Q1.

This question is about magnesium and its compounds.

(a) State **one** observation when magnesium reacts with steam.

Give an equation, including state symbols, for this reaction.

Observation _____

_____

Equation

_____

(2)

(b) Describe the bonding in magnesium.

_____

_____

_____

_____

(2)

(c) Explain, in terms of structure and bonding, why magnesium chloride has a high melting point.

_____

_____

_____

_____

_____

_____

(3)

(d) Give **one** medical use for magnesium hydroxide.

_____

_____

(1)

(Total 8 marks)

Q2.

This question is about sodium and some of its compounds.

(a) Use your knowledge of structure and bonding to explain why sodium bromide has a melting point that is higher than that of sodium, and higher than that of sodium iodide.

(6)

(b) When 250 mg of sodium were added to 500 cm^3 of water at 25 °C a gas was produced.

Give an equation for the reaction that occurs.
Calculate the volume, in cm^3, of the gas formed at 101 kPa

The gas constant, R = 8.31 J K^{-1} mol^{-1}

Equation _____

Volume _____ cm^3

(6)

(c) Calculate the concentration, in mol dm^{-3}, of sodium ions in the solution produced in the reaction in **part (b)**.

Concentration _____ mol dm^{-3}

(1)

(d) Sodium reacts with ammonia to form the compound $NaNH_2$ that contains the NH_2^- ion.

Draw the shape of the NH_2^- ion.
Include any lone pairs of electrons that influence the shape.

Predict the bond angle.
Justify your prediction.

Shape

Bond angle _____

Justification _____

_____

(4)

(Total 17 marks)

Q3.

(a) Nickel is a metal with a high melting point.

(i) State the block in the Periodic Table that contains nickel.

_____

(1)

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

_____

_____

_____

_____

_____

(2)

(iii) Draw a labelled diagram to show the arrangement of particles in a crystal of nickel.
In your answer, include at least six particles of each type.

(2)

(iv) Explain why nickel is ductile (can be stretched into wires).

_____

_____

_____

(1)

(b) Nickel forms the compound nickel(II) chloride ($NiCl_2$).

(i) Give the full electron configuration of the Ni^{2+} ion.

_____

(1)

(ii) Balance the following equation to show how anhydrous nickel(II) chloride can be obtained from the hydrated salt using $SOCl_2$
Identify **one** substance that could react with both gaseous products.

.....$NiCl_2.6H_2O(s)$ + ... $SOCl_2(g)$ ⟶ .....$NiCl_2(s)$ + ...$SO_2(g)$ + ...$HCl(g)$

Substance _____

(2)

(Total 9 marks)

Q4.

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.

_____

_____

_____

_____

(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)

Q5.

Group 2 metals and their compounds are used commercially in a variety of processes.

(a) Strontium is extracted from strontium oxide (SrO) by heating a mixture of powdered strontium oxide and powdered aluminium.

Consider these standard enthalpies of formation.

	SrO(s)	$Al_2O_3(s)$
$\Delta H_f^{\ominus}$ / kJ mol^{-1}	– 590	– 1669

$$3SrO(s) + 2Al(s) \longrightarrow 3Sr(s) + Al_2O_3(s)$$

Use these data and the equation to calculate the standard enthalpy change for this extraction of strontium.

The use of powdered strontium oxide and powdered aluminium increases the surface area of the reactants.
Suggest **one** reason why this increases the reaction rate.

Suggest **one** major reason why this method of extracting strontium is expensive.

(5)

(b) Explain why calcium has a higher melting point than strontium.

(2)

(c) Magnesium is used in fireworks. It reacts rapidly with oxygen, burning with a bright white light. Magnesium reacts slowly with cold water.

Write an equation for the reaction of magnesium with oxygen.

Write an equation for the reaction of magnesium with cold water.

Give a medical use for the magnesium compound formed in the reaction of magnesium with cold water.

(3)

(Total 10 marks)

Mark schemes

Q1.

