2+}(\text{aq}) + \text{O}_2(\text{g}) + 8\text{OH}^-(\text{aq}) + 2\text{H}_2\text{O}(\text{l}) \longrightarrow 4\text{Mn}(\text{OH})_2(\text{s})$ [1]
- (c) $3\text{MnO}_4^{2-}(\text{aq}) + 2\text{H}_2\text{O}(\text{l}) \longrightarrow 2\text{MnO}_4^-(\text{aq}) + \text{MnO}_2(\text{s}) + 4\text{OH}^-(\text{aq})$ [1]

ASL06(II)_11

- (a) q has the highest b.p. and [1]
a sudden drop in b.p. occurs from q to r. [1]
q: carbon r: nitrogen [1]
- (b) Both t and u have simple molecular structure. [1]
t has more electrons while u has less electrons. [1]

- OR t exists in diatomic molecules while u in monoatomic molecules
t has stronger van der Waals' forces than that in u. [1]
- (c) Both v and w have metallic bonds. [1]
Number of electrons participated in metallic bond formation in v is less than that in w, [1]
Cationic size of v is larger than that of w, [1]
So metallic bond of v is weaker. [1]

AL07(I)_03

- Place the chromatographic paper in an atmosphere of ammonia. [1]
 $\text{Fe}^{3+}(\text{aq})$ reacts with $\text{OH}^{-}(\text{aq})$ to give brown $\text{Fe}(\text{OH})_3(\text{s})$. [1]
 $\text{Cu}^{2+}(\text{aq})$ reacts with $\text{NH}_3(\text{aq})$ to give deep blue complex $[\text{Cu}(\text{NH}_3)_4]^{2+}(\text{aq})$. [1]

ASL07(II)_02

- Na_2O is an ionic oxide. O^{2-} reacts with H_2O to give an alkaline solution. [1]
 $\text{O}^{2-} + \text{H}_2\text{O} \longrightarrow 2\text{OH}^{-}$
 SiO_2 has a giant covalent network structure. It has no reaction with water. [1]
In SO_2 , S carries a partial positive charge and it is susceptible to (nucleophilic) attack by H_2O . An acid solution is formed. [1]
 $\text{H}_2\text{O} + \text{SO}_2 \longrightarrow \text{H}_2\text{SO}_3$

ASL07(II)_03

- (a) Aluminium oxide is amphoteric. It reacts with $\text{NaOH}(\text{aq})$ to give $[\text{Al}(\text{OH})_4]^{-}(\text{aq})$. [1]
 $\text{Al}_2\text{O}_3(\text{s}) + 2\text{OH}^{-}(\text{aq}) + 3\text{H}_2\text{O}(\text{l}) \longrightarrow 2[\text{Al}(\text{OH})_4]^{-}(\text{aq})$ [1]
Compound of silicon will also react to give soluble silicates. [1]
Oxides of iron are not amphoteric. They can be removed by filtration. [1]
 CO_2 is weakly acidic. Addition of CO_2 can convert $[\text{Al}(\text{OH})_4]^{-}(\text{aq})$ to $\text{Al}_2\text{O}_3(\text{s})$ while the silicates remain unreacted. [1]
 $[\text{Al}(\text{OH})_4]^{-}(\text{aq}) + \text{H}^{+}(\text{aq}) \longrightarrow \text{Al}(\text{OH})_3(\text{s}) + \text{H}_2\text{O}(\text{l})$ [1]
The $\text{Al}(\text{OH})_3(\text{s})$ is removed by filtration and then heated to obtain $\text{Al}_2\text{O}_3(\text{s})$. [1]
 $2\text{Al}(\text{OH})_3(\text{s}) \longrightarrow \text{Al}_2\text{O}_3(\text{s}) + 3\text{H}_2\text{O}(\text{g})$ [1]
- (b) $\text{Al}_2\text{O}_3(\text{s})$ has a very high melting point. [1]
Additional of cryolite can lower the temperature of the electrolytic bath. [1]
- (c) No. [1]
Open-end question. Possible answers: [1]
The extraction of Al from its ore involves electrolysis and a huge amount of energy is required. [1]
Aluminium objects do not contain much impurities. Cost of removal of impurities is low. [1]

AL08(II)_02

- (This question has many possible answers. Marker should exercise their judgment when awarding marks. The principle for awarding marks is 1 point for giving a correct test for each of the compounds.) [1]
For example, [1]
Add water. Only baking soda and sugar are water soluble. [1]
To the water-soluble substance, add vinegar. Only baking soda give effervescence. [1]
Plaster of Paris gives a lot heat when added to water. [1]
For the water-insoluble substances, add tincture of iodine. Only starch will give a purple color. [1]

