A-Level Chemistry

Period 3 Elements and their Oxides

Mark Scheme

Time available: 63 minutes
Marks available: 56 marks

1.

(a) $2\ Na(s) + 2\ H_2O(l) \rightarrow 2\ NaOH(aq) + H_2(g)$

Allow ionic equations

Allow multiples

1

Temperature will go up more **or** reactants can shoot out of the tube

Allow the mixture could explode or glass could shatter or hydrogen could ignite/is flammable

Ignore reaction is exothermic/vigorous

1

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

Allow ionic equations

1

Allow –1 to + 1

Do not allow equations from P_2O_5

1

(c) M1 SiO_2 is macromolecular / giant covalent / giant molecule

Do not allow giant, giant atomic or giant ionic

1

M2 Strong <u>covalent</u> bonds (between atoms) or <u>covalent</u> bonds need a lot of energy to be broken/overcome

1

M3 P_4O_{10} is <u>molecular</u> or <u>simple covalent molecule</u>

1

M4 Weak van der Waals forces <u>between molecules</u> or van der Waals forces <u>between molecules</u> break easily

1

(d) Al_2O_3

1

$Al_2O_3 + 3\ H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3\ H_2O$
or $Al_2O_3 + 6\ H^+ \rightarrow 2\ Al^{3+} + 3\ H_2O$

1

(e) $Mg(OH)_2$

1

(f) Na / sodium

1

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2.

(a) $4Na + O_2 \rightarrow 2Na_2O$

Ignore state symbols

Allow multiples and fractions

Allow $2Na + O_2 \rightarrow Na_2O_2$

1

Yellow/orange flame/light AND white solid/powder/smoke/fumes/ash

Allow yellow solid

Do not allow ppt. Apply list principle

Ignore formulae in observations

1

(b) $4P + 5O_2 \rightarrow P_4O_{10}$ / $P_4 + 5O_2 \rightarrow P_4O_{10}$

Ignore state symbols

Do not allow equations with P_2O_5

Allow $4P + 3O_2 \rightarrow P_4O_6$ / $P_4 + 3O_2 \rightarrow P_4O_6$

1

white flame/light OR white fumes/smoke/solid/powder/ash

Do not allow ppt. Apply list principle

1

(c) Greater/increased charge/charge density on magnesium ion/Mg^{2+} (specific mention of ion(s) can be scored from M2)

Allow magnesium ion is smaller (than sodium ion);

Ignore atomic radius

If mention of molecules, intermolecular forces, metallic bonding then CE=0

1

Stronger attraction for anions/oxide ion / stronger attraction between oppositely charged ions/ stronger attraction between Mg^{2+} and O^{2-} / stronger ionic bonding

Ignore references to covalent character

Mark independently

1

(d) (SiO_2) giant covalent / macromolecular

Do not allow M1 and M2 if it is clear that the candidate is referring to the structure of the elements rather than the oxides. M3 could score from correct comparison of giant covalent to simple molecular

Allow giant molecule

1

(P_4O_{10}) (simple) molecular

Not simple covalent

1

(Covalent) bonds (throughout structure) of SiO_2 much stronger than the forces between molecules/intermolecular forces in P_4O_{10}

Reference to 'between molecules' in M3 would also get M2

Allow van der Waals' forces between molecules

M3 dependent on correct M1 and M2

1

(e) **M1** Sample in suitable melting point apparatus (e.g. capillary in oil bath/Thiele tube / melting point apparatus)

Do not allow water bath

1

M2 Heat slowly/gradually/gently (to establish melting point range)

1

M3 Lower melting point / (broad) range of melting point indicates presence of impurities

OR melting point agrees with/close to data book value / melts sharply/over narrow range / melting point exactly 573K indicates purity

1

[12]

3. (a) $P_4 + 5\ O_2 \longrightarrow P_4O_{10}$

allow 4 P + 5 O_2 ⟶ P_4O_{10}

allow multiples

ignore state symbols

1

(b) React with water / add water / solution (of substances in question)

If no M1 then CE = 0/3

1

Add litmus paper / universal indicator / measure pH (with pH meter)

Allow other reagents in solution, e.g. sodium carbonate solution, that give a positive result

Allow other indicators with appropriate colour changes

1

M3 is dependent on M2

Litmus: blue with sodium oxide (solution) **and** red with phosphorus oxide (solution)OR
If blue litmus added phosphorus oxide solution goes red OR
If red litmus added sodium (hydr)oxide goes blue

Universal Indicator: blue/ purple with sodium oxide (solution) **and** red with phosphorus oxide (solution)

pH meter or Universal Indicator: sodium (hydr)oxide (solution) has a higher pH (than phosphorus oxide (solution)) or vv

sodium (hydr)oxide pH (12 to 14) **and** phosphorus oxide (solution) pH (-1 to 2)

For pH meter or Universal Indicator: allow sodium (hydr)oxide (solution) has a higher pH and phosphorus oxide (solution) has lower pH.

