PEARSON EDEXCEL IAL CHEMISTRY · YCH11

CHEMISTRY



EXAM QUESTION PACK

UNIT 1: IONIC BONDING

SCORE	PERCENTAGE
/123	%

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Q1.

This question is about the compound ammonium dichromate(VI), $(NH_4)_2Cr_2O_7$.

(a) $(NH_4)_2Cr_2O_7$ breaks down at around 180 °C, producing an oxide of chromium, nitrogen and water as the only products.

(i) Write an equation for the reaction.

State symbols are not required.

(2)

(ii) Give a name for this type of reaction.

(1)

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(b) When 0.00100 mol of ammonium dichromate(VI) was heated, 25.2 cm^3 of nitrogen gas, measured at laboratory temperature, was formed.

Calculate the temperature in the laboratory, in degrees Celsius, using the ideal gas equation. Use atmospheric pressure = 101 kPa.

$$[pV = nRT \quad R = 8.31\,J\,mol^{-1}\,K^{-1}]$$

(4)

(c) (i) Draw a dot-and-cross diagram of the ammonium ion.

Use dots (●) for the nitrogen electrons and crosses (X) for the hydrogen electrons.

(2)

(ii) Explain the shape of the ammonium ion using electron-pair repulsion theory.

(2)

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(d) Ammonium dichromate(VI) comes with several warnings on its packaging.

- This compound is toxic when inhaled and by passing through the skin.
- Handle with extreme caution.
- Contact can irritate and burn the skin and eyes, with possible eye damage.
- Inhaling can irritate the nose and throat.
- Ammonium dichromate(VI) is a strong oxidiser that enhances the combustion of other substances.

(i) Some of the symbols shown are used for ammonium dichromate(VI).

Identify the symbols for ammonium dichromate(VI) by placing a tick (✓) in the box under each relevant symbol.

(2)

(ii) Suggest why ammonium dichromate(VI) is **not** stored in the same cupboard as alkanes.

(1)

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(Total for question = 14 marks)

Q2.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which properties of an **anion** result in it being most easily polarised?

☒ **A** large radius and large charge

☒ **B** large radius and small charge

☒ **C** small radius and small charge

☒ **D** small radius and large charge

(Total for question = 1 mark)

Q3.

This question is about compounds containing chlorine.

(a) A precipitate of silver chloride is formed when silver nitrate solution reacts with sodium chloride solution.

A student wrote an ionic equation for the reaction.

$$Ag^{2+}(l) + 2Cl^{-}(l) \rightarrow AgCl_2(s)$$

Explain why this equation is incorrect, even though it is balanced.

(2)

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(b) A sample of a compound is analysed and found to contain **only** 3.09 g carbon, 0.26 g hydrogen and 9.15 g chlorine.

The molar mass of the compound is 97.0 g mol^{-1}.

Calculate the molecular formula of this compound.

You **must** show your working.

(3)

(c) Nitrogen trichloride has the formula NCl_3.

(i) A sample of nitrogen trichloride contained only nitrogen atoms with mass number 14, and chlorine atoms with mass numbers 35 and 37.

Give the formula and mass/charge ratio for each of the **four** ions responsible for the molecular ion peaks in the mass spectrum of nitrogen trichloride.

(2)

(ii) Complete the table to predict the shape and Cl—N—Cl bond angle in nitrogen trichloride.

(3)

Number of bonding pairs of electrons on nitrogen	
Number of lone pairs of electrons on nitrogen	
Shape of molecule	
Cl—N—Cl bond angle	

(d) Aluminium chloride exists as an ionic lattice in the solid state and as a covalent dimer, Al_2Cl_6, in the gas phase, just above its boiling temperature.

(i) Explain why aluminium chloride in the solid state has significant covalent character.

(2)

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(ii) Describe how two $AlCl_3$ molecules are joined together in the dimer.

Include a diagram in your answer.

(2)

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(Total for question = 14 marks)

Q4.

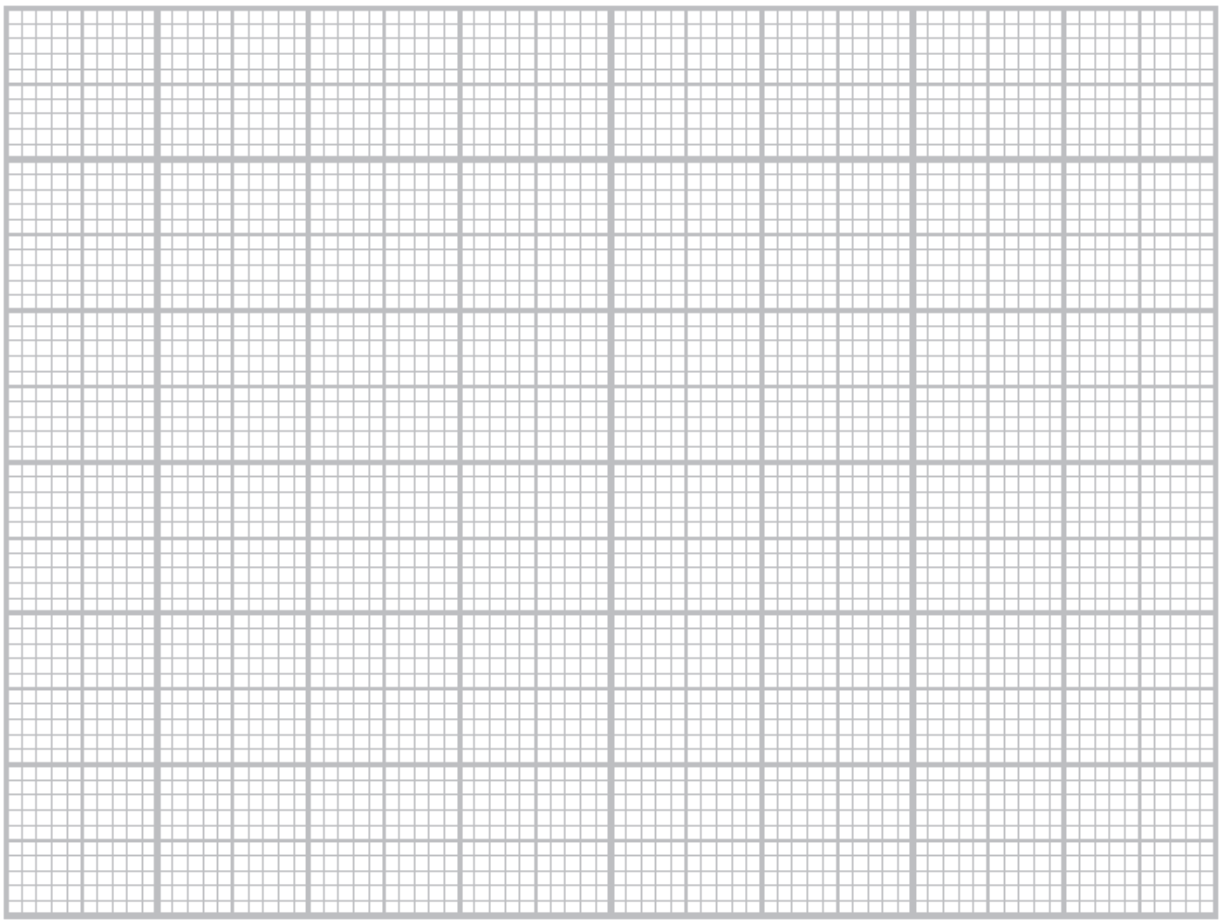
This question is about the elements in Period 3 of the Periodic Table, and some of their compounds.

(a) The atomic radii of six of the elements are given.

Symbol	Na	Mg	Al	Si	P	S	Cl	Ar
Atomic number	11	12	13	14	15	16	17	18
Atomic radius / nm	0.191	0.160	0.130			0.102	0.099	0.095

(i) Plot a graph of atomic radius against atomic number.

(2)



(ii) Use the graph to estimate the atomic radius of silicon, Si.

(1)

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(iii) Suggest an explanation for the decrease in atomic radius as atomic number increases across a period.

(3)

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(b) The melting temperatures of sodium, sodium chloride and chlorine are given in the table.

Complete the table to show the type of structure, the type of bond or force broken on melting and the particles involved.

(6)

Substance	Sodium	Sodium chloride	Chlorine
Melting temperature / °C	98	801	−101
Type of structure	giant		simple molecular
Type of bond or force broken on melting			
Particles involved			chlorine molecules

(c) Solid phosphorus(V) chloride contains PCl_4^+ ions.