(a) Bright light / white light / white powder/ash/solid

1

$Mg(s) + H_2O(g) \rightarrow MgO(s) + H_2(g)$

State symbols essential

1

(b) M1: Attraction between (lattice of) Mg^{2+} ions

M1 attraction between nucleus and delocalised electrons or between + ions and delocalised electrons

1

M2: And <u>delocalised</u> electrons

M2 outer shell electrons delocalised

1

(c) (Giant) ionic lattice / lots of Mg^{2+} and Cl^- ions

1

Strong (electrostatic) forces of attraction

1

Between Mg^{2+} and Cl^- ions

Allow oppositely charged ions

1

(d) Indigestion relief / laxative / neutralise (excess stomach) acid

Allow milk of magnesia

1

[8]

Q2.

This question is marked using Levels of Response. Examiners should apply a 'best-fit' approach to the marking.	
Level 3 5-6 marks	All stages are covered and the explanation of each stage is generally correct and virtually complete. Answer is communicated coherently and shows a logical progression from stage 1 to stage 2 and then stage 3. Coherent communication requires that there is a comparison between the types of bonding and that the bonding is correct for each substance.
Level 2 3-4 marks	All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR two stages are covered and the explanations are generally correct and virtually complete.

	Answer is mainly coherent and shows some progression from stage 1 to stage 2 and then stage 3.
Level 1 1-2 marks	Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR only one stage is covered but the explanation is generally correct and virtually complete. Answer shows some progression between two stages
Level 0 0 marks	Insufficient correct chemistry to gain a mark.

Indicative chemistry content. Contradictions (eg molecules, IMFs, covalent bonding,) negate statements.

Stage 1 - **Na**
1a) Na has metallic bonding
1b) there is attraction/ bonding between the positive nucleus/ ion and the delocalised electrons in Na
1c) Na has a giant/lattice structure

Stage 2 – **NaBr or NaI**
2a) Ionic bonding in NaBr and/or NaI
2b) There is attraction/ bonding between the + and – ions in NaBr and/or NaI
2c) NaBr and/or NaI have a giant/lattice structure

Stage 2 – **comparison of bonding**
3a) The ionic bonds are stronger (or wtte) than the metallic bonds
3b) there is stronger attraction (or wtte) between the + and – ions in NaBr than in NaI
3c) since the Br^- ion is smaller than the I^- ion

6

(b) **M1** $Na + H_2O \rightarrow NaOH + \frac{1}{2} H_2$

Allow multiples

1

M2 (Mass Na = 0.250 g so moles Na = 0.250/23.0) = 0.0109

CE: If not divided by 23, max 3/5 calculation marks – M3, M4 and M5

AE: If not divided by 1000 and final answer is 1.33 × 10^5 cm^3 4/5

1

M3 moles H_2 = 5.43 × 10^{-3} to 5.45 × 10^{-3}

M3 = M2 /2

CE: If incorrect ratio used max 3/5 calculation marks – M2, M4 and M5

1

M4 T = 298 (K) and P = 101000 (Pa)

1

M5 V = nRT/P or (5.435 × 10^{-3} × 8.31 × 298)/101000 or 1.33 × 10^{-4} (m^3)

1

M6 V = 133 – 134 cm^3

Allow to 2 significant figures or more

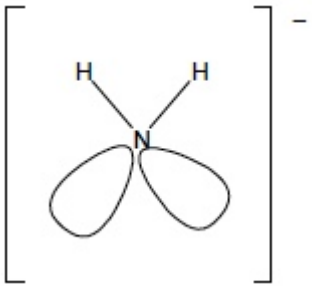
1

(c) Conc = 0.0109/ 500 × 10^{-3} = 0.0217-0.022 (mol dm^{-3})

Allow M2 from question (b)

1

(d) **M1**



Ignore charge and brackets

1

M2 104.5°

Allow 104-106

1

M3 (4) electron pairs repel to be as far apart as possible

1

M4 lp/lp repulsion> lp/bp repulsion (> bp/bp repulsion)

For M4 allow lone pairs repel more than bonding pairs

Mark independently

1

[16]

Q3.

(a) (i) d (block) **OR** D (block)

Ignore transition metals / series.

