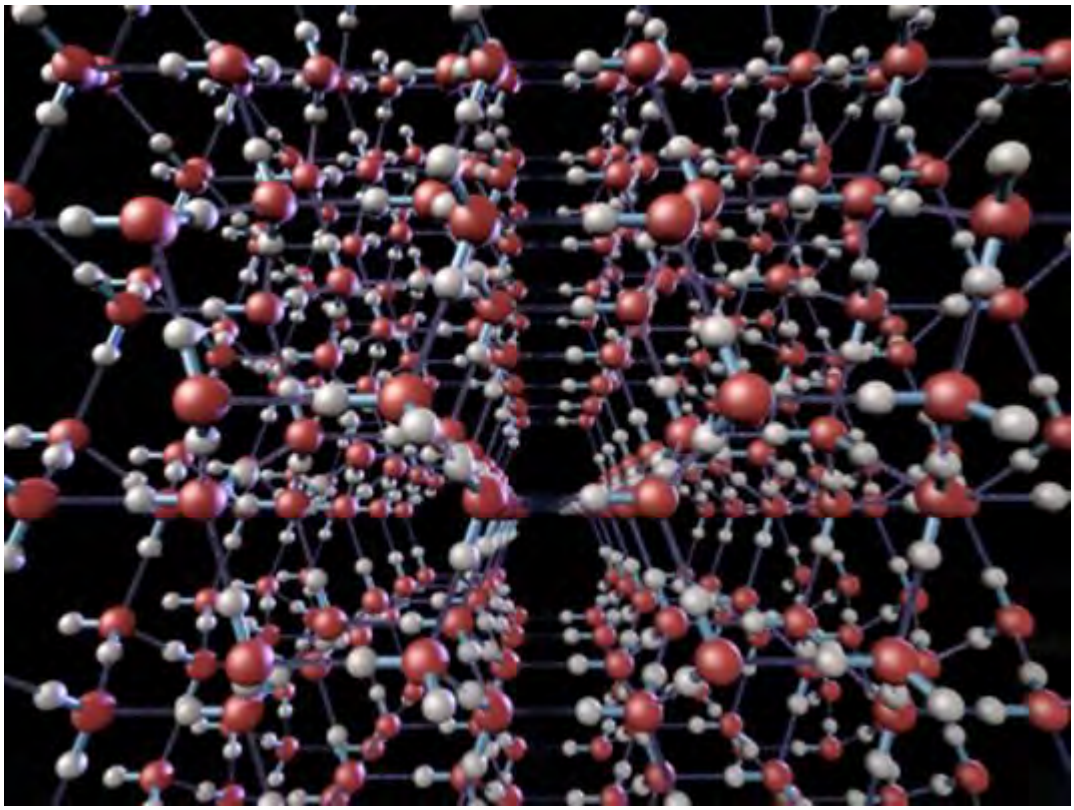
Q1. Water can be found as ice, water and steam.

(a) The following diagram shows the arrangement of some of the water molecules in a crystal of ice.



With reference to the structure shown above give **one** reason why ice is less dense than water.

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(1)

(b) Water and methane have similar relative molecular masses and both contain the element hydrogen.
The table below gives some information about water and methane.

	H_2O	CH_4
M_r	18.0	16.0

Melting point / K	273	91

(i) State the strongest type of intermolecular force holding the water molecules together in the ice crystal.

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(1)

(ii) State the strongest type of intermolecular force in methane.

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(1)

(iii) Give **one** reason why the melting point of ice is higher than the melting point of methane.

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(1)

(c) A molecule of H_2O can react with an H^+ ion to form an H_3O^+ ion.

(i) Draw and name the shape of the H_3O^+ ion. Include any lone pairs of electrons.

Shape of the H_3O^+ ion

Name of shape .....

(2)

(ii) Suggest a value for the bond angle in the H_3O^+ ion.

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(1)

(iii) Identify **one** molecule with the same number of atoms, the same number of electrons and the same shape as the H_3O^+ ion.

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(1)

(d) Water can also form the hydroxide ion.
State the number of lone pairs of electrons in the hydroxide ion.

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(1)
(Total 9 marks)

Q2. The table below shows the electronegativity values of some elements.

	H	C	N	O
Electronegativity	2.1	2.5	3.0	3.5

(a) State the meaning of the term *electronegativity*.

