2.6 The Periodic Table and Inorganic Chemistry: 30-minute Pack

AQA 7405 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 The table below gives approximate melting points for four Period 3 elements.
Na: 371 K Mg: 923 K Al: 933 K Si: 1687 K

(a) Explain, in terms of structure and bonding, why the melting point increases from sodium to magnesium to aluminium. **(3)**

(b) Silicon has a much higher melting point than aluminium. Explain why. **(2)**

(c) The melting point drops sharply between silicon and phosphorus (P_4 melts at 317 K). Explain why. **(2)**

(d) Predict, with a reason, how the melting points of P_4, S_8 and Cl_2 compare with one another. **(3)**

(Total for Question 1 is 10 marks)

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2 This question is about the oxides of Period 3 elements and their reactions with water.

(a) Write an equation for the reaction of sodium oxide, Na_2O, with water, and state the approximate pH of the resulting solution. **(2)**

(b) Write an equation for the reaction of phosphorus(V) oxide, P_4O_{10}, with water, and state the approximate pH of the resulting solution. **(2)**

(c) Aluminium oxide, Al_2O_3, does not react with water, but it reacts with both dilute hydrochloric acid and dilute sodium hydroxide solution. Write an equation for each of these two reactions and state the term used to describe an oxide that behaves in this way. **(4)**

(d) Using your answers to parts (a) to (c), deduce and explain the overall pattern in the acid-base character of Period 3 oxides as you move from sodium oxide to phosphorus(V) oxide. **(3)**

(Total for Question 2 is 11 marks)

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Mark scheme · 2.6 The Periodic Table and Inorganic Chemistry: 30-minute Pack

Question 1

(a) Na, Mg and Al are all giant metallic structures held together by metallic bonding oe **B1**

(a) going from Na to Mg to Al, each atom contributes one more delocalised electron (1, then 2, then 3) to the 'sea' of electrons, and the ionic charge on the metal ion also increases (+1, +2, +3) **B1**

(a) stronger electrostatic attraction between the metal cations and the increased number/density of delocalised electrons requires more energy to overcome, raising the melting point oe **B1**

(a) Answer: Na, Mg and Al are giant metallic lattices; going across the series the ionic charge and the number of delocalised electrons per atom both increase, strengthening the metallic bonding and so raising the melting point

(b) silicon has a giant covalent (macromolecular) structure, in which each Si atom is joined to four others by strong covalent bonds oe **B1**

(b) melting requires breaking many strong covalent bonds throughout the lattice, which needs much more energy than overcoming the (weaker, delocalised) metallic bonding in aluminium oe **B1**

(b) Answer: Silicon has a giant covalent lattice held together by strong covalent bonds in all directions; melting means breaking these strong bonds, which needs far more energy than overcoming the metallic bonding in aluminium

(c) phosphorus (as P_4) exists as small, simple covalent molecules, unlike the giant covalent lattice of silicon oe **B1**

(c) only weak London (van der Waals) forces act between P_4 molecules, and these require little energy to overcome, so the melting point is much lower oe **B1**

(c) Answer: P_4 is a simple molecular substance; only weak London forces exist between the P_4 molecules, which need much less energy to overcome than the strong covalent bonds in giant covalent silicon

(d) predicted order: S_8 has the highest melting point, then P_4, then Cl_2 the lowest (accept correct order stated either way round with reasoning) **B1**

(d) melting point depends on the strength of London (van der Waals) forces between molecules, which increases with the number of electrons in the molecule / with relative molecular mass oe **B1**

(d) S_8 has the most electrons (largest Mr), then P_4, then Cl_2 has the fewest, so this order matches the strength of the London forces between molecules oe **B1**

(d) Answer: S_8 (highest) > P_4 > Cl_2 (lowest); melting point rises with the number of electrons per molecule (London forces), and S_8 has the most electrons per molecule, followed by P_4, then Cl_2

Question 2

(a) $Na_2O + H_2O \rightarrow 2NaOH$ cao (state symbols not required) **B1**

(a) pH approximately 13-14 (accept 'strongly alkaline') **B1**

(a) Answer: $Na_2O + H_2O \rightarrow 2NaOH$; pH approximately 13-14

(b) $P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$ cao **B1**

(b) pH approximately 0-1 (accept 'strongly acidic') **B1**

(b) Answer: $P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$; pH approximately 0-1

(c) $Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$ cao **B1**

(c) $Al_2O_3 + 2NaOH + 3H_2O \rightarrow 2NaAl(OH)_4$ (sodium aluminate) oe (accept $2NaOH + Al_2O_3 \rightarrow 2NaAlO_2 + H_2O$) **B1**

(c) term: amphoteric **B1**

(c) amphoteric means the oxide can react as both a base (with acid) and an acid (with alkali) oe **B1**

(c) Answer: $Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$; $Al_2O_3 + 2NaOH + 3H_2O \rightarrow 2NaAl(OH)_4$; amphoteric (reacts with both acids and bases)

(d) the oxides change from strongly basic (Na_2O, MgO) through amphoteric (Al_2O_3) to acidic then strongly acidic (SiO_2 weakly/not reactive, P_4O_{10} strongly acidic) across the period oe **B1**

(d) this matches a change in bonding from ionic (Na_2O, MgO, metal oxides) to covalent (SiO_2, P_4O_{10}, non-metal oxides), with Al_2O_3 intermediate/having mixed ionic-covalent character oe **B1**

(d) ionic oxides release OH^- ions (or accept H^+ readily) making solutions basic, while covalent oxides of non-metals react with water to form acidic solutions (releasing H^+) oe **B1**

(d) Answer: Across Period 3 the oxides go from strongly basic (Na_2O, MgO) to amphoteric (Al_2O_3) to acidic (SiO_2, weakly) to strongly acidic (P_4O_{10}), reflecting the change in bonding from ionic (metal oxides) to covalent (non-metal oxides)

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