(i) Draw a dot-and-cross diagram of a PCl_4^+ ion.

Show only outer shell electrons.

(1)

(ii) Predict the shape of a PCl_4^+ ion.

Justify your answer.

(3)

Shape .....

Justification

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(Total for question = 16 marks)

Q5.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

A drop of an aqueous solution of green copper(II) chromate(VI) is placed in the centre of a strip of damp filter paper.
The ends of the filter paper are connected to a DC power supply.

What is observed after a few minutes?

☒ **A** a green colour has moved to the negative end

☒ **B** a green colour has moved to the positive end

☒ **C** a yellow colour has moved to the positive end and a blue colour to the negative end

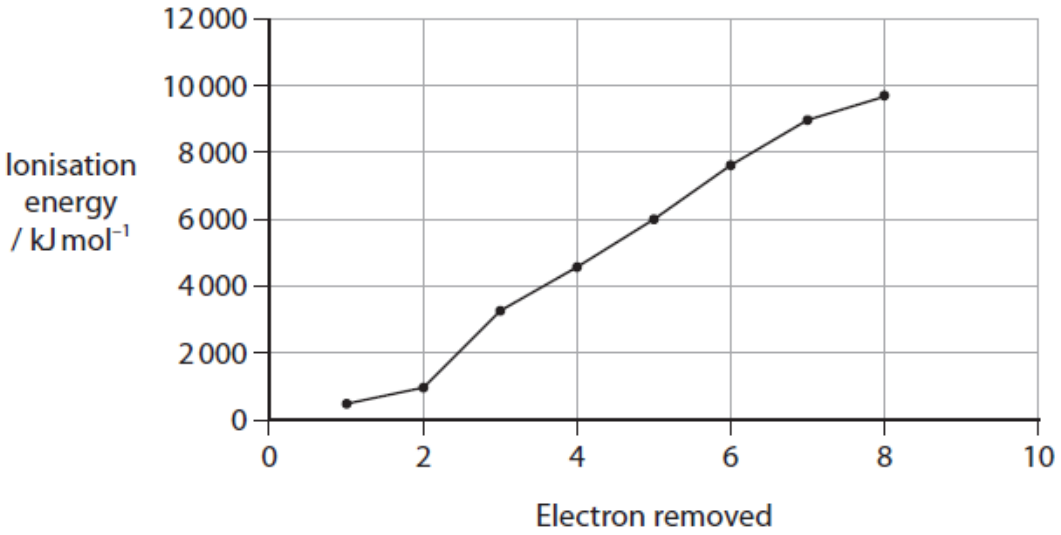
☒ **D** a blue colour has moved to the positive end and a yellow colour to the negative end

(Total for question = 1 mark)

Q6.

This question is about barium and barium compounds.

(a) The graph shows the first eight ionisation energies of barium.



(i) Write an equation, including state symbols, for the **third** ionisation energy of barium.

(1)

(ii) State how the graph confirms that barium is in Group 2 in the Periodic Table.

(1)

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(b) An acidified aqueous solution of barium chloride, $BaCl_2$, is used to test for sulfate ions.

(i) Draw a dot-and-cross diagram for barium chloride.

Show the outer electrons only.

(2)

(ii) Calculate the mass of barium chloride needed to form 150 cm^3 of $BaCl_2(aq)$ with a concentration of 0.200 mol dm^{-3}.

Give your answer to an appropriate number of significant figures.

(2)

(iii) The barium chloride solution is acidified to prevent carbonate ions giving a false positive result.

Write the **ionic** equation for the reaction of hydrochloric acid with carbonate ions. State symbols are not required.

(1)

(c) Give a reason why solid barium chloride does not conduct electricity.

(1)

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(Total for question = 8 marks)

Q7.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which properties of a **cation** result in the greatest polarising power?

☒ **A** large radius and large charge

☒ **B** large radius and small charge

☒ **C** small radius and small charge

☒ **D** small radius and large charge

(Total for question = 1 mark)

Q8.

The ionic radius of Al^{3+} is smaller than that of N^{3-}.

This is because Al^{3+} has

☒ **A** fewer protons but more electrons than N^{3-}

☒ **B** more protons but fewer electrons than N^{3-}

☒ **C** more protons than N^{3-} but the same number of electrons as N^{3-}

☒ **D** the same number of protons as N^{3-} but fewer electrons

(Total for question = 1 mark)

Q9.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which pair of ions will form the compound with the most covalent character?

☒ **A** Li^+ and I^-

☒ **B** Na^+ and Br^-

☒ **C** K^+ and Cl^-

☒ **D** Rb^+ and F^-

(Total for question = 1 mark)

Q10.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Covalent bonding is best described as the electrostatic attraction between

☒ **A** oppositely charged ions

☒ **B** positive ions and delocalised electrons

☒ **C** a shared pair of electrons

☒ **D** two nuclei and a shared pair of electrons

(Total for question = 1 mark)

Q11.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

Which of these has the **greatest** electrical conductivity?

☒ **A** $SF_6(g)$

☒ **B** $H_2O(l)$

☒ **C** $Hg(l)$

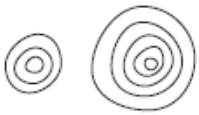
☒ **D** $Na_2O(s)$

(Total for question = 1 mark)

Q12.

Which diagram best represents the electron density map of a hydrogen chloride molecule?

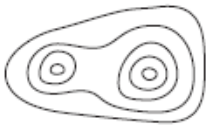
☒ **A**



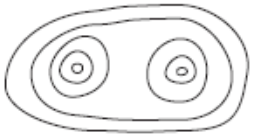
☒ **B**



☒ **C**



☒ **D**



(Total for question = 1 mark)

Q13.

This question is about the chlorides of beryllium and calcium.

(a) Complete the electronic configurations of the atoms of beryllium and calcium using the s, p, d notation.

(2)

Be $1s^2$

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Ca $1s^2$

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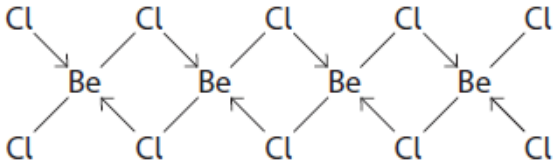
(b) In the gaseous state, beryllium chloride is molecular.

Draw a dot-and-cross diagram to show the bonding in a molecule of beryllium chloride, $BeCl_2$.

(2)

(c) In the solid state, beryllium chloride forms a polymeric structure.

The diagram shows part of this structure.



The diagram uses lines and arrows to represent the two different types of covalent bond.

Describe how each type of bond is formed.

(2)

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(d) The Cl—Be—Cl bond angle is different in the two forms of beryllium chloride.

Predict the two bond angles, justifying your answers by referring to electron-pair repulsion theory.

(4)

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(e) Anhydrous calcium chloride is a crystalline, ionic solid which melts at 772 °C.

Draw a dot-and-cross diagram for calcium chloride.
Show the outer electrons only.

(2)

(f) Explain why gaseous beryllium chloride and solid calcium chloride have different types of bonding.

(3)

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(Total for question = 15 marks)

Q14.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which row in the table shows the correct forces in a crystal of lithium iodide?

	Attractive forces between ions with opposite charges	Repulsive forces between ions with like charges	Some covalent bonding forces
☒ **A**	✓	X	X
☒ **B**	✓	✓	X
☒ **C**	✓	X	✓
☒ **D**	✓	✓	✓

Use this space for any rough working. Anything you write in this space will gain no credit.

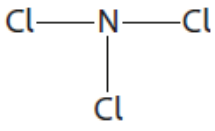
(Total for question = 1 mark)

Q15.

This question is about the structure and bonding of Group 5 chlorides.

(a) Nitrogen trichloride, NCl_3 , has a molecular structure.

The displayed formula of a molecule of NCl_3 is shown.



Complete the table for this molecule.

(3)

Number of bond pairs around N atom	
Number of lone pairs around N atom	
Cl-N-Cl bond angle	
Name of shape of molecule	

(b) Under standard conditions, phosphorus(V) chloride (PCl_5) is a solid made up of PCl_4^+ cations and PCl_6^- anions.

Antimony(V) chloride ($SbCl_5$) is a liquid made up of $SbCl_5$ molecules.

(i) Explain why PCl_5 has a higher melting temperature than $SbCl_5$.

