1 (a) Write an equation for the reaction that occurs when magnesium is heated in steam.
Describe what you would observe when this reaction occurs.

Equation ....

Observations ....

....

....

....

(3)

(b) Write an equation for the reaction that occurs when sodium is heated in oxygen.
Describe what you would observe when this reaction occurs.

Equation ....

Observations ....

....

....

....

(3)
(Total 6 marks)

2 (a) The table below contains data that show a trend in the melting points of some oxides of the Period 3 elements.

Oxide	Sodium oxide	Magnesium oxide	Aluminium oxide	Silicon(IV) oxide	Phosphorus(V) oxide	Sulfur(IV) oxide
Melting point / K		3125	2345	1883	573	

(i) Use data from the table above to predict an approximate melting point for sodium oxide.

Tick (✓) **one** box.

250 K	☐
500 K	☐
1500 K	☐
3500 K	☐

(1)

(ii) Explain, in terms of structure and bonding, why sodium oxide has a high melting point.

....

....

....

....

....

(2)

(iii) Use data from the table above to predict a value for the melting point of sulfur(IV) oxide.

Suggest, in terms of structure and bonding, why the melting point of sulfur(IV) oxide is different from that of phosphorus(V) oxide.

Predicted melting point of sulfur(IV) oxide ....

Why the melting point is different from phosphorus(V) oxide ....

....

....

....

(3)

(b) Write an equation for the reaction of sulfur(IV) oxide with water.

Suggest the pH value of the resulting solution.

Equation

....

pH value ....

(2)

(c) Silicon(IV) oxide is insoluble in water.

Explain, using an equation, why silicon(IV) oxide is classified as an acidic oxide.

....

....

....

....

....

(2)
(Total 10 marks)

3 (a) Explain why the atomic radii of the elements decrease across Period 3 from sodium to chlorine.

....

....

....

....

....

....

(2)

(b) Explain why the melting point of sulfur (S_8) is greater than that of phosphorus (P_4).

....

....

....

....

....

....

(2)

(c) Explain why sodium oxide forms an alkaline solution when it reacts with water.

....

....

....

....

....

(2)

(d) Write an ionic equation for the reaction of phosphorus(V) oxide with an excess of sodium hydroxide solution.

....

(1)
(Total 7 marks)

4 This question is about some Period 3 elements and their oxides.

(a) Describe what you would observe when, in the absence of air, magnesium is heated strongly with water vapour at temperatures above 373 K.
Write an equation for the reaction that occurs.

Observations ....

....

....

....

....

Equation ....

(3)

(b) Explain why magnesium has a higher melting point than sodium.

....

....

....

....

(Extra space) ....

....

(2)

(c) State the structure of, and bonding in, silicon dioxide.
Other than a high melting point, give **two** physical properties of silicon dioxide that are characteristic of its structure and bonding.

Structure ....

Bonding...

Physical property 1..

Physical property 2..

(4)

(d) Give the formula of the species in a sample of solid phosphorus(V) oxide.
State the structure of, and describe fully the bonding in, this oxide.

Formula ....

Structure ....

Bonding...

....

....

....

(4)

(e) Sulfur(IV) oxide reacts with water to form a solution containing ions.

Write an equation for this reaction.

....

(1)

(f) Write an equation for the reaction between the acidic oxide, phosphorus(V) oxide, and the basic oxide, magnesium oxide.

....

(1)
(Total 15 marks)

5 Magnesium oxide, silicon dioxide and phosphorus(V) oxide are white solids but each oxide has a different type of structure and bonding.

(a) State the type of bonding in magnesium oxide.
Outline a simple experiment to demonstrate that magnesium oxide has this type of bonding.

Type of bonding ....

Experiment ....

....

....

....

....

....

(3)

(b) By reference to the structure of, and the bonding in, silicon dioxide, suggest why it is insoluble in water.

....

....

....

....

....

....

....

(3)

(c) State how the melting point of phosphorus(V) oxide compares with that of silicon dioxide. Explain your answer in terms of the structure of, and the bonding in, phosphorus(V) oxide.

Melting point in comparison to silicon dioxide ....

Explanation ....

....

....

....

....

....

(3)

(d) Magnesium oxide is classified as a basic oxide.

Write an equation for a reaction that shows magnesium oxide acting as a base with another reagent.

....