ASL09(II)_09

- Boiling point: increases from Na to Si and then decreases to Ar. [2]
For Na, Mg and Al, the interatomic attraction is metallic bond. Its strength increases with the number of valence electrons. \therefore b.p. $\text{Na} < \text{Mg} < \text{Al}$
Si has a giant covalent network structure. It has the highest boiling point.
For the simple molecules, the intermolecular attraction is van der Waals' forces. The strength of which depend on relative molecular mass. Phosphorus exists as P_4 , sulphur as S_8 , chlorine as Cl_2 and argon as Ar. \therefore b.p. $\text{Ar} < \text{Cl}_2 < \text{P}_4 < \text{S}_8$

Melting point: increases from Na to Si then decreases to Ar. [2]

Melting point depends on both the strength of interatomic / intermolecular forces and degree of compactness of particles in solid state.

- For Na, Mg and Al, the interatomic attraction is metallic bond. Its strength increases with the number of valence electrons. \therefore b.p. $\text{Na} < \text{Mg} < \text{Al}$
Si has a giant covalent network structure. It has the highest boiling point.
For the simple molecules, the intermolecular attraction is van der Waals' forces. The strength of which depend on relative molecular mass. Phosphorus exists as P_4 , sulphur as S_8 , chlorine as Cl_2 and argon as Ar. \therefore m.p. $\text{Ar} < \text{Cl}_2 < \text{P}_4 < \text{S}_8$

Electronegativity: increases from Na to Cl [2]

As the atomic decreases across the period, the effective nuclear charge experienced by the outermost electrons increases. Hence, electronegativity increases across the period.

AL10 (I)_03

- A pale blue precipitate is formed. The precipitate dissolves in excess $\text{NH}_3(\text{aq})$ to give a deep blue solution. [1]
 $\text{Cu}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) \longrightarrow \text{Cu}(\text{OH})_2(\text{s})$ [1]
 $\text{Cu}(\text{OH})_2(\text{s}) + 4\text{NH}_3(\text{l}) \rightleftharpoons [\text{Cu}(\text{NH}_3)_4]^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq})$ [1/2]

ASL10 (II)_05

- (a) Both neon and argon exist as monoatomic molecules. Their intermolecular attraction is van der Waals' forces. [1]
Ar has a greater number of electrons per molecule / has greater relative molecular (atomic) size / has greater polarizability. ∴ Ar has a higher boiling point. [1]
- (b) $\text{Al}_2\text{O}_3(\text{s})$ is amphoteric. [1]
 $\text{Al}_2\text{O}_3(\text{s}) + 6\text{H}^+(\text{aq}) \longrightarrow 2\text{Al}^{3+}(\text{aq}) + 3\text{H}_2\text{O}(\text{l})$ [½]
 $\text{Al}_2\text{O}_3(\text{s}) + 2\text{OH}^-(\text{aq}) + 3\text{H}_2\text{O}(\text{l}) \longrightarrow 2[\text{Al}(\text{OH})_4]^{-}(\text{aq})$ [½]

ASL11(I)_04

- K is highly electropositive while O is electronegative. In KOH, K exists as K^+ ions and O as OH^- ions. [½]
KOH is basic because it ionizes in water to give $\text{K}^+(\text{aq})$ and $\text{OH}^-(\text{aq})$ ions. [½]
HOBr is acidic because it ionizes in water to give $\text{H}^+(\text{aq})$ and $\text{OBr}^-(\text{aq})$ ions. [½]
 $\text{HOBr}(\text{aq}) \rightleftharpoons \text{H}^+(\text{aq}) + \text{OBr}^-(\text{aq})$
Br is an electronegative element. Ionization of HOBr in water gives $\text{H}^+(\text{aq})$ and $\text{OBr}^-(\text{aq})$ instead of $\text{OH}^-(\text{aq})$ and $\text{Br}^+(\text{aq})$ as the latter system is highly unstable. / $\text{OBr}^-(\text{aq})$ is stabilized by electronegative Br. [½]