(2)

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(ii) Draw a dot-and-cross diagram to show the bonding in a molecule of $SbCl_5$.

Use dots (•) to represent the Sb electrons, and crosses (**x**) to represent the Cl electrons. Show outer electrons only.

(2)

(c) At low temperatures, $SbCl_5$ converts to Sb_2Cl_{10} which contains dative covalent bonds.

(i) State what is meant by the term dative covalent bond.

(1)

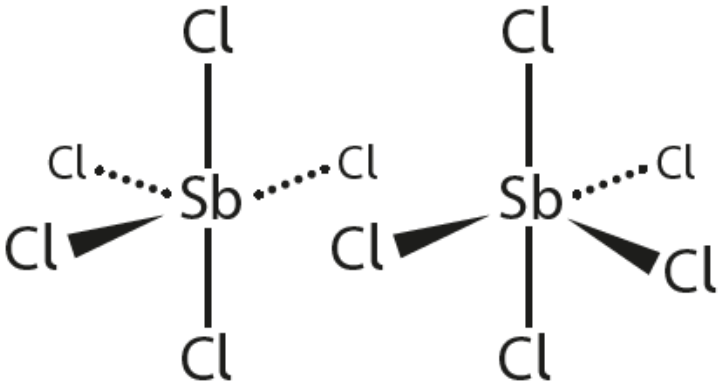
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(ii) Complete the diagram to show the dative covalent bonds in Sb_2Cl_{10} .

(1)



(d) Arsenic also forms a pentachloride with the formula $AsCl_5$.

Give **one** possible reason why nitrogen is the only Group 5 element that does **not** form a pentachloride.

(1)

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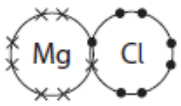
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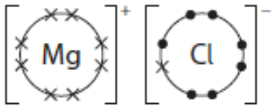
Q16.

Which is the dot-and-cross diagram for magnesium chloride?

Only outer shell electrons are shown.

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(Total for question = 1 mark)

Q17.

Which ion has the greatest polarising power?

☒ **A** Cl^-

☒ **B** Mg^{2+}

☒ **C** Na^+

☒ **D** S^{2-}

(Total for question = 1 mark)

Q18.

Some ionic radii are shown.

Ion	Ionic radius / nm
Na^+	0.102
K^+	0.138
F^-	0.133
Cl^-	0.180

Which compound has the strongest ionic bonding?

(1)

☒ **A** sodium fluoride

☒ **B** sodium chloride

☒ **C** potassium fluoride

☒ **D** potassium chloride

(Total for question = 1 mark)

Q19.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which of these ions has the smallest ionic radius?

(1)

☒ **A** Al^{3+}

☒ **B** Ga^{3+}

☒ **C** Mg^{2+}

☒ **D** F^{-}

(Total for question = 1 mark)

Q20.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

Which of these ions has the **greatest** ionic radius?

☒ **A** N^{3-}

☒ **B** F^{-}

☒ **C** Na^{+}

☒ **D** Al^{3+}

(Total for question = 1 mark)

Q21.

In which pair are the ions isoelectronic?

(1)

☒ **A** Ca^{2+} and S^{2-}

☒ **B** K^{+} and Br^{-}

☒ **C** Li^{+} and F^{-}

☒ **D** Mg^{2+} and Cl^{-}

(Total for question = 1 mark)

Q22.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which of these isoelectronic ions has the smallest ionic radius?

☒ **A** N^{3-}

☒ **B** F^{-}

☒ **C** Na^{+}

☒ **D** Al^{3+}

(Total for question = 1 mark)

Q23.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which of these compounds would you expect to have the highest melting temperature?

☒ **A** NaCl

☒ **B** NaF

☒ **C** KCl

☒ **D** KF

(Total for question = 1 mark)

Q24.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Element **X** is in Group 2 of the Periodic Table and element **Y** is in Group 7. **X** and **Y** are not the symbols of the elements.

(a) What is the formula of the compound formed from **X** and **Y**?

(1)

☒ **A** **XY**

☒ **B** $\mathbf{X_2Y}$

☒ **C** $\mathbf{XY_2}$

☒ **D** $\mathbf{X_2Y_2}$

(b) Under what conditions does the compound formed from **X** and **Y** conduct electricity?

(1)

☒ **A** in the solid state and in the liquid state and in aqueous solution

☒ **B** in the solid state and in aqueous solution only

☒ **C** in the solid state and in the liquid state only

☒ **D** in the liquid state and in aqueous solution only

(Total for question = 2 marks)

Q25.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

A p-block element in **Period 3** of the Periodic Table reacts to form an ionic compound.

What could be the electronic configuration of the **ion** formed by this element?

☒ **A** $1s^2 2s^2 2p^6 3s^2$

☒ **B** $1s^2 2s^2 2p^6 3s^2 3p^6$

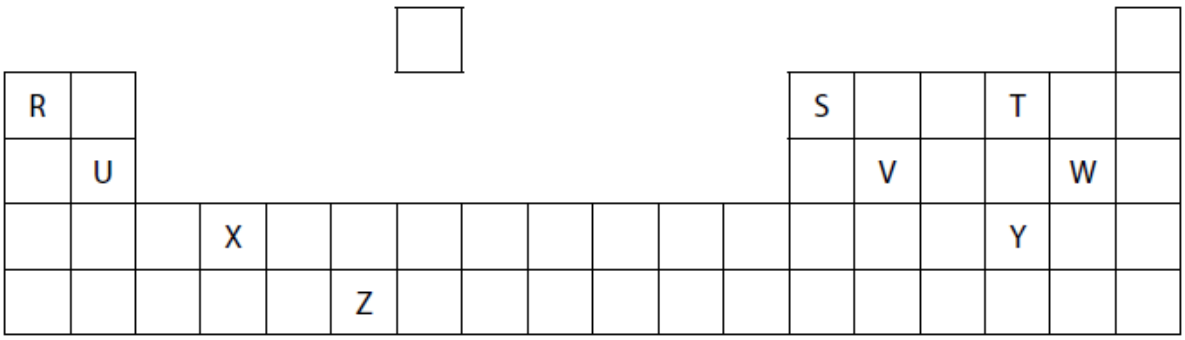
☒ **C** $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$

☒ **D** $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$

(Total for question = 1 mark)

Q26.

An outline of part of the Periodic Table is shown.
The letters are not the usual symbols of the elements.



(a) Which elements are in the s-block of the Periodic Table?

(1)

☒ **A** R and U

☒ **B** T and Y

☒ **C** V and W

☒ **D** X and Z

(b) Which element has four occupied quantum shells, with six electrons in the outermost shell?

(1)

☒ **A** V

☒ **B** X

☒ **C** Y

☒ **D** Z

(c) In which pair do the ions have the same electronic configuration?

(1)

☒ **A** R^{+} and T^{2-}

☒ **B** T^{2-} and Y^{2-}

☒ **C** U^{2+} and T^{2-}

☒ **D** U^{2+} and W^{-}

(Total for question = 3 marks)

Q27.

Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Some physical properties of five substances are shown.
The letters are **not** element symbols.

Substance	Electrical conductivity			Melting temperature /°C
	Solid	Liquid	Solution in water	
L	poor	good	good	770
M	good	good	reacts	98
N	good	good	insoluble	1083
P	poor	poor	insoluble	113
Q	poor	poor	good	10

(a) Which of these substances could be metals?

☒ **A** N only

☒ **B** L and M only

☒ **C** M and N only

☒ **D** L, M and N only

(b) Which substance has properties showing that it changes from a molecular structure to ions when it dissolves in water?

☒ **A** L

☒ **B** M

☒ **C** P

☒ **D** Q

(Total for question = 2 marks)

Q28.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which ion is the most polarisable?

☒ **A** Mg^{2+}

☒ **B** Ca^{2+}

☒ **C** Cl^{-}

☒ **D** I^{-}

(Total for question = 1 mark)

Q29.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

Which of these ions has the **greatest** polarising power?

☒ **A** S^{2-}

☒ **B** Cl^{-}

☒ **C** K^{+}

☒ **D** Ca^{2+}

(Total for question = 1 mark)

Q30.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which of these isoelectronic ions has the **largest** radius?

☒ **A** Na^{+}

☒ **B** Mg^{2+}

☒ **C** O^{2-}

☒ **D** F^-

(Total for question = 1 mark)

Q31.

Magnesium is a metal in Group 2 of the Periodic Table. It reacts with chlorine to form the salt magnesium chloride, $MgCl_2$.