(2)

(e) Phosphorus(V) oxide is classified as an acidic oxide.

Write an equation for its reaction with sodium hydroxide.

....

(1)

(Total 12 marks)

6 Some melting points of Period 3 oxides are given in this table.

	Na_2O	SiO_2	SO_2	SO_3
Melting point / K	1548	1883	200	290

(a) Explain, in terms of structure and bonding, why sodium oxide has a high melting point.

....

....

....

....

(2)

(b) Explain, in terms of structure and bonding, why sulfur trioxide has a higher melting point than sulfur dioxide.

....

....

....

....

(2)

(c) Some Period 3 oxides have basic properties.

State the type of bonding in these basic oxides.
Explain why this type of bonding causes these oxides to have basic properties.

Type of bonding ....

Explanation ....

....

....

....

....

(3)

(d) Sulfur dioxide reacts with water to form a weakly acidic solution.

(i) Ions are formed when sulfur dioxide reacts with water.
Write an equation for this reaction.

....

(1)

(ii) With reference to your equation from part (d)(i), suggest why sulfur dioxide forms a weakly acidic solution.

....

....

....

(1)

(e) Suggest why silicon dioxide is described as an acidic oxide even though it is insoluble in water.

....

....

(1)
(Total 10 marks)

7 White phosphorus (P_4) is a hazardous form of the element. It is stored under water.

(a) Suggest why white phosphorus is stored under water.

....

....

....

(1)

(b) Phosphorus(V) oxide is known as phosphorus pentoxide.
Suggest why it is usually represented by P_4O_{10} rather than by P_2O_5

....

....

....

(1)

(c) Explain why phosphorus(V) oxide has a higher melting point than sulfur(VI) oxide.

....

....

....

....

....

(2)

(d) Write an equation for the reaction of P_4O_{10} with water to form phosphoric(V) acid.
Give the approximate pH of the final solution.

Equation ....

pH ....

(2)

(e) A waste-water tank was contaminated by P_4O_{10}. The resulting phosphoric(V) acid solution was neutralised using an excess of magnesium oxide. The mixture produced was then disposed of in a lake.

(i) Write an equation for the reaction between phosphoric(V) acid and magnesium oxide.

....

(1)

(ii) Explain why an excess of magnesium oxide can be used for this neutralisation.

....

....

....

(1)

(iii) Explain why the use of an excess of sodium hydroxide to neutralise the phosphoric(V) acid solution might lead to environmental problems in the lake.

....

....

....

(1)
(Total 9 marks)

8 The data in the table below show the melting points of oxides of some Period 3 elements.

	Na_2O	P_4O_{10}	SO_2
T_m/K	1548	573	200

(a) In terms of structure and bonding, explain why

(i) sodium oxide has a high melting point

....

....

....

(Extra space) ....

....

(2)

(ii) sulfur dioxide has a low melting point.

....

....

....

....

....

(Extra space) ....

....

(2)

(b) Explain why the melting point of P_4O_{10} is higher than the melting point of SO_2

....

....

....

....

(Extra space) ....

....

(2)

(c) Write equations for the reactions of Na_2O and P_4O_{10} with water. In each case give the approximate pH of the resulting solution.

Equation for Na_2O...

pH ....

Equation for P_4O_{10}...

pH ....

....

(4)

(d) Write an equation for the acid–base reaction that occurs when Na_2O reacts with P_4O_{10} in the absence of water.

....

(1)
(Total 11 marks)

9 This question is about the chemistry of the Period 3 elements and the trends in their properties.

(a) (i) Describe what you would observe when magnesium burns in oxygen. Write an equation for the reaction that occurs. State the type of bonding in the oxide formed.

Observations ....

....

....

....

Equation ....

Type of bonding ....

(4)

(ii) Describe what you would observe when sulfur burns in oxygen. Write an equation for the reaction that occurs. State the type of bonding in the oxide formed.

Observations ....

....

....

....

Equation ....

Type of bonding ....

(4)

(b) State the type of bonding in sodium oxide. Explain why sodium oxide reacts to form an alkaline solution when added to water.

Type of bonding ....

Explanation...

....

....

....

(3)

(c) Outline an experiment that could be used to show that aluminium oxide contains ions.

....

....

....

(Extra space) ………………………………………………………………………………

....

(2)

(d) Suggest one reason why a thin layer of aluminium oxide protects aluminium from corrosion in moist air.