AL11(I)_07

- (a) Add $\text{HCl}(\text{aq})$ / $\text{KCl}(\text{aq})$. Only $\text{Pb}^{2+}(\text{aq})$ gives a white precipitate. [1]
 $\text{Pb}^{2+}(\text{aq}) + 2\text{Cl}^-(\text{aq}) \longrightarrow \text{PbCl}_2(\text{s})$ [1]
OR, Add $\text{NaOH}(\text{aq})$. Only $\text{Pb}^{2+}(\text{aq})$ gives a white precipitate which is soluble in excess alkali.
 $\text{Pb}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq}) \longrightarrow \text{Pb}(\text{OH})_2(\text{s})$
 $\text{Pb}(\text{OH})_2(\text{s}) + 2\text{OH}^-(\text{aq}) \longrightarrow [\text{Pb}(\text{OH})_4]^{2-}(\text{aq})$
OR, Add $\text{KI}(\text{aq})$. Only $\text{Pb}^{2+}(\text{aq})$ gives a yellow precipitate.
 $\text{Pb}^{2+}(\text{aq}) + 2\text{I}^-(\text{aq}) \longrightarrow \text{PbI}_2(\text{s})$
- (b) Add acidified $\text{AgNO}_3(\text{aq})$. $\text{Cl}^-(\text{aq})$ gives a white precipitate, while $\text{Br}^-(\text{aq})$ gives a pale yellow precipitate. [1]
 $\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \longrightarrow \text{AgCl}(\text{s})$ [1]
OR, Add $\text{Cl}_2(\text{aq})$. Only $\text{Br}^-(\text{aq})$ gives a brown solution.
 $\text{Cl}_2(\text{aq}) + 2\text{Br}^-(\text{aq}) \longrightarrow \text{Br}_2(\text{aq}) + 2\text{Cl}^-(\text{aq})$
OR, Treat solution with acidified $\text{KMnO}_4(\text{aq})$. $\text{Cl}^-(\text{aq})$ causes decolorization slowly; $\text{Br}^-(\text{aq})$ gives an orange solution.
 $10\text{X}^-(\text{aq}) + 2\text{MnO}_4^-(\text{aq}) + 16\text{H}^+(\text{aq}) \longrightarrow 5\text{X}_2(\text{g/l}) + 2\text{Mn}^{2+}(\text{aq}) + 8\text{H}_2\text{O}(\text{l})$

AL11 (II)_06

- White precipitate is formed and the precipitate dissolves in excess alkali to give a colorless solution. [1]
 $\text{Al}^{3+}(\text{aq}) + 3\text{OH}^-(\text{aq}) \longrightarrow \text{Al}(\text{OH})_3(\text{s})$ [1]
 $\text{Al}(\text{OH})_3(\text{s}) + \text{OH}^-(\text{aq}) \longrightarrow [\text{Al}(\text{OH})_4]^{-}(\text{aq})$ [1]

ASL12(I)_01

- Any TWO of the following: [2]
- Fe compound are colored, e.g. $\text{Fe}^{3+}(\text{aq})$ is yellow.
 - Iron / Fe compounds can have catalytic properties.
 - e.g. Fe in the Haber process / $\text{Fe}^{2+}(\text{aq})$ catalyze the reaction of $\text{I}^-(\text{aq})$ with $\text{S}_2\text{O}_8^{2-}(\text{aq})$.
 - Iron can exhibit variable oxidation states, e.g. Fe^{2+} and Fe^{3+}
 - Many Fe compounds are paramagnetic, e.g. Fe^{3+} .
 - Many Fe compounds are non-stoichiometric, eg. FeS.

ASL12(I)_11

Chemical Knowledge (10 marks)

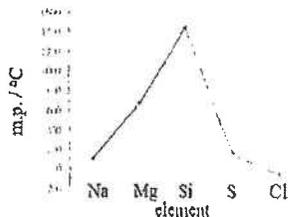
Chemical knowledge (including bonding, structure and electrical conducting property of solids) covers four areas A, B, C and D.

Solid substance can be classified into four types, namely metals, molecular solids, giant covalent network solids and ionic solids.