Do not allow any numbers in the answer.

1

(ii) Contains positive (metal) ions or protons or nuclei and <u>delocalised / mobile / free / sea of</u> electrons

Ignore atoms.

1

<u>Strong attraction</u> between them or <u>strong metallic</u> bonds

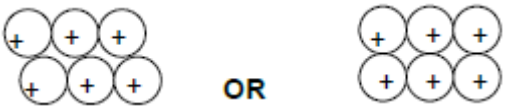
Allow 'needs a lot of energy to break / overcome' instead of 'strong'.

If strong attraction between incorrect particles, then CE = 0 / 2.

If molecules / intermolecular forces / covalent bonding / ionic bonding mentioned then CE=0.

1

(iii)



OR

M1 is for regular arrangement of atoms / ions (min 6 metal particles).

M2 for + sign in each metal atom / ion.

Allow 2^+ sign.

2

(iv) Layers / planes / sheets of atoms or ions can slide over one another

QoL.

1

(b) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ (4s^0)$

Only.

1

(ii) $NiCl_2.6H_2O$ + **6** $SOCl_2$ ⟶ $NiCl_2$ + **6** SO_2 + **12** HCl

Allow multiples.

1

NaOH / NH_3 / $CaCO_3$ / CaO

Allow any name or formula of alkali or base.

Allow water.

1

[9]

Q4.

(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 between molecules

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]

Q5.

(a) **M1 (could be scored by a correct mathematical expression**

*Correct answer to the calculation gains all of **M1**, **M2** and **M3***

M1 $\Delta H = \Sigma \Delta H_f$ (**products**) − $\Sigma \Delta H_f$ (**reactants**)

Credit 1 mark for − 101 (kJ mol^{-1})

OR a correct cycle of balanced equations

M2 = − 1669 − 3(− 590)
= − 1669 + 1770
(This also scores M1)

M3 = **+ 101** (kJ mol^{-1})

Award 1 mark ONLY for − 101

For other incorrect or incomplete answers, proceed as follows

- *check for an arithmetic error (AE), which is either a transposition error or an incorrect multiplication; this would score 2 marks (**M1** and **M2**)*
- *If no AE, check for a correct method; this requires either a correct cycle with 3Sr and 2Al OR a clear statement of **M1** which could be in words and scores **only M1***

M4 - Using powders
Any **one** from

- To increase collision frequency / collisions in a given time / rate of collisions
- To increase the surface contact / contact between the solids / contact between (exposed) particles

Ignore dividing final answer by 3

*Penalise **M4** for reference to molecules.*

5

M5 Major reason for expense of extraction
Any **one** from

- Aluminium is extracted by electrolysis ***OR*** aluminium extraction uses (large amounts of) electricity
- Reaction / process / It / the mixture requires heat
- It is endothermic

(b) Calcium has a higher melting point than strontium, because

Ignore general Group 2 statements.

Correct reference to size of cations / proximity of electrons
M1 (For Ca) delocalised electrons closer to cations / positive ions / atoms / nucleus
OR cations / positive ions / atoms are smaller
OR cation / positive ion / atom or it has fewer (electron) shells / levels

*Penalise **M1** if either of Ca or Sr is said to have more or less delocalised electrons OR the same nuclear charge.*

Ignore reference to shielding.

Relative strength of metallic bonding
M2 (Ca) has stronger attraction between the cations / positive ions / atoms / nucleus and the delocalised electrons
OR
stronger metallic bonding

(assume argument refers to Ca but credit converse argument for Sr)

CE= 0 *for reference to molecules or Van der Waals forces or intermolecular forces or covalent bonds.*

2

(c) **M1** **2**Mg + O_2 ⟶ **2**MgO

M2 Mg + **2**H_2O ⟶ $Mg(OH)_2$ + H_2

Credit multiples of the equations.

M3 Magnesium hydroxide is used as an antacid / relieve indigestion (heartburn) / neutralise (stomach) acidity / laxative

Not simply "milk of magnesia" in ***M3***

3

[10]