....

....

(1)

(e) Write an ionic equation in each case to show how aluminium oxide reacts with the following

(i) hydrochloric acid

....

(1)

(ii) aqueous sodium hydroxide.

....

(1)
(Total 16 marks)

10 There is a link between the properties of the oxides of the Period 3 elements and their structure and bonding. The table below shows the melting points of the oxides of some Period 3 elements.

	Na_2O	SiO_2	P_4O_{10}
T_m/K	1548	1883	573

(a) In terms of crystal structure and bonding, explain in each case why the melting points of sodium oxide and silicon dioxide are high.

Na_2O ....

....

....

SiO_2 ....

....

....

(4)

(b) Predict whether the melting point of lithium oxide is higher than, the same as, or lower than the melting point of sodium oxide and explain your prediction.

Prediction ....

Explanation ....

....

....

(3)

(c) Phosphorus(V) oxide has a lower melting point than sodium oxide.

(i) State the structure of and bonding in phosphorus(V) oxide.

....

....

....

(2)

(ii) Explain why the melting point of phosphorus(V) oxide is low.

....

....

(1)

(d) Separate samples of phosphorus(V) oxide and sodium oxide were reacted with water.
In each case, predict the pH of the solution formed and write an equation for the reaction.

pH with P_4O_{10} ……..

Equation ....

pH with Na_2O..

Equation ....

(4)

(e) Write an equation for the reaction between Na_2O and P_4O_{10}
State the general type of reaction illustrated by this example.

Equation ....

Reaction type ....

(2)
(Total 16 marks)

11 Sodium, aluminium and silicon are solid elements with a silver colour. These elements react with oxygen to form oxides with high melting points. Aluminium is a reactive metal, but it resists corrosion in water because it has a surface coating of aluminium oxide.

(a) In terms of its structure and bonding, explain why silicon dioxide has a high melting point.

....

....

....

(3)

(b) State the type of bonding in aluminium oxide.

....

(1)

(c) Write an equation for the reaction of aluminium with oxygen.

....

(1)

(d) Suggest **one** property of the aluminium oxide coating that causes aluminium to resist corrosion in water.

....

(1)

(e) Sodium metal is **not** resistant to corrosion in water, despite having a surface coating of sodium oxide. Write an equation to show how sodium oxide reacts with water.

....

(1)

(f) Aluminium oxide is amphoteric. It reacts with acids and alkalis.

(i) Write an equation for the reaction between aluminium oxide and hydrochloric acid.

....

(1)

(ii) Write an equation for the reaction between aluminium oxide and an excess of aqueous sodium hydroxide.

....

(1)

(g) Silicon dioxide does **not** react with hydrochloric acid but it does react with sodium hydroxide. State **one** property of silicon dioxide that can be deduced from this information and write an equation for its reaction with sodium hydroxide.

Property …...

Equation ....

(2)
(Total 11 marks)

12 (a) State and explain the trend in electronegativities across Period 3 from sodium to sulfur.

....

....

....

....

....

....

....

(4)

(b) Explain why the oxides of the Period 3 elements sodium and phosphorus have different melting points. In your answer you should discuss the structure of and bonding in these oxides, and the link between electronegativity and the type of bonding.

....

....

....

....

....

....

....

....

....

....

....

(6)

(c) A chemical company has a waste tank of volume 25 000 dm^3. The tank is full of phosphoric acid (H_3PO_4) solution formed by adding some unwanted phosphorus(V) oxide to water in the tank.

A 25.0 cm^3 sample of this solution required 21.2 cm^3 of 0.500 mol dm^{-3} sodium hydroxide solution for complete reaction.

Calculate the mass, in kg, of phosphorus(V) oxide that must have been added to the water in the waste tank.

....

....

....

....

....

....

....

....

....

....

(5)
(Total 15 marks)

13 (a) The melting points of some of the oxides formed by Period 3 elements are given in a random order below.

Oxide	**A**	**B**	**C**	**D**	**E**
T_m/°C	2852	–73	1610	1275	300

(i) Using the letters **A** to **E**, give **two** oxides which have simple molecular structures.

Explain your answer.

Oxide 1 ....

Oxide 2 ....

Explanation ....

....

(ii) Give a simple chemical test which could be used to show which of the oxides in the table is sodium oxide. State the observation you would make.