- A. Metal (and alloys) e.g. Na, Fe [3]
- Bonding between atoms is metallic bond which is non-directional. Metallic bond is electrostatic attraction between metallic cations and delocalized electrons.
 - Metals are good electrical conductor as the delocalized electrons can move in the direction of the applied voltage.
- B. Molecular solid [5]
- Simple molecular, e.g. P_4 , S_8 , glucose, etc.
- Within a molecule, atoms are attracted by covalent bond / sharing of electrons. Attraction between molecules is mainly van der Waals' forces, sometimes hydrogen-bond or even ionic bond.
 - Most simple molecular solids are insulators as molecules are electrically neutral. Macromolecular, e.g. polymeric materials, proteins, carbohydrates
 - Bonding between atoms in molecule is predominately covalent bond. Attraction between molecules is commonly van der Waals' forces, e.g. polyethylene
 - Most polymeric materials are insulator, e.g. polyethylene
- C. Covalent network solid, e.g. Si, C, SiO_2 [3]
- Bonding between atoms is covalent bond in covalent network structure (diamond / graphite / silicon)
 - Electrical conducting property:
Insulators (e.g. diamond / silica) + explanation (bonding electrons are localized)
Conductors (e.g. graphite / carbon nanotubes)
Semi-conductors (e.g. Si). The electrical conductivity of semi-conductors increases with temperature and is affected by the addition of doping agent (e.g. In an Sb)
- D. Ionic solid, e.g. NaCl, MgO [3]
- Bonding between cations and anions is ionic bond / transfer of electrons from an electropositive atom to an electronegative atom.

- Structure; giant ionic lattice, e.g. NaCl structure, CsCl structure
- With cations and anions occupying fixed positions in the lattice, ionic solids cannot conduct electricity.

ASL12(II)_05



[2]

Both Cl & S exist as simple molecules. Their intermolecular attraction is van der Waals' forces. [½]

They have low melting point. [½]

Both Na & Mg have metallic structure. Their interparticle attraction is metallic bond.

Si has a covalent network structure. The atoms are held by covalent bond. It has the higher melting point among the five elements.

Chlorine exists as Cl₂ molecules and sulphur as S₈.

The strength of van der Waals' force increases with the number of electrons in the molecule. [1]

∴ m.p. of S > m.p. of Cl

Metallic bond strength is affected by (1) no. of valence electrons per atom participating in metallic bonding; (2) atomic radius; (3) degree of compactness. [1]

As compared with Na, (1) Mg has greater number of valence electrons, (2) Mg atoms has a smaller size, and (3) Mg atoms are more closely packed in solid state. ∴ m.p. of Mg > m.p. of Na.

(For metallic bond strength, accept any ONE of the correct explanations.)

ASL13(II)_02

Behavior with water:

- Na₂O(s) dissolves in water to give an alkaline solution.
- Al₂O₃(s) and SiO₂(s) are insoluble.
- P₄O₁₀(s) dissolves in water to give an acidic solution.

Explanation:

Across period 3, the structure of the oxides changes from ionic crystals to covalent network and then to simple molecules. [2]

- Na₂O(s) is an ionic oxide. The O²⁻ ions react with water to give OH⁻(aq) ions.
- Al₂O₃(s) is an ionic solid with a very strong ionic bond. The interactions between ions and water are much weaker than the ionic bond in Al₂O₃. It is insoluble in water.
- SiO₂(s) has a giant covalent network structure. Its atoms are bounded by strong covalent bonds. It is insoluble in water.
- P₄O₁₀(s) hydrolyzes / reacts with water to give an acidic solution.

490

AL13(II)_02

Transition metal ions usually have unoccupied 3rd (or 4th) electron shell. [1]

Transition of electrons in these electron shell involves absorption of electromagnetic radiation in the visible light region. [1]

Thus transition metal compounds are usually colored.

DSE11SP_14

Sodium oxide dissolves in water to give an alkaline solution (NaOH(aq)). [1]



Sulphur dioxide dissolves in water to give an acidic solution (H₂SO₃(aq)). [1]



DSE12PP_09

(a)	MgO	Al ₂ O ₃	SiO ₂	P ₄ O ₁₀	SO ₂	[2]
Structure	IC	IC	CN	SM	SM	
Acid-base property	BA	AM	AC	AC	AC	

(b) Ionic oxides are basic, while covalent oxides are acidic. [1]

(c) (In this question, award 1 mark for the reagents used in each of tests for acidic, basic and amphoteric oxides, and 1 mark for a correct observation. One possible method is shown below.)

Add each oxide to HCl(aq) and measure the pH of the mixture. Only MgO(s) and [1]

Al₂O₃(s) react with HCl(aq) and the pH increases. These two oxides demonstrate basic properties. [1]

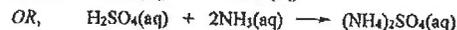
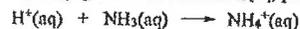
Add each oxide to NaOH(aq) and measure the pH of the mixture. Only Al₂O₃(s), SiO₂(s), P₄O₁₀(s) and SO₂(g) react with NaOH(aq) (SiO₂(s) reacts with hot conc. NaOH(aq), and the pH decreases. These oxides demonstrate acidic properties. [1]

