Percentage	
Grade	

TUTOR ZONE

A Level Chemistry

Bonding

Duration: 1 hour 30 min

Total Marks: 88

Information for Candidates:

- Use black or blue ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional paper is used, the question number(s) must be clearly shown
- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.

Do not write in this table	
Question	Mark
TOTAL	

3 The table below shows the boiling points of some hydrogen compounds formed by Group 6 elements.

	H_2O	H_2S	H_2Se	H_2Te
Boiling point / K	373	212	232	271

3 (a) State the strongest type of intermolecular force in water and in hydrogen sulfide (H_2S).

Water .....

Hydrogen sulfide .....

(2 marks)

3 (b) Draw a diagram to show how two molecules of water are attracted to each other by the type of intermolecular force you stated in part (a). Include partial charges and all lone pairs of electrons in your diagram.

(3 marks)

3 (c) Explain why the boiling point of water is much higher than the boiling point of hydrogen sulfide.

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(1 mark)

3 (d) Explain why the boiling points increase from H_2S to H_2Te

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(2 marks)

3 (e) When H^+ ions react with H_2O molecules, H_3O^+ ions are formed.

Name the type of bond formed when H^+ ions react with H_2O molecules.
Explain how this type of bond is formed in the H_3O^+ ion.

Type of bond .....

Explanation .....

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(2 marks)

3 (f) Sodium sulfide (Na_2S) has a melting point of 1223 K.
Predict the type of bonding in sodium sulfide and explain why its melting point is high.

Type of bonding .....

Explanation .....

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(3 marks)

(Extra space) .....

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13

Turn over for the next question

for marking

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

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

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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(5 marks)

(Extra space) .....

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5

END OF QUESTIONS

Section A

Answer **all** questions in the spaces provided.

1 Fluorine forms many compounds that contain covalent bonds.

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

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(1 mark)

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

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(1 mark)

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 marks)

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

.....

(1 mark)

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

1 (d) (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 marks)

(Extra space) .....

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

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(1 mark)

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.

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

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 marks)

11

Section B

Answer **all** questions in the spaces provided.

7 Iodine and graphite are both solids. When iodine is heated gently a purple vapour is seen. Graphite will not melt until the temperature reaches 4000 K. Graphite conducts electricity but iodine is a very poor conductor of electricity.

7 (a) State the type of crystal structure for each of iodine and graphite.

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(2 marks)

7 (b) Describe the structure of and bonding in graphite and explain why the melting point of graphite is very high.

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(4 marks)

(Extra space) .....

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7 (c) Explain why iodine vaporises when heated gently.

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(2 marks)

7 (d) State why iodine is a very poor conductor of electricity.

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(1 mark)

9

Turn over for the next question

Section A

Answer **all** questions in the spaces provided.

1 Fluorine forms compounds with many other elements.

1 (a) Fluorine reacts with bromine to form liquid bromine trifluoride (BrF_3).
State the type of bond between Br and F in BrF_3 and state how this bond is formed.

Type of bond .....

How bond is formed .....

.....

(2 marks)

1 (b) Two molecules of BrF_3 react to form ions as shown by the following equation.

$$2BrF_3 \longrightarrow BrF_2^+ + BrF_4^-$$

1 (b) (i) Draw the shape of BrF_3 and predict its bond angle.
Include any lone pairs of electrons that influence the shape.

Shape of BrF_3

Bond angle .....

(2 marks)

1 (b) (ii) Draw the shape of BrF_4^- and predict its bond angle.
Include any lone pairs of electrons that influence the shape.

Shape of BrF_4^-

Bond angle .....

(2 marks)

1 (c) BrF_4^- ions are also formed when potassium fluoride dissolves in liquid BrF_3 to form $KBrF_4$
Explain, in terms of bonding, why $KBrF_4$ has a high melting point.

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(3 marks)

(Extra space) .....

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1 (d) Fluorine reacts with hydrogen to form hydrogen fluoride (HF).

1 (d) (i) State the strongest type of intermolecular force between hydrogen fluoride molecules.

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(1 mark)

1 (d) (ii) Draw a diagram to show how two molecules of hydrogen fluoride are attracted to each other by the type of intermolecular force that you stated in part **(d) (i)**. Include all partial charges and all lone pairs of electrons in your diagram.