Chemical test ....

....

Observation ....

(6)

(b) The base calcium oxide can be used to remove sulfur dioxide from flue-gases produced when fossil fuels are burnt in coal-fired power stations. Calcium oxide is produced when calcium carbonate, is decomposed by heat.

(i) Write an equation for the action of heat on calcium carbonate.

....

(ii) Identify the product formed when sulfur dioxide reacts with calcium oxide.

....

(iii) Despite the additional cost, operators of power stations are encouraged to remove the sulfur dioxide from flue-gases. Explain why this may not be environmentally beneficial.

....

....

(4)
(Total 10 marks)

14 Consider the following oxides.

Na_2O, MgO, Al_2O_3, SiO_2, P_4O_{10}, SO_3

(a) Identify one of the oxides from the above which

(i) can form a solution with a pH less than 3 ....

(ii) can form a solution with a pH greater than 12 ....

(2)

(b) Write an equation for the reaction between

(i) MgO and HNO_3

....

(ii) SiO_2 and $NaOH$

....

(iii) Na_2O and H_3PO_4

....

(3)

(c) Explain, in terms of their type of structure and bonding, why P_4O_{10} can be vaporised by gentle heat but SiO_2 cannot.

....

....

....

....

(4)
(Total 9 marks)

Mark schemes

1 (a) $Mg + H_2O \rightarrow MgO + H_2$

ignore state symbols

1

White solid / powder / ash / smoke

ignore precipitate

ignore fumes

1

(Bright) <u>white</u> light / flame

allow glow

penalise effervescence under list principle

1

(b) $2Na + \frac{1}{2}O_2 \rightarrow Na_2O$ / $4Na + O_2 \rightarrow 2Na_2O$

Allow multiples, ignore state symbols

Allow $2Na + O_2 \rightarrow Na_2O_2$

1

white / yellow solid / ash / smoke

ignore precipitate

ignore fumes

1

orange / yellow flame

1

[6]

2 (a) (i) 1500

1

(ii) Ionic lattice / giant ionic

Mention of vdW / covalent bonding / molecules / atoms / metal etc.
CE = 0

1

Strong <u>attraction</u> between <u>oppositely charged ions</u> / Na^+ and O^{2-}
OR
lots of energy required to separate / overcome attraction between oppositely charged ions / Na^+ and O^{2-}

Do not allow incorrect formulae for ions.

1

(iii) 200 (K)

Allow range 10−273 (K)

CE = 0 if temperature >573 K, otherwise mark on

Allow correct answers in °C but units must be given.

1

SO_2 smaller (molecule) (than P_4O_{10}) (or converse)

also SO_2 has lower M_r / less surface area / less polarisable / fewer electrons

penalise SO_3 and P_2O_5 for M2 only

1

vdW forces <u>between molecules</u> are weaker / require less energy to separate molecules

ignore dipole−dipole

If covalent bonds broken lose M2 and M3 but can gain M1

1

(b) $SO_2 + H_2O \rightarrow H_2SO_3$ / $H^+ + HSO_3^-$ / $2H^+ + SO_3^{2-}$

can be equilibrium sign instead of arrow

1

1

Allow values between 1−3

mark independently

1

(c) Reacts with / neutralises bases / alkalis

Allow any given base or alkali including OH^-

1

$SiO_2 + 2NaOH \rightarrow Na_2SiO_3 + H_2O$

Allow $CaO + SiO_2 \rightarrow CaSiO_3$ or equation with any suitable base

M2 can score M1 even if equation unbalanced or incorrect

1

[10]

3 (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]

4 (a) White powder / solid / ash / smoke

Ignore ppt / fumes

1

Bright / white light / flame

Allow glows white / glows bright

1

$Mg + H_2O \rightarrow MgO + H_2$

Ignore state symbols

Ignore reference to effervescence or gas produced

1

(b) Mg^{2+} / magnesium ion has higher charge than Na^+

Allow Mg^{2+} ions smaller / greater charge density than Na^+ ions

Allow Mg atoms smaller than Na (atoms)

Allow magnesium has more delocalised electrons

Must be a comparison

Ignore reference to nuclear charge

1

Attracts delocalised / free / sea of electrons more strongly / metal–metal bonding stronger / metallic bonding stronger