Al₂O₃(s) reacts both cases. It is amphoteric. [1]

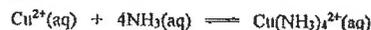
Effective communications (Award 1 mark if candidates can express their ideas clearly.) [1]

DSE12PP_13

(c) H₂SO₄(aq) reacts with the NH₃(aq) present:



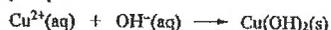
Removal of NH₃(aq) causes the position of the following equilibrium to shift to the left. [1]



NH₃(aq) is a weak base:

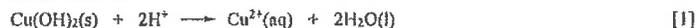


When [Cu²⁺(aq)] builds up it will react with the OH⁻(aq) ions to give the blue precipitate.



491

When excess $\text{H}_2\text{SO}_4(\text{aq})$ is added, it will react with the $\text{Cu}(\text{OH})_2(\text{s})$ formed to give a blue solution.



(3 marks for chemical equations; 1 mark for explanation of the shift in equilibrium position; 1 mark for the formation of blue precipitate.)

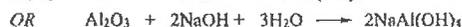
DSE12_16

(a) Na_2O , MgO , Al_2O_3 [1]

(b) SiO_2 has a giant covalent structure, and the Si and O atoms are linked by strong covalent bonds. (Not accept strong covalent structure / giant covalent bonds) [1]

Other covalent oxides are discrete molecules attracted by weak van der Waals' forces / weak intermolecular forces / weak dipolar interactions. (NOT accept VDW forces) [1]

(c) $\text{Al}_2\text{O}_3 + 2\text{OH}^- + 3\text{H}_2\text{O} \longrightarrow 2\text{Al}(\text{OH})_4^-$ [1]



DSE13_13

Nitrogen < lithium < beryllium < carbon (graphite) [1]

N_2 has the lowest melting point as it has a simple molecular structure, weak van der Waals' forces / intermolecular forces need to be overcome. [1]

Both Li and Be have metallic structure, metallic bond in Li is weaker than that in Be. $\therefore \text{Li} < \text{Be}$ in melting points. [1]

C has the highest melting point as it has a giant covalent structure, large amount of energy is needed to break strong covalent bonds between atoms in melting. [1]

Effective communication [1]

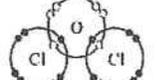
DSE14_11

(a) Vanadium exhibits variable oxidation numbers and its ions in aqueous solution carry colors. [1]

DSE15_10

(a) (i)  [1]

It gives an alkaline / a base solution / NaOH / sodium hydroxide [1]

(ii)  [1]

It gives an acidic solution / HOCl / hypochlorous acid [1]

(b) Any TWO of the following (answers should have examples) [2]

- Fe can have variable oxidation numbers – +2, +3, Fe^{2+} , Fe^{3+}
- Fe can act as a catalyst – e.g. Fe in Haber Process
- Fe forms colored compounds – $\text{Fe}^{2+}(\text{aq})$ is green, $\text{Fe}^{3+}(\text{aq})$ is yellow
- Fe can form complexes – e.g. the Fe complex in rust indicator, $\text{K}_3[\text{Fe}(\text{CN})_6]$
- Fe has magnetic properties – e.g. iron metal can be attracted by magnets.

DSE16_14

Electrical conductivity: aluminium > sodium > silicon = sulphur (or: silicon > sulphur) [1]

Any 3 of the following items, each 1 mark [3]

- Both aluminium and sodium have giant metallic structures with delocalized / mobile electrons so that electrical conductivity of them is high / their electrical conductivity is higher than that of silicon and sulphur.

- The number of delocalized / mobile electrons of aluminium is more than that of sodium so that electrical conductivity of aluminium is higher than that of sodium.

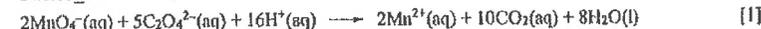
- Silicon has giant covalent structure and its electrons are not mobile and cannot conduct electricity / its electrical conductivity is lower than that of aluminium and sodium.

OR: Silicon has giant covalent structure and its electrons are not mobile. But silicon is a semi-metal and can conduct electricity in some conditions.