(a) Draw a dot-and-cross diagram for magnesium chloride.

Show outer shell electrons only.

(1)

(b) Magnesium conducts electricity when it is in the solid state. Magnesium chloride conducts electricity when it is molten or dissolved in water but not when it is in the solid state.

Explain these observations.

(3)

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(c) Magnesium chloride can also be made by reacting magnesium oxide with dilute hydrochloric acid.

$$MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$$

(i) Write the **ionic** equation, including state symbols, for this reaction.

(1)

(ii) Calculate the minimum volume of 2.00 mol dm^{-3} hydrochloric acid needed to completely react with 2.45 g of magnesium oxide.

(3)

Minimum volume of hydrochloric acid = ... cm^3

(d) A further method for making magnesium chloride is by reacting magnesium carbonate with dilute hydrochloric acid.

$$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l) + CO_2(g)$$

Calculate the maximum mass of magnesium chloride that could be formed when 2.25 g of magnesium carbonate is added to excess dilute hydrochloric acid.

(2)

Maximum mass magnesium chloride = ... g

(e) Explain why the reaction to make magnesium chloride from magnesium oxide has a higher atom economy than the reaction using magnesium carbonate.

No calculation is required.

(2)

.....

.....

.....

.....

(Total for question = 12 marks)

Q32.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Ammonium iron(II) sulfate, $(NH_4)_2Fe(SO_4)_2 \cdot 6H_2O$, is a double salt that is used as a source of iron(II) ions.

(a) What is the relative formula mass of the double salt?

[A_r values: H = 1.0 N = 14.0 O = 16.0 S = 32.1 Fe = 55.8]

(1)

☒ **A** 277.9

☒ **B** 284.0

☒ **C** 392.0

☒ **D** 447.8

(b) Ammonium sulfate is used in the preparation of the double salt.

What types of bond are present in ammonium sulfate?

(1)

☒ **A** ionic only

☒ **B** covalent and ionic only

☒ **C** dative covalent and ionic only

☒ **D** ionic, covalent and dative covalent

(c) What is the **total** number of ions present in 0.1 mol of the double salt?

[Avogadro constant (L) = 6.02×10^{23} mol^{-1}]

(1)

☒ **A** 1.80×10^{23}

☒ **B** 2.41×10^{23}

☒ **C** 3.01×10^{23}

☒ **D** 6.62×10^{23}

(Total for question = 3 marks)

Q33.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which pair of ions gives the strongest ionic bonding?

☒ **A** Na^+ and F^-

☒ **B** K^+ and Br^-

☒ **C** Mg^{2+} and O^{2-}

☒ **D** Ca^{2+} and S^{2-}

(Total for question = 1 mark)

Q34.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which statement is **not** true for sodium chloride?

☒ **A** sodium chloride conducts electricity in aqueous solution

☒ **B** sodium chloride conducts electricity when molten

☒ **C** sodium chloride has a molecular structure

☒ **D** sodium chloride has a giant structure

(Total for question = 1 mark)

Q35.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

In which series are the ions in order of **decreasing** ionic radius?

☒ **A** $Al^{3+} > Mg^{2+} > Na^{+}$

☒ **B** $Li^{+} > Na^{+} > K^{+}$

☒ **C** $N^{3-} > O^{2-} > F^{-}$

☒ **D** $O^{2-} > S^{2-} > Se^{2-}$

(Total for question = 1 mark)

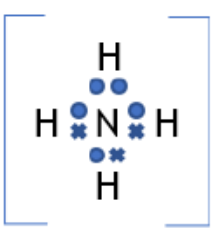
Mark Scheme

Q1.

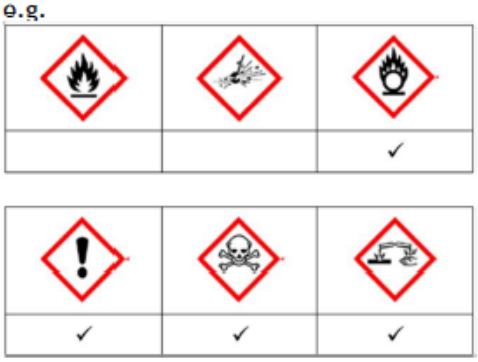
Question Number	Answer	Additional guidance	Mark
(a)(i)	• $(NH_4)_2Cr_2O_7 \rightarrow N_2 + 4H_2O + Cr_2O_3$	1 mark for Cr_2O_3 1 mark for all the rest being correct Allow multiples Marks are standalone	(2)

Question Number	Answer	Additional guidance	Mark
(a)(ii)	• (thermal) decomposition **or** redox	Ignore oxidation or reduction on their own	(1)

Question Number	Answer	Additional guidance	Mark
(b)	• conversion of units for *P* and *V* (1) • substitution in equation and rearrange (1) • answer in K (1) • convert to °C (1)	Example of calculation: $P = 101000 / 1.01 \times 10^5$ Pa $V = 0.0000252 / 2.52 \times 10^{-5}$ m^3 Allow incorrect use standard form e.g. 10.1×10^4 Pa $T = \frac{101000 \times 0.0000252}{0.001 \times 8.31}$ $T = 306.28$ (K) $T = 33.3$(°C) (33.1°C if 273.15 is used for conversion of kelvin to Celsius) Ignore SF except 1 SF on final answer TE throughout but only award for MP4 if final answer in °C is between 0 and 50°C Units if given must be correct *Comment:* *Correct answer with no working scores 4* *306.28(K) scores 3* *30.85 °C scores 3* *33.7 °C scores 3 as they have used R as 8.3* *33.55 °C scores 3 using 8.3 and 273.15* *306.7K scores 2 as they have used R as 8.3*	(4)

Question Number	Answer	Additional guidance	Mark
(c)(i)	A drawing that shows: • four pairs of electrons and 4 hydrogen atoms around nitrogen (1) • one dative covalent bond **and** plus sign (1)	 Allow answers without brackets Allow use of any symbol for the electrons as long as it is clear which is the dative covalent bond (e.g. by use of an arrow) Ignore placement of positive sign	(2)

Question Number	Answer	Additional guidance	Mark
(c)(ii)	An explanation that makes reference to: • tetrahedral / tetrahedron (1) • (four) **pairs of electrons** arranged in position of minimum repulsion / maximum separation (1)	MP1 may be scored with a 3D diagram or an answer given in 19(c)(i) Allow phonetic spelling Allow equal repulsion of electron-pairs Allow reference to bonding pairs Ignore reference to bonds Ignore all bond angles Do not award references to lone pairs Marks are standalone	(2)

Question Number	Answer	Additional guidance	Mark
(d)(i)	Four correct ticks scores 2 marks, Three correct ticks scores 1 mark Four correct ticks and one incorrect tick scores 1 mark	e.g.  	(2)

Question Number	Answer	Additional guidance	Mark
(d)(ii)	An answer containing an appropriate suggestion: • dichromate/oxidising agents promote(s) combustion/burning of alkanes/fuels OR alkanes are flammable/combustible **and** dichromate is an oxidising agent	Allow fuels/alkanes would catch fire more easily Ignore dichromate causes alkanes to burn Do not award dichromate catches fire	(1)

Q2.

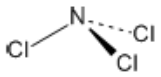
Question Number	Answer	Mark
	The only correct answer is A (large radius and large charge) **B** *is not correct because the charge should be large* **C** *is not correct because the charge and radius should be large* ***D*** *is not correct because radius should be large*	(1)

Q3.