Wrong type of bonding (vdW, imf), mention of molecules CE = 0

1

(c) **Structure:** Macromolecular / giant molecule / giant covalent

Mark independently

1

Bonding: Covalent / giant covalent

1

Physical Properties:

Any **two** from: Hard/
Brittle / not malleable
Insoluble
Non conductor

Ignore correct chemical properties

Ignore strong, high boiling point, rigid

2

(d) **Formula:** P_4O_{10}

Mention of ionic or metallic, can score M1 only

1

Structure: Molecular

If macromolecular, can score M1 & M3 only

1

Bonding: Covalent / shared electron pair

1

van der Waals' / dipole–dipole forces <u>between molecules</u>

Allow vdW, imf and dipole–dipole imf but do not allow imf alone

1

(e) $SO_2 + H_2O \rightarrow H^+ + HSO_3^-$

Products must be ions

Allow $SO_2 + H_2O \rightarrow 2H^+ + SO_3^{2-}$

Allow two equations showing intermediate formation of H_2SO_3 *that ends up as ions*

Ignore state symbols

Allow multiples

1

(f) $P_4O_{10} + 6MgO \rightarrow 2Mg_3(PO_4)_2$

OR $P_4O_{10} + 6MgO \rightarrow 6Mg^{2+} + {}_4PO_4^{3-}$

OR $P_2O_5 + 3MgO \rightarrow Mg_3(PO_4)_2$ etc

Ignore state symbols

Allow multiples

1

[15]

5 (a) MgO is ionic

If not ionic, CE = 0

1

Melt it

If solution mentioned, cannot score M2 or M3

1

(Molten oxide) conducts electricity

Allow acts as an electrolyte.

Cannot score M3 unless M2 is correct.

1

(b) Macromolecular

CE = 0 if ionic, metallic or molecular.

Allow giant molecule.

1

Covalent bonding

Giant covalent scores M1 and M2

1

Water cannot (supply enough energy to) break the covalent bonds / lattice

Hydration enthalpy < bond enthalpy.

1

(c) (Phosphorus pentoxide's melting point is) lower

If M1 is incorrect, can only score M2

1

Molecular with covalent bonding

M2 can be awarded if molecular mentioned in M3

1

Weak / easily broken / not much energy to break intermolecular forces
OR weak vdW / dipole-dipole forces of attraction between molecules

Intermolecular / IMF means same as between molecules.

1

(d) Reagent (water or acid)

Can be awarded in the equation.

1

Equation eg $MgO + 2HCl \rightarrow MgCl_2 + H_2O$

$MgO + H_2O \rightarrow Mg(OH)_2$

Equations can be ionic but must show all of the reagent eg $H^+ + Cl^-$

Simplified ionic equation without full reagent can score M2 only.

Allow $6MgO + P_4O_{10} \rightarrow 2Mg_3(PO_4)_2$

1

(e) $P_4O_{10} + 12NaOH \rightarrow 4Na_3PO_4 + 6H_2O$

Allow P_2O_5 *and acid salts.*

Must be NaOH not just hydroxide ions.

1

[12]

6

(a) Na_2O is an ionic lattice / giant ionic / ionic crystal

CE= 0 if molecules, atoms, metallic mentioned

Mention of electronegativity max 1 out of 2

1

With strong forces of attraction between ions

Allow strong ionic bonds / lots of energy to separate ions

1

(b) SO_3 is a larger molecule than SO_2

Allow greater M_r / surface area

1

So van der Waals' forces between molecules are stronger

Any mention of ions, CE= 0

1

(c) Ionic

Do not allow ionic with covalent character

1

Contains O^{2-} ions / oxide ions

Equations of the form $O^{2-} + H^+ \rightarrow OH^-$ / $O^{2-} + 2H^+ \rightarrow H_2O$ / $O^{2-} + H_2O \rightarrow 2OH^-$ score M2 and M3

1

These / O^{2-} ions (accept protons to) form OH^- / hydroxide / water (must score M2 to gain M3)

1

(d) (i) $SO_2 + H_2O \rightarrow H^+ + HSO_3^-$

Allow $2H^+ + SO_3^{2-}$ but no ions, no mark

Only score (d)(ii) if (d)(i) correct

1

(ii) Reaction is an equilibrium / reversible reaction displaced mainly to the left / partially ionised / dissociated

