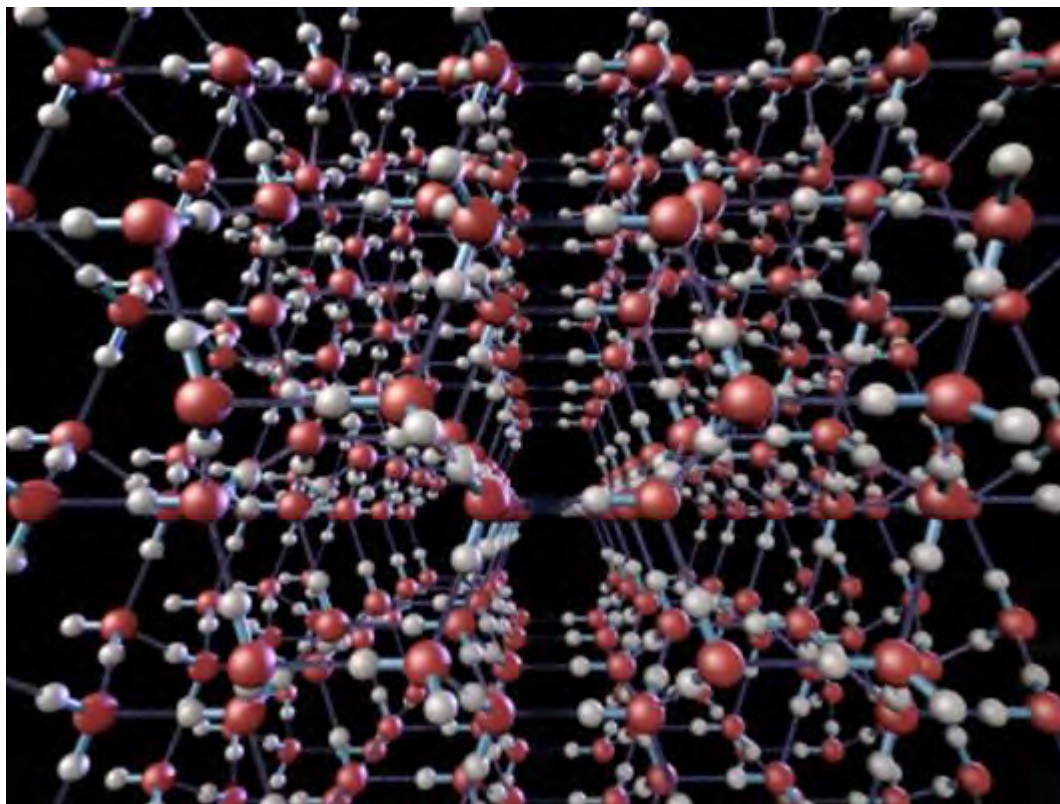


Q1. Water can be found as ice, water and steam.

- (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 <sub>2</sub> O	CH <sub>4</sub>
<i>M<sub>r</sub></i>	18.0	16.0

Melting point / K	273	91
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- (i) State the strongest type of intermolecular force holding the water molecules together in the ice crystal.

.....

(1)

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

.....

(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  $\text{H}_2\text{O}$  can react with an  $\text{H}^+$  ion to form an  $\text{H}_3\text{O}^+$  ion.

- (i) Draw and name the shape of the  $\text{H}_3\text{O}^+$  ion. Include any lone pairs of electrons.

Shape of the  $\text{H}_3\text{O}^+$  ion

Name of shape .....

(2)

- (ii) Suggest a value for the bond angle in the  $\text{H}_3\text{O}^+$  ion.

.....

(1)

(iii) Identify **one** molecule with the same number of atoms, the same number of electrons and the same shape as the  $\text{H}_3\text{O}^+$  ion.

.....

(1)

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

.....

(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*.

.....  
.....  
.....

(2)

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

Methane ( $\text{CH}_4$ ) .....

Ammonia ( $\text{NH}_3$ ) .....