1

(c) For silicon dioxide - giant covalent (molecule)/ macromolecular

1

For sulfur trioxide - molecular / (simple) molecule

1

Do not allow simple covalent

(d) Covalent bonds (between atoms) in SiO_2

1

Van der Waals between molecules / intermolecular forces in SO_3

1

Covalent bonds are stronger than van der Waals forces

1

(Covalent bonds) take more energy to be overcome/broken or (Van der Waals) take less energy to be overcome/broken

1

If covalent bonds between molecules of SiO_2 lose M1 only

If hydrogen bonds in SO_3 lose M2 only

If metallic or ionic max score = 1 (either M1 or M2)

If IMF in SiO_2 then max 1 (M2 only)

Allow dipole-dipole forces between molecules

For M3 and M4 comparison is required/implied

(e) $SO_3 + 2KOH \longrightarrow K_2SO_4 + H_2O$

$SO_3 + KOH \longrightarrow KHSO_4$

$SO_3 + 2OH^- \longrightarrow SO_4^{2-} + H_2O$

$SO_3 + OH^- \longrightarrow HSO_4^-$

Allow multiples

Ignore state symbols

1

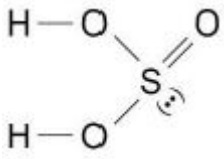
(f) $3\ MgO + 2\ H_3PO_4 \longrightarrow Mg_3(PO_4)_2 + 3\ H_2O$

Allow multiples

Ignore state symbols

1

(g)



Ignore lone pairs

1

[13]

4. (a) The number of protons increases (across the period) / nuclear charge increases

1

Therefore, the attraction between the nucleus and electrons increases

Can only score M2 if M1 is correct

1

(b) S_8 molecules are bigger than P_4 molecules

Allow sulfur molecules have bigger surface area and sulfur molecules have bigger M_r

1

Therefore, van der Waals / dispersion / London forces between molecules are stronger in sulfur

1

(c) Sodium oxide contains O^{2-} ions

1

These O^{2-} ions react with water forming OH^- ions

$O^{2-} + H_2O \longrightarrow 2OH^-$ scores M1 and M2

1

(d) $P_4O_{10} + 12OH^- \longrightarrow 4PO_4^{3-} + 6H_2O$

1

[7]

5. (a) (i) Covalent

Ignore simple / molecular

Do not allow macromolecular/giant covalent/dative/dipole-dipole/Hydrogen bonds

Ignore VdW

1

(ii) P / phosphorus / P_4

1

(iii) $P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$

*Mark independently of **(a)(ii)***

Accept multiples/fractions

Ignore state symbols

Allow ions on the RHS ($\longrightarrow 12H^+ + 4PO_4^{3-}$)

Allow correct equations from P_4O_6, P_2O_3 and P_2O_5

$P_4O_6 + 6H_2O \longrightarrow 4H_3PO_3$

$P_2O_3 + 3H_2O \longrightarrow 2H_3PO_3$

$P_2O_5 + 3H_2O \longrightarrow 2H_3PO_4$

1

(b) (i) Ionic

Ignore giant / lattice

1

(ii) Na / Sodium

1

(iii) $2Na + 2H_2O \longrightarrow 2Na^+ + 2OH^- + H_2$

Allow equation to form 2NaOH

Accept multiples/fractions

Ignore state symbols

1

(iv) $Na_2O + 2HCl \longrightarrow 2NaCl + H_2O$

Accept multiples/fractions

Ignore state symbols

Allow ions, but do not allow H+ only for the acid

1

(c) (i) Ionic

Allow ionic and covalent / ionic with covalent character

1

(ii) Al_2O_3

Ignore state symbols

1

(iii) Reacts with acids and bases

Allow reacts with acids and alkalis / acts as both an acid and a base / shows acidic and basic properties

1

(iv) $Al_2O_3 + 6HCl \longrightarrow 2Al^{3+} + 6Cl^- + 3H_2O$

$Al_2O_3 + 6H^+ \longrightarrow 2Al^{3+} + 3H_2O$

Allow equation to form $2AlCl_3$ (but not Al_2Cl_6)

Allow equations with other acids

1

$Al_2O_3 + 2NaOH + 3H_2O \longrightarrow 2Na^+ + 2[Al(OH)_4]^-$

$Al_2O_3 + 2OH^- + 3H_2O \longrightarrow 2[Al(OH)_4]^-$

$Al_2O_3 + 2NaOH + 7H_2O \longrightarrow 2Na^+ + 2[Al(OH)_4\ (H_2O)_2]^-$

$Al_2O_3 + 2OH^- + 7H_2O \longrightarrow 2[Al(OH)_4\ (H_2O)_2]^-$

Allow equations to form $2Na[Al(OH)_4]$ or $2Na[Al(OH)_4(H_2O)_2]$

Allow equations with other alkalis

Allow correct equations which form $[Al(OH)_6]^{3-}$

Allow equations to form $[Al(OH)_x(H_2O)_{6-x}]^{3-x}$ etc

Ignore state symbols

1

[12]