Allow reaction does not go to completion

1

(e) SiO_2 reacts with bases / NaOH / CaO / $CaCO_3$

Ignore incorrect formulae for silicate

1

[10]

7

(a) To prevent it coming into contact/reacting with oxygen/air

Allow because it reacts with air/oxygen

And because with air/oxygen it forms an oxide. (Oxide, if identified, must be correct :- P_4O_{10}, P_2O_5, P_4O_6, P_2O_6)

1

(b) One molecule contains 4P and 10O/the molecular formula is P_4O_{10}

Allow exists as P_4O_{10}

Do not allow reference to combination of two P_2O_5 molecules

Ignore any reference to stability

1

(c) P_4O_{10} is a bigger molecule (than SO_3)/greater M_r/more electrons/ greater surface area

Penalise SO_2 for one mark (max 1)

CE = 0 if mention of hydrogen bonding/ionic/ giant molecule/breaking of covalent bonds

1

Van der Waals / vdW forces between molecules are stronger/require more energy to break

Do not allow just more vdW forces

Ignore any reference to dipole-dipole forces

1

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

Allow correct ionic equations

Ignore state symbols

1

pH must be in the range –1 to +2

Allow –1 to +2

Mark independently

1

(e) (i) $3MgO + 2H_3PO_4 \rightarrow Mg_3(PO_4)_2 + 3H_2O$
OR $MgO + 2H_3PO_4 \rightarrow Mg(H_2PO_4)_2 + H_2O$
OR $MgO + H_3PO_4 \rightarrow MgHPO_4 + H_2O$

Allow $MgO + 2H^+ \rightarrow Mg^{2+} + H_2O$

Allow magnesium phosphates shown as ions and ionic equations

Ignore state symbols

1

(ii) MgO is sparingly soluble/insoluble/weakly alkaline

Excess/unreacted MgO can be filtered off/separated

1

(iii) An excess of NaOH would make the lake alkaline/toxic/kill wildlife

Allow pH increases

1

[9]

8 (a) (i) Ionic lattice / solid / giant ionic

CE = 0/2 if molecules / IMFs / atoms / metallic

1

Strong (electrostatic) forces/attraction between ions

Allow strong ionic bonds for M2 only

Allow lot of energy to break ionic bonds

1

(ii) Molecular/molecules

1

Weak dipole-dipole and/or van der Waals forces between molecules

QoL

Type of force must be mentioned

1

(b) P_4O_{10} bigger molecule/has larger surface area than SO_2

Allow M_r of P_4O_{10} greater than for SO_2

If P_4O_{10} macromolecule/ionic, CE = 0/2

1

van der Waals forces between molecules stronger

Allow stronger IMF

1

(c) $Na_2O + H_2O \longrightarrow 2Na^+ + 2OH^-$

Allow 2NaOH

1

14

Allow 12–14

1

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

Allow ions

1

0

Allow –1 to +2

1

(d) $6Na_2O + P_4O_{10} \longrightarrow 4Na_3PO_4$

Allow ionic

Allow correct formula of product with atoms in any order

1

[11]

9 (a) (i) white flame / white light

Mark flame independent of other observations

1

solid / powder / smoke / ash / <u>white fumes</u>

penalise precipitate

penalise wrong colour

if more than one observation for M2 apply list principle. (If an observation is incorrect, the incorrect observation negates a correct one)

1

$2Mg + O_2 \rightarrow 2MgO$

ignore state symbols

allow multiples

1

ionic

do not allow reference to covalent character

1

(ii) blue flame

do not allow any other colour

Mark flame independent of other observations

1

fumes or misty or pungent/choking/smelly gas

do not allow incorrect smell (e.g. bad eggs)

apply list principle as in (a) (i)

do not allow just 'gas' or 'colourless gas'

$S + O_2 \rightarrow SO_2$

ignore state symbols

allow multiples and S_8

1

covalent

penalise giant covalent

1

(b) ionic

If covalent, can only score M3

1

O^{2-} / oxide ion reacts with water / accepts a proton

M2 requires reference to O^{2-} / oxide ion

1

forming OH^- ions/ NaOH / sodium hydroxide
(can show in equation from Na_2O even if incorrect)

allow

1

$O^{2-} + H_2O \rightarrow 2OH^-$ or

$O^{2-} + H^+ \rightarrow OH^-$ to score M2 & M3

also allow equations with spectator Na+ ions on both sides.