- Sulphur has simple molecular structure and its electrons are not mobile and cannot conduct electricity / its electrical conductivity is lower than that of aluminium and sodium. [1]

- Effective communication

DSE17_14



Manganese exhibits variable oxidation numbers. The oxidation number of manganese changes from +7 in MnO_4^- to +2 in Mn^{2+} in the reaction. [1]

Manganese forms colored ions in aqueous solution. $\text{MnO}_4^- (\text{aq})$ ions exhibit purple / $\text{Mn}^{2+} (\text{aq})$ ions exhibit pale pink. [1]

From the graph, it shows that the reaction rate increases when Mn^{2+} ions form / when the reaction proceeds. [1]

Manganese has catalytic properties. Mn^{2+} ions act as a catalyst for the reaction. [1]

Communication mark [1]

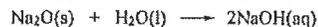
Chemical knowledge = 0 to 2, mark = 0,

Chemical knowledge = 3 to 4, mark = 0 or 1,

Incomplete answer / difficult to understand, mark = 0)

DSE18_14

Na₂O(s) dissolves in water to give NaOH(aq)



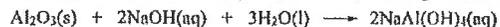
OR Na₂O(s) reacts with HCl(aq) to give NaCl(aq) and H₂O



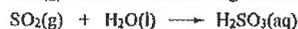
Al₂O₃(s) reacts with HCl(aq) to give AlCl₃(aq) and H₂O



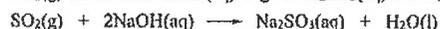
Al₂O₃(s) reacts with NaOH(aq) to give NaAl(OH)₄(aq) and H₂O



SO₂(g) dissolves in water to give H₂SO₃(aq).



OR SO₂(g) reacts with NaOH(aq) to give Na₂SO₃(aq) and H₂O(l)



Able to mention Na₂O is a basic (alkaline) oxide, Al₂O₃ is an amphoteric oxide, and SO₂ is an acidic oxide.

Communication mark

Chemical knowledge = 0 to 3, communication mark = 0

Chemical knowledge = 4 to 5, communication mark = 0 or 1

Incomplete answer or difficult to understand, communication mark = 0

Notes:

- If the candidate gives the answer in the form of a chemical equation, it is not necessary to have the chemical equation correctly balanced.
- The answer should state the reagents and products correctly (including the water formed in the neutralization reaction).
- If the candidate gives the answer in the form of a correct ionic equation, or state the reagents and the products in correct ionic forms, the answer is considered to have correct chemical concept, but failed to state the reagents and products completely. (Maximum) Deduct 1 mark for the whole question. Example: If the candidate only stated 4 correct ionic equations, but in each of the entries the reagents and the products were not stated explicitly, maximum 3 marks will be awarded for the chemical knowledge.
- The following answers are considered to have the products stated correctly.

[1]

[1]

[1]

[1]

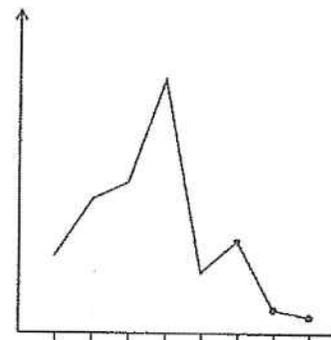
[1]

[1]

494

DSE19_14

(a)



[1]

- 1: The m.p. of S must not be higher than that of Mg;
 - 2: The m.p. of Cl and Ar must not be higher than that of P;
 - 3: The m.p. of Ar must be lower than that of Cl
- (b) The metallic bond in Mg is stronger than that in Na as Mg has more delocalised electrons / more outermost shell electrons than Na. [1]
- OR The metallic bond in Mg is stronger than that in Na as Mg has two outermost shell delocalised electrons while Na only has one
- (c) Melting of Si needs high energy to break the strong covalent bonds between Si atoms in the giant covalent structure. [1]
- Melting of P only needs smaller energy to break the weak intermolecular forces. / P has a simple molecular structure, there are weak van der Waals' forces between molecules. [1]
- OR Si has a giant covalent structure while P has a simple molecular structure. [1]
- High energy is needed to break the strong covalent bonds between Si atoms, while smaller energy is needed to break the weak van der Waals' forces between phosphorus molecules. [1]

DSE20_12

12. • Cobalt/Co²⁺ acts as a catalyst as the rate of formation of gas bubbles (CO₂) increases / rate of reaction increases when Co²⁺ ions are added. [1]
 - and the pink Co²⁺ ions regenerate / remain (chemically) unchanged / do not consume at the end of reaction. [1]
 - Coloured ion / formation of coloured compound: Co²⁺(aq) is pink / the cobalt(III) compound formed is green. [1]
 - Variable oxidation states: cobalt has cobalt(II) and cobalt(III) compounds / can exist as Co²⁺ and Co³⁺. [1]
- (The answers have to be illustrated with the experimental observations provided in the question.)

495