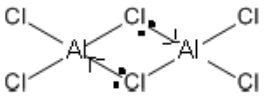
Question number	Answer	Additional guidance	Mark
24(a)	An explanation that makes reference to the following points: • (I) is incorrect because the solutions are aqueous **or** ions are (in the) aqueous (state) the state symbols should be (aq) instead of (I) • silver ions should have one positive charge / Ag^+ **or** silver chloride is AgCl	Allow silver nitrate and sodium chloride are aqueous Do not award if incorrect state symbol for one of the species in the equation e.g. Ag is (s) / AgCl is (aq) Ignore just the charge on the silver ion is incorrect / the formula of silver chloride is incorrect	**(2)**

Question number	Answer	Additional guidance	Mark
(b)	• calculation of mol of C, H and Cl **(1)** • calculation of empirical formula **(1)** • calculation of molecular formula **(1)**	Example of calculation: C : H : Cl mol $\frac{3.09}{12} : \frac{0.26}{1} : \frac{9.15}{35.5}$ = 0.2575 : 0.26 : 0.2577 (ratio 1 : 1 : 1) Empirical formula is CHCl molar mass CHCl = 12 + 1 + 35.5 = 48.5 $\frac{\text{molar mass } (CHCl)_n}{\text{molar mass CHCl}} = \frac{97}{48.5} = 2$ Molecular formula is $C_2H_2Cl_2$ Allow symbols in any order Do not award 2CHCl Ignore SF in mol and ratio Correct molecular formula with some working scores (3) **Alternative method** scores (3) no. C atoms = $\frac{3.09 \times 97}{12.5 \times 12} = 2 / 1.9982$ no. H atoms = $\frac{0.26 \times 97}{12.5 \times 1} = 2(.0176)$ no. Cl atoms = $\frac{9.15 \times 97}{12.5 \times 35.5} = 2$	**(3)**

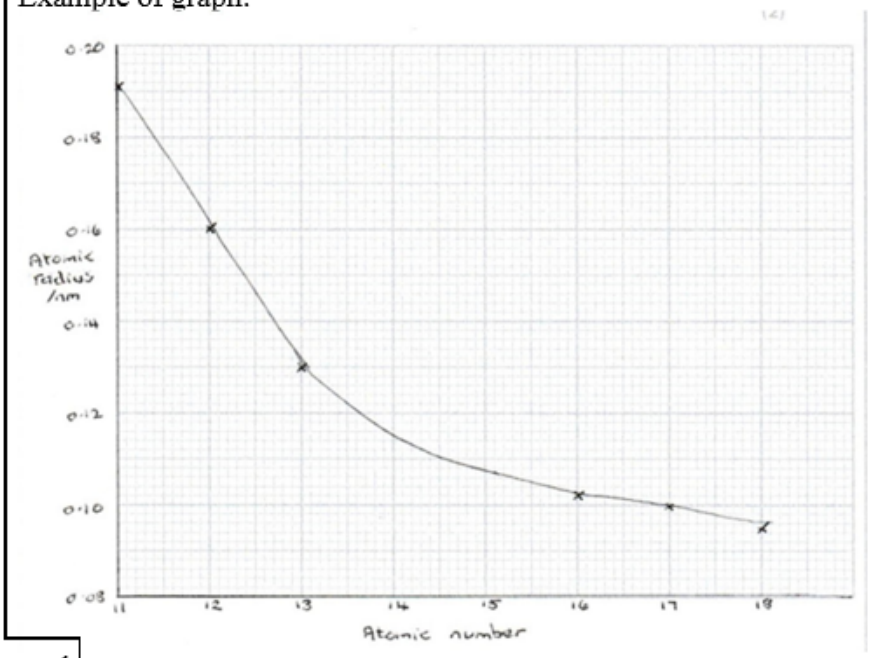
Question number	Answer	Additional guidance	Mark
(c)(i)	• all 4 ion formulae • all 4 (corresponding) *m* / *z* values	Example of answer: ions *m* / *z* $N(^{35}Cl)_3^+$ 119 $N(^{35}Cl)_2{}^{37}Cl^+$ 121 $N^{35}Cl(^{37}Cl)_2^+$ 123 $N(^{37}Cl)_3^+$ 125 Allow any other unambiguous way of representing the formulae e.g. in words Allow (1) for any two *m* / *z* values with corresponding ion formulae Ignore missing / incorrect charge on ion Ignore mass number on N Ignore bonds or + between Cl atoms / order of atoms e.g. $N\text{-}^{35}Cl\text{-}^{35}Cl\text{-}^{35}Cl$	(2)

Question number	Answer	Additional guidance	Mark
(c)(ii)	• number of bonding pairs **and** number of lone pairs • shape • bond angle	Example of table: Number of bonding pairs of electrons on nitrogen: 3 Number of lone pairs on electrons on nitrogen: 1 Shape of molecule: trigonal pyramidal Bond angle: 107° **Shape:** Allow 3-dimensional drawing e.g.  There must be at least 1 dotted/dashed line or wedge for 3-d Allow just 'pyramidal' Allow pyramid for pyramidal Do not award tetrahedral **Bond angle:** Allow any number in the range 106-108° Ignore missing °	(3)

Question number	Answer	Additional guidance	Mark
24(d)(i)	An explanation that makes reference to one of the following pairs of points: **Polarisation route** • an aluminium ion / cation is (very) small **and** highly charged **or** Al^{3+} has a small ionic radius / is small • so it polarises / distorts the chloride ion / Cl^- / anion **Allow Electronegativity route** • there is a (relatively) small difference in electronegativity between aluminium and chlorine • so the electrons are (partially) shared	Marks must come from the same route – maximum 1 mark if one point from one route and one point from the other route Allow the aluminium ion has a high charge density Allow a description of polarisation Allow chlorine anion / ion Ignore the aluminium chloride is polarised Ignore size of chloride ion	(2)

Question number	Answer	Additional guidance	Mark
24(d)(ii)	A description including the following points: • diagram showing two $AlCl_3$ molecules joined through two chlorine atoms • dative (covalent) bonds **or** coordinate bonds	Example of diagram:  Allow dot-and-cross diagram Ignore missing arrow heads and lone pairs from diagram Do not award diagram with Al-Al / Cl-Cl bond(s) Allow dative covalent bonds labelled on diagram / shown as arrows from Cl to Al Allow description of dative bonds Allow M2 even if only 1 dative bond shown / mentioned Do not award M2 if dative bonds starting from aluminium Do not award M2 for any answer that mentions ions / ionic bonds	**(2)**

Q4.

Q	Answer	Additional guidance	Mark
(a)(i)		Example of graph:  	**2**
	• axes correct and labelled with atomic radius /nm and atomic number **(1)**	Allow y axis with 191 etc and label as pm or x 10^{-3} nm Ignore symbols on x axis Do not award M1 if x axis scale starts at 0	
	• points plotted correctly **(1)**	The points for Si / atomic number 14 and P / atomic number 15 do not need to be marked Accept graph with or without line drawn **Comment** If atomic radius is plotted on the x axis, allow (1) for correct graph	

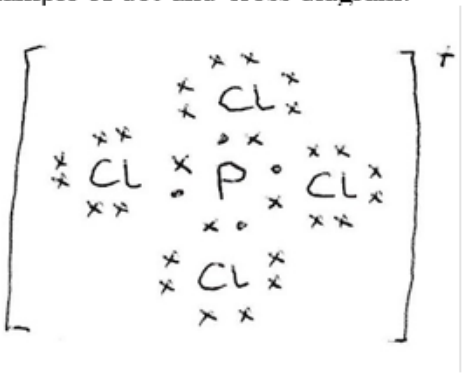
Q	Answer	Additional guidance	Mark
(a)(ii)	• value in allowed range	Allow 0.112 to 0.118 (nm) Allow value written in table Ignore any value given for phosphorus	**1**

Q	Answer	Additional guidance	Mark
(a)(iii)	An explanation that makes reference to the following points: • (as the atomic number increases / across the period) the nuclear charge increases / the number of protons (in the nucleus) increases **(1)** **Any two from:** • this is only partially offset by the increased electron (-electron) repulsion as the number of electrons in the (outer) shell increases **(1)** • the electrons are all the same (quantum) shell / experience similar shielding **(1)** • so there is an increase in attractive force between the nucleus and (outer) electrons **(1)**	Allow effective nuclear charge increases Allow the same amount of shielding Allow same number of (occupied quantum) shells Do not award electrons in the same subshell / orbital	**3**

Q	Answer	Additional guidance	Mark
(b)	• giant for structure of sodium chloride **(1)** • metallic bonding for sodium **(1)** • ionic bonding for sodium chloride **(1)** • intermolecular (forces) for chlorine **(1)** • Na^+ **and** electrons / cations **and** electrons (particles in sodium) **(1)** • Na^+ **and** Cl^- /cations **and** anions (particles in sodium chloride) **(1)**	Allow giant ionic / (giant) lattice Ignore metal Ignore ion(s) Ignore electrostatic attractions in M2 and M3 Accept London / dispersion (forces) Allow van der Waals' (forces) Ignore weak (forces) Allow positive ions **and** electrons Allow sodium atoms / ions **and** electrons Allow positive (sodium) ion and negative (chloride / chlorine) ion Ignore just sodium ions and chloride ions Penalise incorrect charge on an ion once only e.g. Na^{2+}	**6**

Example of table:

Substance	Sodium	Sodium chloride	Chlorine
Melting temperature /°C	(98)	(801)	(−101)
Type of structure	(giant)	giant	(simple molecular)
Type of bond or force broken on melting	metallic	ionic	intermolecular forces
Particles involved	Na^+ **and** electrons / cations **and** electrons	Na^+ **and** Cl^- /cations **and** anions	(chlorine molecules)

Q	Answer	Additional guidance	Mark
(c)(i)	• correct dot-and-cross diagram	Example of dot-and-cross diagram:  Allow any combination of dots and crosses, including all dots or all crosses Allow overlapping circles Allow electrons in bonds along the axis of the bond Ignore missing bracket and charge Ignore lines representing covalent bonds e.g. x	1

Q	Answer	Additional guidance	Mark
(c)(ii)	• Shape – tetrahedral **(1)** • Justification – (four) bonding pairs /pairs of electrons (around P) **(1)** • (electron pairs) arranged to minimise repulsion **(1)**	Stand alone No TE on (c)(i) for shape Allow the number of electron pairs shown in (c)(i) Allow regions of electron density for electron pairs Ignore reference to lone pair-lone pair / lone pair-bond pair repulsion Allow (electron pairs) arranged for maximum separation / as far apart as possible Ignore electron pairs repel equally Penalise use of bonds for electron pairs once only in M2 and M3	3
			(Total for Question = 16 marks)

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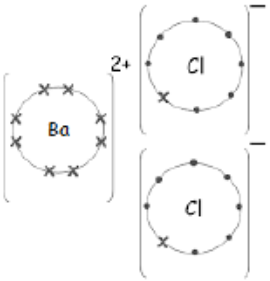
Q5.

Question Number	Answer	Mark
	The only correct answer is C (a yellow colour has moved to the positive end and a blue colour to the negative end) **A** *is not correct because the green colour is formed from yellow and blue ions* **B** *is not correct because the green colour is formed from yellow and blue ions* **D** *is not correct because the blue Cu^{2+} ions will move to the negative end and the yellow CrO_4^{2-} ions will move to the positive end*	(1)

Q6.

Question Number	Correct Answers	Additional Guidance	Mark
(a)(i)	$Ba^{2+}(g) \rightarrow Ba^{3+}(g) + e^{(-)}$ OR $Ba^{2+}(g) - e^{(-)} \rightarrow Ba^{3+}(g)$	Allow $e^{(-)}(g)$ / $1e^{(-)}$ Do not award multiples Allow ions shown as $Ba^{+2}(g)$ and $Ba^{+3}(g)$ Allow Ba^{++} / Ba^{+++} Comment – allow lower case 'ba^{2+}' etc	1

Question Number	Correct Answers	Additional Guidance	Mark
(a)(ii)	An answer that makes reference to the following: • there is a **large** increase (in ionisation energy) **and** • between the 2nd and 3rd ionisations	Note – there must be some indication of a significant increase Allow just there is a jump Allow 'after 2 electrons are removed' / between the 2nd and 3rd electrons Ignore comments related to first ionisation energy	1

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(i)	An answer that makes reference to one of the following points: • barium ion shown correctly (1) • one chloride ion shown correctly **and** an indication of two chloride ions present (1) example of dot-and-cross diagram  	Allow barium ion with no electrons shown Allow lower case 'ba' Ignore any inner shells shown for Ba^{2+} If inner shells shown for Cl^- they must be correct Allow all dots or all crosses Ignore absence of square brackets Ignore any working Do not award covalent diagrams Comment If all charges are omitted, we assume the bonding is covalent so scores zero	2

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(ii)	• calculation of moles of barium chloride (1) • calculation of mass of barium chloride to 2 or 3 SF (1)	<u>Example of calculation</u> $0.200 \times (150 \div 1000) = 0.03$ (mol) Ignore units in M1 even if incorrect $0.03 \times 208.3 = 6.249$ = 6.2 / 6.25 (g) Do not award 6.3 Ignore absence of units but if given must be correct in M2 Correct answer with no working scores 2 marks Allow 0.03 x 208 = 6.24 / 6.2 for M2 Allow TE from M1 to M2	2

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(iii)	$2H^+ + CO_3^{2-} \rightarrow H_2O + CO_2$	Accept $2H_3O^+ + CO_3^{2-} \rightarrow 3H_2O + CO_2$ Allow H_2CO_3 Allow multiples Ignore state symbols even if incorrect Do not award uncancelled chloride ions	1

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)	An answer that makes reference to the following point: • (the) ions are not free to move (and carry charge) / (the) ions are in a fixed position (so cannot carry charge)	Do not award 'electrons are not free to move' Do not award if any statement that $BaCl_2$ is covalent	1

Q7.

Question Number	Answer	Mark
	The only correct answer is D (small radius and large charge) *A is not correct because radius should be small* **B** *is not correct because the radius should be small and the charge should be large* **C** *is not correct because the charge should be large*	(1)

Q8.

Question number	Answer	Mark
	The only correct answer is C *(more protons than N^{3-} but the same number of electrons as N^{3-})* ***A*** *is incorrect because Al^{3+} has more protons and the same number of electrons as N^{3-}* ***B*** *is incorrect because Al^{3+} has the same number of electrons as N^{3-}* ***D*** *is incorrect because Al^{3+} has more protons and the same number of electrons as N^{3-}*	**(1)**

Q9.

Question number	Answer	Mark
	The only correct answer is A (Li^+ and I^-) *B is incorrect because the positive ion is larger and the negative ion is smaller than* LiI *C is incorrect because the positive ion is larger and the negative ion is smaller than* LiI *D is incorrect because the positive ion is larger and the negative ion is smaller than* LiI	**(1)**

Q10.

Question Number	Answer	Mark
	The only correct answer is D (two nuclei and a shared pair of electrons) **A** *is not correct because this describes ionic bonding* **B** *is not correct because this describes metallic bonding* **C** *is not correct because electrons do not attract one another*	**(1)**

Q11.

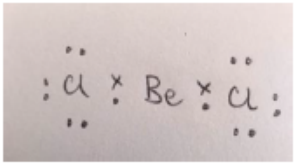
Question number	Answer	Mark
	The only correct answer is C (Hg(l)) ***A*** *is incorrect because simple molecules do not conduct electricity* ***B*** *is incorrect because simple molecules do not conduct electricity* ***D*** *is incorrect because ionic compounds do not conduct electricity as solids*	**1**

Q12.

Question number	Answer	Mark
	The only correct answer is C  ***A*** *is incorrect because this is the electron density map showing two ions* ***B*** *is incorrect because this is the electron density map with a polarised anion* ***D*** *is incorrect because this is the electron density map of a covalent molecule with two identical atoms*	**(1)**

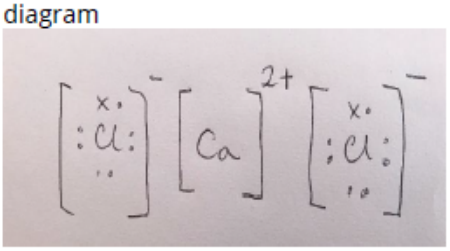
Q13.

Question Number	Answer	Additional Guidance	Mark
(a)	• $2s^2$ **(1)** • $2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$ **(1)**	Ignore extra $1s^2$ for both Be and Ca Accept $p_x^2\ p_y^2\ p_z^2$ for p^6	**(2)**

Question Number	Answer	Additional Guidance	Mark
(b)	Answer that shows ..... • 2 single covalent bonds **(1)** • 6 non-bonding electrons shown on chlorine **(1)**	Example of correct dot-and-cross diagram:  Allow non-bonding electrons unpaired Allow all dots or all crosses Allow shared electrons on the axis of the bond If Ca in place of Be Max 1 Ignore line showing covalent bond Ignore overlapping circles Ionic bond scores 0 overall Reject incorrect total number of electrons for M2	**(2)**

Question Number	Answer	Additional Guidance	Mark
(c)	• a line/covalent bond is when electron(s) come from both/each atom(s) **(1)** • arrow / dative covalent/ co-ordinate bond which is (a lone pair of) electrons donated from chlorine/ (only) one atom **(1)**	Ignore references to attraction between bonding pair and nucleus. Do not award any statement stating that the donation comes from Beryllium	**(2)**