1

(c) (heat until) molten

or dissolve in molten cryolite

do not allow solution in water

1

conducts electricity / can be electrolysed / electrolyse and identify Al / O_2 at an electrode

M2 can only be gained if M1 scored

1

(d) insoluble (in water)

allow oxide impermeable to air / water

or oxide is unreactive / inert

1

(e) (i) $Al_2O_3 + 6H^+ \; 2Al^{3+} + 3H_2O$

allow $O^{2-} + 2H^+ \rightarrow H_2O$

and formation of aquated Al^{3+} species

allow spectator Cl^- ions

penalise HCl (not ionic!)

1

(ii) $Al_2O_3 + 2OH^- + 3H_2O \rightarrow 2Al(OH)_4^-$

or $Al_2O_3 + 6OH^- + 3H_2O \rightarrow 2Al(OH)_6^{3-}$

allow formation of $Al(H_2O)_2(OH)_{4-}$

allow Na^+ *spectator ions*

penalise NaOH (not ionic!)

1

[16]

10 (a) Na_2O ionic

mention of molecules/intermolecular forces/delocalised electrons, CE = 0

1

Strong forces between ions/strong ionic bonding

Allow lots of energy to break bonds provided M1 scored

1

SiO_2 macromolecular

Allow giant molecular/giant covalent.

If ions mentioned, CE = 0

1

Strong covalent bonds (between atoms)

Allow lots of energy to break covalent bonds

If breaking intermolecular forces are mentioned, CE = 0 for M4

1

(b) Higher

1

Li^+ (or Li ion) smaller than Na^+

Must imply Li^+ *ion*

Allow Li^+ *has higher charge/size ratio* ***not*** *charge/mass*

1

Attracts O^{2-} ion more strongly

Allow stronger ionic bonding

Allow additional attraction due to polarisation in Li_2O

M3 can only be scored if M2 gained

1

(c) (i) Molecular

Do not allow simple covalent BUT simple covalent molecule scores M1 and M2

1

Covalent bonds (between P and O)

Ignore reference to van der Waals' or dipole-dipole

1

(ii) Weak van der Waals' forces and/or dipole-dipole forces <u>between molecules</u>

Allow weak <u>inter-molecular</u> forces – can score "between" molecules in (c)(i)

CE = 0 if ionic or macromolecular mentioned in (c)(i)

Must state van der Waals' forces are weak OR low energy needed to break van der Waals' forces

1

(d) Allow –1 to +2

1

$P_4O_{10} + 6H_2O \rightarrow 12H^+ + 4PO_4^{3-}$ (or $4H_3PO_4$)

Allow balanced equations to form HPO_4^{2-} or $H_2PO_4^-$

ignore state symbols

1

Allow 12 to 14

1

$Na_2O + H_2O \rightarrow 2Na^+ + 2OH^-$

Allow $2Na^+ + O^{2-}$ on LHS, 2NaOH on RHS, ignore s.s.

Mark independently

1

(e) $6Na_2O + P_4O_{10} \rightarrow 4Na_3PO_4$

1

Acid-base

Allow neutralisation, mark independently of M1

Do not allow Acid + Base → Salt + Water

1

[16]

11 (a) Macromolecular

Or giant molecule
Or giant covalent (also gains M2)
Do not allow giant atomic

Ionic/metallic CE=0 for all 3 marks

1

Covalent bonding (between atoms)

Do NOT allow if between molecules

1

Many/strong bonds to be broken (or lots of energy required)

Lose both bonding marks if contradiction e.g. mention of intermolecular forces
*Note: 'covalent bonds between molecules' loses M2 but **not** M3*

1

(b) Al_2O_3 ionic

Allow ionic + covalent/ionic with covalent character

1

(c) $2Al + 3/2O_2 \rightarrow Al_2O_3$

Allow multiples

Ignore state symbols

1

(d) Insoluble/impermeable/non-porous

Or does not react/inert

Do not allow thick layer

Must imply property of Al_2O_3 *not Al*

1

(e) $Na_2O + H_2O \rightarrow 2NaOH$

Or $Na_2O + H_2O \rightarrow 2Na^+ + 2OH^-$

1

(f) (i) $Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$

Ionic equations with Al_2O_3 *possible*

e.g. $Al_2O_3 + 6H^+ \rightarrow 2Al^{3+} + 3H_2O$

Do not allow formation of Al_2Cl_6

1

(ii) $Al_2O_3 + 2NaOH + 3H_2O \rightarrow 2NaAl(OH)_4$

Other equations with Al_2O_3 *are possible e.g.*

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

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

1

(g) SiO_2 acidic/Lewis acid/electron pair acceptor

1

$SiO_2 + 2NaOH \rightarrow Na_2SiO_3 + H_2O$

*Allow SiO_2 **not** amphoteric*

Do NOT allow BL acid

Other equations with SiO_2 are possible e.g.