(3 marks)

1 (e) The boiling points of fluorine and hydrogen fluoride are –188 °C and 19.5 °C respectively.
Explain, in terms of bonding, why the boiling point of fluorine is very low.

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(2 marks)

(Extra space) .....

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15

4 Fritz Haber, a German chemist, first manufactured ammonia in 1909.
Ammonia is very soluble in water.

4 (a) State the strongest type of intermolecular force between one molecule of ammonia and one molecule of water.

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(1 mark)

4 (b) Draw a diagram to show how one molecule of ammonia is attracted to one molecule of water. Include all partial charges and all lone pairs of electrons in your diagram.

(3 marks)

4 (c) Phosphine (PH_3) has a structure similar to ammonia.

In terms of intermolecular forces, suggest the main reason why phosphine is almost insoluble in water.

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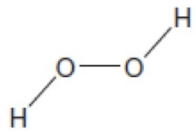
(1 mark)

5

1 A hydrogen peroxide molecule can be represented by the structure shown.



(a) Suggest a value for the H–O–O bond angle.

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(1)

(b) Hydrogen peroxide dissolves in water.

(i) State the strongest type of interaction that occurs between molecules of hydrogen peroxide and water.

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(1)

(ii) Draw a diagram to show how one molecule of hydrogen peroxide interacts with one molecule of water.
Include all lone pairs and partial charges in your diagram.

(3)

(c) Explain, in terms of electronegativity, why the boiling point of H_2S_2 is lower than H_2O_2.

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(2)
(Total 7 marks)

4 Solid potassium, K, solid potassium bromide, KBr, and ice, H_2O, all exist as lattices.

Their melting points are shown in the table below.

(a) Complete the table.

solid	melting point / °C	type of lattice
K	63	giant metallic
KBr	734	
H_2O	0	

[2]

(b) Explain why there is a difference in the melting points of K, KBr and H_2O.

In your answer you should refer to the types of particle, the types of forces between the particles and the relative strength of the forces between the particles in solid K, KBr and H_2O.

In your answer, you should use appropriate technical terms spelled correctly.

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..... **[6]**

(c) Potassium metal reacts with water.

$$2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$$

0.2346 g of potassium is reacted with excess water.

Calculate the volume of gas formed.

The gas volume is measured in cm^3 at room temperature and pressure.

answer = ... cm^3 **[3]**

[Total: 11]

5 Hydrogen chloride is a colourless gas which forms white fumes in moist air.

(a) Molecules of hydrogen chloride, HC*l*, and molecules of fluorine, F_2, contain the same number of electrons. Hydrogen chloride boils at –85 °C and fluorine boils at –188 °C.

Explain why there is a difference in the boiling points of HC*l* and F_2.

In your answer you should refer to the types of force acting between molecules and the relative strength of the forces between the molecules.

In your answer, you should use appropriate technical terms, spelled correctly.

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..... **[4]**

(b) Hydrogen chloride reacts with water to produce an ion with the formula H_3O^+.

An H_3O^+ ion has one dative covalent bond.

Draw a '*dot-and-cross*' diagram to show the bonding in H_3O^+.

Show **outer** electrons only.

[2]

(c) Borax, $Na_2B_4O_7 \bullet 10H_2O$, can be used to determine the concentration of acids such as dilute hydrochloric acid.

A student prepares 250 cm^3 of a 0.0800 mol dm^{-3} solution of borax in water in a volumetric flask.

Calculate the mass of borax crystals, $Na_2B_4O_7 \bullet 10H_2O$, needed to make up 250 cm^3 of 0.0800 mol dm^{-3} solution.

answer = ... g **[3]**

Question 5 continues on page 12

(d) The student found that 22.50 cm^3 of 0.0800 mol dm^{-3} $Na_2B_4O_7$ reacted with 25.00 cm^3 of dilute hydrochloric acid.

$$Na_2B_4O_7 + 2HCl + 5H_2O \rightarrow 2NaCl + 4H_3BO_3$$

(i) Calculate the amount, in mol, of $Na_2B_4O_7$ used.

amount = ... mol **[1]**

(ii) Calculate the amount, in mol, of HCl used.

amount = ... mol **[1]**

(iii) Calculate the concentration, in mol dm^{-3}, of the HCl.

concentration = ... mol dm^{-3} **[1]**

[Total: 12]

END OF QUESTION PAPER