Question Number	Answer	Additional Guidance	Mark
(d)	• bond angle in $BeCl_2$(g)/linear is 180° **(1)** • bond angle in $BeCl_2$(s)/polymeric is 109.5° **(1)** • electron pairs/bonds repel each other to minimise repulsion **(1)** • 4 electron pairs/bonds in solid **or** 2 bonding pairs/2 bonds (no lone pairs) in gas	Ignore references to shape ALLOW any bond angle between 110 ° and 95 °. [98° actual value] Ignore references to shape Allow to a maximum separation Do not award repulsion between atoms/elements or between lone pairs Ignore references to lp-lp/lp-bp repulsion	**(4)**

Question Number	Answer	Additional Guidance	Mark
(e)	• correct charges shown and two chloride ions (1) • electronic configuration of all ions (1)	Example of correct dot-and-cross diagram  Accept Ca with 8 electrons Allow all dots or all crosses or any combination Ignore inner electron shells	(2)

Question Number	Answer	Additional Guidance	Mark
(f)	• Beryllium is smaller /has fewer electron shells/ has a higher charge density (than calcium) OR beryllium is more electronegative (than calcium) (1) • Beryllium ion/ Be^{2+} is more polarising (than calcium /ion Ca^{2+}) OR calcium loses (outer) electrons more easily (than beryllium) OR difference in electronegativity between calcium and chlorine is greater (than between beryllium and chlorine) (1) • beryllium-chlorine bond has a higher degree of covalency (than calcium-chlorine bond)	Allow beryllium is more polarising than calcium Accept bonding in beryllium chloride is (more) covalent/ bonding in calcium chloride is (more) ionic. M3 is dependent on either M1 or M2 being scored Allow reverse arguments throughout	(3)

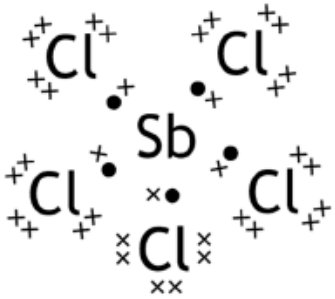
Q14.

Question number	Answer	Mark
	The only correct answer is D (attractive forces between oppositely charged ions, repulsive forces between like charged ions and some covalent bonding forces) ***A*** *is not correct because the ions with the same charge will repel and there will be some covalency with* Li^+ *and* I^- ***B*** *is not correct because there will be some covalency with* Li^+ *and* I^- *ions* ***C*** *is not correct because the ions with the same charge will repel*	**1**

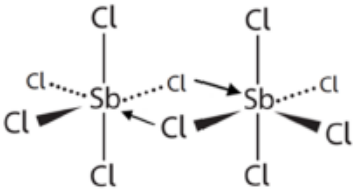
Q15.

Question Number	Answer	Additional guidance	Mark
(a)	A completed table showing: • correct number of bond pairs **and** lone pairs (1) • correct Cl–N–Cl bond angle (1) • correct name of shape (1)	**Mark all points independently** Number of bond pairs around N atom: 3 Number of lone pairs around N atom: 1 Cl–N–Cl bond angle: 107(o) Allow 106(o) – 108(o) Name of shape of molecule: (Trigonal) pyramidal Allow pyramid Ignore tetrahedral Do not award bipyramidal	**3**

Question Number	Answer	Additional guidance	Mark
(b)(i)	An explanation that makes reference to the following points: • strong(er) (electrostatic) attraction between ions (in PCl_5) (1) • (than) weak intermolecular forces (in $SbCl_5$) (1)	**Mark M1 and M2 independently** Ignore reference to solid/liquid Allow strong ionic bonds / strong ionic lattice Allow strong attraction between positive and negative charges Allow strong attraction between cations and anions / PCl_4^+ and PCl_6^- Ignore just PCl_5 is (giant) ionic Do not award reference to PCl_5 molecules/ intermolecular forces Do not award reference to breaking of covalent bonds Accept just London/van der Waals/dispersion/ temporary-induced dipole/instantaneous-induced dipole forces Ignore just $SbCl_5$ is (simple) molecular Do not award reference to breaking of covalent/ionic bonds Ionic bonding is stronger than intermolecular forces scores (2)	2

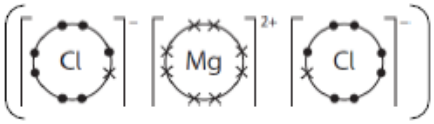
Question Number	Answer	Additional guidance	Mark
(b)(ii)	Dot-and-cross diagram showing the following: • central Sb with five bond pairs and no lone pairs (1) • five Cl atoms each with one bond pair and three lone pairs (1)	**Mark M1 and M2 independently** Example of dot-and-cross diagram:  TE on M1 for three or four Cl atoms Allow any combination of crosses and dots Allow circles to indicate outer shells Ignore inner shells Ignore lines showing the covalent bonds	2

Question Number	Answer	Additional guidance	Mark
(c)(i)	• suitable description of a dative covalent bond	For credit to be awarded, it must be clear that: i) a pair of / two electrons are involved ii) these electrons are shared/bonding iii) these electrons come from the same atom eg shared electrons in which both electrons come from the same atom eg lone pair/full orbital from one atom overlaps with empty orbital of another Allow element for atom Allow just both electrons in the bond come from the same element Allow one element donates/gives/shares both electrons to the bond Allow one atom shares both electrons Do not award just one atom donates/gives both electrons (or any reference to ions being formed) Do not award ion/molecule/species for atom	1

Question Number	Answer	Additional guidance	Mark
(c)(ii)	• two correct dative covalent bonds shown as arrows	 Ignore lone pairs shown on Cl Do not award dative bonds from any other Cl atoms	1

Question Number	Answer	Additional guidance	Mark
(d)	An answer that makes reference to one of the following points: • no 2d orbitals **or** (nitrogen) cannot expand its octet **or** • (nitrogen is) too small (to bond to 5 atoms) **or** • repulsion between electron **pairs** would be too great	Accept reverse arguments Allow no d orbitals as only two (quantum) shells Allow no d orbitals (accessible) Allow (nitrogen) cannot have more than eight electrons in its outer shell Ignore just cannot expand its outer/valence shell Ignore just nitrogen obeys the octet rule Ignore just (nitrogen has a) very small/smallest atomic radius Ignore Cl atoms too large Ignore nitrogen has fewest/only two shells Ignore just repulsion between electron pairs Ignore repulsion between Cl atoms Ignore not enough room for 5 electron pairs	1

Q16.

Question number	Answer	Mark
	 **The only correct answer is D** ***A*** *is incorrect because magnesium chloride has ionic bonding* ***B*** *is incorrect because magnesium chloride has ionic bonding* ***C*** *is incorrect because the charges are incorrect*	**(1)**

Q17.

Question number	Answer	Mark
	The only correct answer is B (Mg^{2+}) ***A*** *is incorrect because anions are polarised and do not cause polarisation* ***C*** *is incorrect because Na^+ has less polarising ability than Mg^{2+} as it has a larger radius and a lower charge* ***D*** *is incorrect because anions are polarised and do not cause polarisation*	**(1)**

Q18.

Question number	Answer	Mark
	The only correct answer is A (sodium fluoride) *B is incorrect because the strongest ionic bonding is between the smallest ions* *C is incorrect because the strongest ionic bonding is between the smallest ions* *D is incorrect because the strongest ionic bonding is between the smallest ions*	**(1)**

Q19.

Question number	Answer	Mark
	The only correct answer is A (Al^{3+}) (53 pm) *B is incorrect because Ga is below Al in the Periodic Table so has more shells of electrons (62 pm)* *C is incorrect because Mg^{2+} has fewer protons than Al^{3+} (72 pm)* *D is incorrect because F^- has fewer protons than Al^{3+} (133 pm)*	**(1)**

Q20.

Question number	Answer	Mark
	The only correct answer is A (N^{3-}) **B** *is incorrect because F^- has more protons than N^{3-} so greater nuclear attraction on the outer electrons* **C** *is incorrect because Na^+ has more protons than N^{3-} so greater nuclear attraction on the outer electrons* **D** *is incorrect because Al^{3+} has more protons than N^{3-} so greater nuclear attraction on the outer electrons*	1

Q21.

Question number	Answer	Mark
	The only correct answer is A (Ca^{2+} and S^{2-}) **B** *is incorrect because K^+ has 18 electrons and Br^- has 36 electrons* **C** *is incorrect because Li^+ has 2 electrons and F^- has 10 electrons* **D** *is incorrect because Mg^{2+} has 10 electrons and Cl^- has 18 electrons*	(1)

Q22.