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(2)

(b) State the strongest type of intermolecular force in the following compounds.

Methane (CH_4) .....

Ammonia (NH_3) .....

(2)

(c) Use the values in the table to explain how the strongest type of intermolecular force arises between two molecules of ammonia.

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(3)

(d) Phosphorus is in the same group of the Periodic Table as nitrogen.
A molecule of PH_3 reacts with an H^+ ion to form a PH_4^+ ion.
Name the type of bond formed when PH_3 reacts with H^+ and explain how this bond is formed.

Type of bond .....

Explanation .....

.....

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(3)

(e) Arsenic is in the same group as nitrogen. It forms the compound AsH_3
Draw the shape of an AsH_3 molecule, including any lone pairs of electrons. Name the shape made by its atoms.

Shape

Name of shape .....

(2)

(f) The boiling point of AsH_3 is –62.5 °C and the boiling point of NH_3 is –33.0 °C.
Suggest why the boiling point of AsH_3 is lower than that of NH_3

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(1)

(g) Balance the following equation which shows how AsH_3 can be made.

..... $AsCl_3$ + ... $NaBH_4$ → ..... AsH_3 + ... NaCl + ... BCl_3

(1)

(Total 14 marks)

Q3. (a) Complete the electronic configuration for the sodium ion, Na^+

$1s^2$ .....

(1)

(b) (i) Write an equation, including state symbols, to represent the process for which the energy change is the second ionisation energy of sodium.

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(2)

(ii) Explain why the second ionisation energy of sodium is greater than the second ionisation energy of magnesium.

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(3)

(iii) An element **X** in Period 3 of the Periodic Table has the following successive ionisation energies.

	First	Second	Third	Fourth
Ionisation energies / kJ mol^{-1}	577	1820	2740	11600

Deduce the identity of element **X**.

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(1)

(c) State and explain the trend in atomic radius of the Period 3 elements from sodium to chlorine.

Trend .....

Explanation .....

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(3)

(d) Explain why sodium has a lower melting point than magnesium.

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(3)

(e) Sodium reacts with ammonia to form the compound $NaNH_2$ which contains the NH_2^- ion. Draw the shape of the NH_2^- ion, including any lone pairs of electrons.
Name the shape made by the three atoms in the NH_2^- ion.

Shape of NH_2^-

Name of shape .....

(2)

(f) In terms of its electronic configuration, give **one** reason why neon does not form compounds with sodium.

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(1)

(Total 16 marks)

Q4. Fluorine forms many compounds that contain covalent bonds.

(a) (i) State the meaning of the term *covalent bond*.

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(1)

(ii) Write an equation to show the formation of one molecule of ClF_3 from chlorine and fluorine molecules.

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(1)

(b) Draw the shape of a dichlorodifluoromethane molecule (CCl_2F_2) and the shape of a chlorine trifluoride molecule (ClF_3). Include any lone pairs of electrons that influence the shape.

Shape of CCl_2F_2 Shape of ClF_3

(2)

(c) Suggest the strongest type of intermolecular force between CCl_2F_2 molecules.

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(1)

(d) BF_3 is a covalent molecule that reacts with an F^- ion to form a BF_4^- ion.

(i) Name the type of bond formed when a molecule of BF_3 reacts with an F^- ion.
Explain how this bond is formed.

Type of bond .....

Explanation .....

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(3)

(ii) State the bond angle in the BF_4^- ion

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(1)

(e) An ultrasound imaging agent has the formula C_4F_{10}
It can be made by the reaction of butane and fluorine as shown in the following equation.

$$C_4H_{10} + 10F_2 \rightarrow C_4F_{10} + 10HF$$

Calculate the percentage atom economy for the formation of C_4F_{10} in this reaction.
Give your answer to three significant figures.

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(2)
(Total 11 marks)

Q5. A molecule of ClF_3 reacts with a molecule of AsF_5 as shown in the following equation.

$$ClF_3 + AsF_5 \rightarrow ClF_2^+ + AsF_6^-$$

Use your understanding of electron pair repulsion to draw the shape of the AsF_5 molecule and the shape of the ClF_2^+ ion. Include any lone pairs of electrons.

Name the shape made by the atoms in the AsF_5 molecule and in the ClF_2^+ ion.

Predict the bond angle in the ClF_2^+ ion.

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(Total 5 marks)