$SiO_2 + 2OH^- \rightarrow SiO_3^{2-} + H_2O$

$SiO_2 + 2OH^- + 2H_2O \rightarrow Si(OH)_6^{2-}$

1

[11]

12 (a) Electronegativity increases

1

Proton number increases (increase in nuclear charge)

1

Same number of electron shells/levels

Or same radius or Shielding of outer electrons remains the same

1

Attraction of <u>bond pair</u> to nucleus increases

Allow 'electrons in bond' instead of 'bond pair'

1

(b) Big <u>difference</u> in electronegativity leads to ionic bonding, smaller covalent

Lose a mark if formula incorrect

1

Sodium oxide ionic lattice

1

Strong forces of attraction <u>between ions</u>

1

P_4O_{10} covalent molecular

Must have covalent and molecular (or molecules)

1

Weak (intermolecular) forces between molecules

Or weak vdW, or weak dipole–dipole between molecules

1

melting point Na_2O greater than for P_4O_{10}

Or argument relating mpt to strength of forces

1

(c) Moles NaOH = 0.0212 × 0.5 = 0.0106

M1 moles of NaOH correct

1

Moles of H_3PO_4 = 1/3 moles of NaOH (= 0.00353)

M2 is for 1/3

1

Moles of P in 25000 l = 0.00353 × 10^6 = 3.53 × 10^3

M3 is for factor of 1,000,000

1

Moles of P_4O_{10} = 3.53 × 10^3/4

M4 is for factor of 1/4 (or 1/2 if P_2O_5)

1

Mass of P_4O_{10} = 3.53 × 10^3/4 × 284 = 0.251 × 10^6 g
= 251 kg

(Or if P_2O_5 3.53 × 10^3/2 × 142)
M5 is for multiplying moles by M_r with correct units
allow conseq on incorrect M4
(allow 250-252)

1

[15]

13 (a) (i) Oxide 1 B

1

Oxide 2 E

1

Explanation Low melting point or weak van der Waals' forces between molecules

1

(ii) Chemical test Add water or flame test

1

Test pH or flame colour

1

Observation pH = 13/14 or colour yellow

1

(b) (i) Equation $CaCO_3 \rightarrow CaO + CO$

1

(ii) Product $CaSO_3$

1

(iii) Disposal of large quantities of $CaSO_3$ (allow $CaSO_4$)

1

Produces CO_2 or uses up $CaCO_3$

1

[10]

14 (a) (i) *can form a solution with pH less than 3*: P_4O_{10} or SO_3 **(1)**

(ii) *can form a solution with with a pH greater than 12*: Na_2O **(1)**

penalise any wrong answer to zero

2

(b) (i) $MgO + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2O$ or an ionic equation **(1)**
i.e. $MgO + 2H^+ \rightarrow Mg^{2+} + H_2O$

<u>*not*</u> *$O^{2-} + 2H^+ \rightarrow H_2O$*

(ii) $2NaOH + SiO_2 \rightarrow Na_2SiO_3 + H_2O$ or ionic equation **(1)**
i.e. $SiO_2 + 2OH^- \rightarrow SiO_3^{2-} + H_2O$

(iii) $3Na_2O + 2H_3PO_4 \rightarrow 2Na_3PO_4 + 3H_2O$ etc or ionic equation **(1)**

i.e. $Na_2O + 2H^+ \rightarrow 2Na^+ + H_2O$

3

(c) P_4O_{10} is a molecular (structure) or simple covalent **(1)**
Weak <u>intermolecular forces or van der Waals</u> forces (between molecules) **(1)**
SiO_2 is a macromolecule / giant covalent / giant molecule **(1)**

Not giant lattice

(Strong) <u>covalent</u> bonds (between atoms) must be broken **(1)**

4

[9]