Question Number	Answer	Mark
	The only correct answer is D (Al^{3+}) **A** *is not correct because the N^{3-} ion has fewer protons so is larger* **B** *is not correct because the F^- ion has fewer protons so is larger* **C** *is not correct because the Na^+ ion has fewer protons so is larger*	(1)

Q23.

Question Number	Answer	Mark
	The only correct answer is B (NaF) **A** *is not correct because the Cl^- ion is larger than F^- so ionic bonding is weaker in NaCl* **C** *is not correct because the K^+ ion is larger than Na^+ and the Cl^- ion is bigger than F^-* **D** *is not correct because the K^+ ion is larger than Na^+*	(1)

Q24.

Question Number	Answer	Mark
(a)	**The only correct answer is C** (XY_2) **A** *is not correct because Group 2 elements combine with Group 7 elements in the ratio 1:2* ***B*** *is not correct because Group 2 elements combine with Group 7 elements in the ratio 1:2* ***D*** *is not correct because Group 2 elements combine with Group 7 elements in the ratio 1:2*	(1)

Question Number	Answer	Mark
(b)	**The only correct answer is D** (in the liquid state and in aqueous solution only) **A** *is not correct because the ions do not move in the solid state* **B** *is not correct because the ions do not move in the solid state* **C** *is not correct because the ions do not move in the solid state*	(1)

Q25.

Question number	Answer	Mark
	The only correct answer is B ($1s^2 2s^2 2p^6 3s^2 3p^6$) ***A*** *is incorrect because this is the electronic configuration of an s-block element* ***C*** *is incorrect because this could not be the electronic configuration of the ion of a p-block element* ***D*** *is incorrect because this could not be the electronic configuration of the ion of a Period 3 element*	1

Q26.

Question number	Answer	Mark
(a)	A R and U	1

Question number	Answer	Mark
(b)	C Y	1

Question number	Answer	Mark
(c)	C U^{2+} and T^{2-}	1

Q27.

Question number	Answer	Mark
(a)	**The only correct answer is C** (M and N only) ***A*** *is not correct because M is also a metal* ***B*** *is not correct because L cannot be a metal because it is a poor conductor in the solid state* ***D*** *is not correct because L cannot be a metal because it is a poor conductor in the solid state*	1

Question number	Answer	Mark
(b)	**The only correct answer is D** (Q) ***A*** *is not correct because L conducts in the liquid state* ***B*** *is not correct because M conducts in the solid and liquid states* ***C*** *is not correct because P does not dissolve in water*	1

Q28.

Q	Answer	Mark
	The only correct answer is D (I^-) ***A*** *is incorrect because cations cause polarisation of anions and are not polarised themselves* ***B*** *is incorrect because cations cause polarisation of anions and are not polarised themselves* ***C*** *is incorrect because a chloride ion is smaller than an iodide ion and large anions are more easily polarised than small anions*	**1**

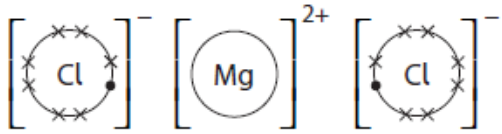
Q29.

Question number	Answer	Mark
	The only correct answer is D (Ca^{2+}) ***A*** *is incorrect because anions do not polarise cations* ***B*** *is incorrect because anions do not polarise cations* ***C*** *is incorrect because K^+ has a smaller charge and a greater ionic radius*	**1**

Q30.

Q	Answer	Mark
	The only correct answer is C (O^{2-}) ***A*** *is incorrect because Na^+ has more protons than oxygen and nitrogen but a lower charge than magnesium* ***B*** *is incorrect because Mg^{2+} is the smallest as it has the most protons and a higher charge than sodium* ***D*** *is incorrect because F^- has one more proton than oxygen and one less electron added to the atom*	**1**

Q31.

Question number	Answer	Additional guidance	Mark
(a)	• dot-and-cross diagram, including charges	Example of diagram:  Allow no electrons or 8 electrons on outer shell of Mg Allow any combination of dots or crosses for electrons Ignore missing square brackets	1

Question number	Answer	Additional guidance	Mark
(b)	An explanation that makes reference to the following points: • identification of charge carriers: magnesium - electrons **and** magnesium chloride - ions (1) • magnesium conducts electricity when solid because delocalised electrons can flow through (1) • magnesium chloride does not conduct when solid because the ions cannot move **and** it does conduct electricity when molten or dissolved in water as the ions can move. (1)		**3**

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Question number	Answer	Additional guidance	Mark
(c)(i)	• correct balanced ionic equation with state symbols	Examples of equation: $MgO(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2O(l)$ or $MgO(s) + 2H_3O^+(aq) \rightarrow Mg^{2+}(aq) + 2H_2O(l)$	1

Question number	Answer	Additional guidance	Mark
(c)(ii)	• calculation of moles of MgO (1) • calculation of moles of HCl (1) • calculation of volume of HCl (1)	Example of calculation: moles MgO = $\frac{2.45}{40.3}$ = 0.060794 moles HCl = 2 × 0.060794 = 0.121588 volume HCl = 0.121588 × $\frac{1000}{2.00}$ = 60.794 cm^3 Ignore SF except 1 SF Allow use of A_r(Mg) = 24 (61.25 cm^3) Correct answer with no working scores full marks	3

Question number	Answer	Additional guidance	Mark
(d)	Either • calculation of moles of $MgCO_3$ (1) • calculation of mass of $MgCl_2$ (1) or • use of both molar masses (1) • calculation of mass of $MgCl_2$ (1)	Example of calculation: moles $MgCO_3$ = $\frac{2.25}{84.3}$ = 0.02669 mass $MgCl_2$ = 0.02669 × 95.3 = 2.5436 (g) or 84.3 g $MgCO_3$ makes 95.3 g $MgCl_2$ so 2.25 g $MgCO_3$ makes $\frac{95.3}{84.3}$ × 2.25 = 2.5436 (g) $MgCl_2$ Ignore SF except 1 SF Allow use of A_r(Mg) = 24 (2.5446 g) Correct answer with no working scores full marks	2

Question number	Answer		Additional guidance	Mark
(e)	An explanation that makes reference to the following points: • (in the reaction with magnesium oxide) there are fewer waste products/no carbon dioxide is released/water is the only waste product • so the molar mass of all products is lower/the denominator of the equation for atom economy is lower or • 1 mol of magnesium compound produces 1 mol of magnesium chloride • but the M_r of magnesium carbonate is greater than the M_r of magnesium oxide/carbon dioxide is an additional waste product from magnesium carbonate.	(1) (1) (1) (1)	Ignore calculations Allow reverse arguments	2

Q32.

Question Number	Answer	Mark
(a)	**The only correct answer is C** (392.0) ***A*** *is incorrect because the brackets have been ignored* ***B*** *is incorrect because the mass of water has been omitted* ***D*** *is incorrect because the iron has been doubled*	(1)

Question Number	Answer	Mark
(b)	**The only correct answer is D** (ionic, covalent and dative covalent) ***A*** *is incorrect because there are both dative covalent and covalent bonds within the ions* ***B*** *is incorrect because there are dative covalent bonds within the ions* ***C*** *is incorrect because there are covalent bonds within the ions*	(1)

Question Number	Answer	Mark
(c)	**The only correct answer is C** (3.01×10^{23}) ***A*** *is incorrect because only one ammonium, one iron and one sulfate ion have been included* ***B*** *is incorrect because the iron ions have not been included* ***D*** *is incorrect because the water molecules have been included*	**(1)**

Q33.

Question Number	Answer	Mark
	The only correct answer is C (Mg^{2+} and O^{2-}) **A** *is not correct because these ions are singly charged* **B** *is not correct because these ions are singly charged* **D** *is not correct because these ions are larger*	**(1)**

Q34.

Question Number	Answer	Mark
	The only correct answer is C (it has a molecular structure) **A** *is not correct because aqueous sodium chloride solution conducts electricity* **B** *is not correct because molten sodium chloride conducts electricity* **D** *is not correct because sodium chloride has a giant structure*	**(1)**

Q35.

Question Number	Answer	Mark
	The only correct answer is C ($N^{3-} > O^{2-} > F^-$) ***A*** *is incorrect because the size of positive ions decreases across Period 3* ***B*** *is incorrect because the size of positive ions increases down Group 1* ***D*** *is incorrect because the size of negative ions increases down Group 6*	**(1)**