(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  $\text{PH}_3$  reacts with an  $\text{H}^+$  ion to form a  $\text{PH}_4^+$  ion.  
Name the type of bond formed when  $\text{PH}_3$  reacts with  $\text{H}^+$  and explain how this bond is formed.

Type of bond .....

Explanation .....

.....  
.....

(3)

- (e) Arsenic is in the same group as nitrogen. It forms the compound  $\text{AsH}_3$ .  
Draw the shape of an  $\text{AsH}_3$  molecule, including any lone pairs of electrons. Name the shape made by its atoms.

Shape

Name of shape .....

(2)

- (f) The boiling point of  $\text{AsH}_3$  is  $-62.5\text{ }^\circ\text{C}$  and the boiling point of  $\text{NH}_3$  is  $-33.0\text{ }^\circ\text{C}$ .  
Suggest why the boiling point of  $\text{AsH}_3$  is lower than that of  $\text{NH}_3$ .

.....  
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(1)

(g) Balance the following equation which shows how AsH<sub>3</sub> can be made.



(1)

(Total 14 marks)

**Q3.** (a) Complete the electronic configuration for the sodium ion, Na<sup>+</sup>

1s<sup>2</sup> .....

(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.

.....

(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 <sup>-1</sup>	577	1820	2740	11600

Deduce the identity of element X.

.....

(1)

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

Trend .....

Explanation .....

.....

.....

(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  $\text{NaNH}_2$  which contains the  $\text{NH}_2^-$  ion. Draw the shape of the  $\text{NH}_2^-$  ion, including any lone pairs of electrons. Name the shape made by the three atoms in the  $\text{NH}_2^-$  ion.

Shape of  $\text{NH}_2^-$

Name of shape .....

(2)

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

.....

(1)  
(Total 16 marks)

**Q4.** Fluorine forms many compounds that contain covalent bonds.

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

.....

.....

(1)

- (ii) Write an equation to show the formation of one molecule of  $\text{ClF}_3$  from chlorine and fluorine molecules.

.....

(1)

- (b) Draw the shape of a dichlorodifluoromethane molecule ( $\text{CCl}_2\text{F}_2$ ) and the shape of a chlorine trifluoride molecule ( $\text{ClF}_3$ ). Include any lone pairs of electrons that influence the shape.

Shape of  $\text{CCl}_2\text{F}_2$

Shape of  $\text{ClF}_3$

(2)

- (c) Suggest the strongest type of intermolecular force between  $\text{CCl}_2\text{F}_2$  molecules.

.....

(1)

(d)  $\text{BF}_3$  is a covalent molecule that reacts with an  $\text{F}^-$  ion to form a  $\text{BF}_4^-$  ion.

(i) Name the type of bond formed when a molecule of  $\text{BF}_3$  reacts with an  $\text{F}^-$  ion. Explain how this bond is formed.

Type of bond .....

Explanation .....

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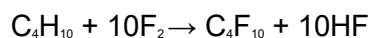
(3)

(ii) State the bond angle in the  $\text{BF}_4^-$  ion

.....

(1)

(e) An ultrasound imaging agent has the formula  $\text{C}_4\text{F}_{10}$ . It can be made by the reaction of butane and fluorine as shown in the following equation.



Calculate the percentage atom economy for the formation of  $\text{C}_4\text{F}_{10}$  in this reaction. Give your answer to three significant figures.

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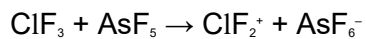
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(2)

(Total 11 marks)

**Q5.** A molecule of  $\text{ClF}_3$  reacts with a molecule of  $\text{AsF}_5$  as shown in the following equation.





Use your understanding of electron pair repulsion to draw the shape of the  $\text{AsF}_5$  molecule and the shape of the  $\text{ClF}_2^+$  ion. Include any lone pairs of electrons.

Name the shape made by the atoms in the  $\text{AsF}_5$  molecule and in the  $\text{ClF}_2^+$  ion.

Predict the bond angle in the  $\text{ClF}_2^+$  ion.

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**(Total 5 marks)**