



# **A-Level Chemistry**

## **Covalent and Dative Bonding**

### **Question Paper**

**Time available: 61 minutes**

**Marks available: 60 marks**

**[www.accesstuition.com](http://www.accesstuition.com)**

1.

(a) Ammonia gas readily condenses to form a liquid when cooled.

(i) Name the strongest attractive force between two ammonia molecules.

\_\_\_\_\_

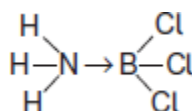
(1)

(ii) Draw a diagram to show how two ammonia molecules interact with each other in the liquid phase.

Include all partial charges and all lone pairs of electrons in your diagram.

(3)

(b) Ammonia reacts with boron trichloride to form a molecule with the following structure.



State how the bond between ammonia and boron trichloride is formed.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

(1)

(c) The following table shows the electronegativity values of some elements.

|                   | H   | Li  | B   | C   | O   | F   |
|-------------------|-----|-----|-----|-----|-----|-----|
| Electronegativity | 2.1 | 1.0 | 2.0 | 2.5 | 3.5 | 4.0 |

(i) Give the meaning of the term **electronegativity**.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

(2)

- (ii) Suggest the formula of an ionic compound that is formed by the chemical combination of two different elements from the table.

\_\_\_\_\_

(1)

- (iii) Suggest the formula of the compound that has the least polar bond and is formed by chemical combination of two of the elements from the table.

\_\_\_\_\_

(1)

(Total 9 marks)

2.

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 \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

(3)

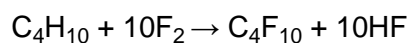
- (ii) State the bond angle in the  $\text{BF}_4^-$  ion

\_\_\_\_\_

(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.

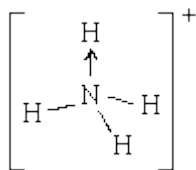
\_\_\_\_\_  
\_\_\_\_\_

(2)

(Total 11 marks)

3.

- (a) An ammonium ion, made by the reaction between an ammonia molecule and a hydrogen ion, can be represented as shown in the diagram below.



- (i) Name the type of bond represented in the diagram by  $\text{N}-\text{H}$

\_\_\_\_\_

- (ii) Name the type of bond represented in the diagram by  $\text{N} \rightarrow \text{H}$

\_\_\_\_\_

(iii) In terms of electrons, explain why an arrow is used to represent this N→H bond.

---

---

(iv) In terms of electron pairs, explain why the bond angles in the NH<sub>4</sub><sup>+</sup> ion are all 109° 28'

---

---

---

---

(7)

(b) Define the term *electronegativity*.

---

---

(2)

(c) A bond between nitrogen and hydrogen can be represented as  $\overset{\delta-}{\text{N}} - \overset{\delta+}{\text{H}}$

(i) In this representation, what is the meaning of the symbol  $\delta+$  ?

---

(ii) From this bond representation, what can be deduced about the electronegativity of hydrogen relative to that of nitrogen?

---

---

(2)

(Total 11 marks)

4.

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.

---

---

---

---

---

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

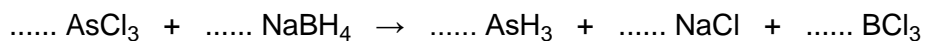
---

---

---

(1)

- (g) Balance the following equation which shows how  $\text{AsH}_3$  can be made.



(1)

(Total 14 marks)

5.

Fluorine forms compounds with many other elements.

- (a) Fluorine reacts with bromine to form liquid bromine trifluoride ( $\text{BrF}_3$ ). State the type of bond between Br and F in  $\text{BrF}_3$  and state how this bond is formed.

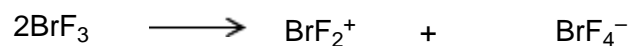
Type of bond \_\_\_\_\_

How bond is formed \_\_\_\_\_

---

(2)

- (b) Two molecules of  $\text{BrF}_3$  react to form ions as shown by the following equation.



- (i) Draw the shape of  $\text{BrF}_3$  and predict its bond angle.  
Include any lone pairs of electrons that influence the shape.

Shape of  $\text{BrF}_3$

Bond angle \_\_\_\_\_

(2)

- (ii) Draw the shape of  $\text{BrF}_4^-$  and predict its bond angle.  
Include any lone pairs of electrons that influence the shape.

Shape of  $\text{BrF}_4^-$

Bond angle \_\_\_\_\_

(2)

- (c)  $\text{BrF}_4^-$  ions are also formed when potassium fluoride dissolves in liquid  $\text{BrF}_3$  to form  $\text{KBrF}_4$ .  
Explain, in terms of bonding, why  $\text{KBrF}_4$  has a high melting point.

---

---

---

---

---

(3)

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

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

---

(1)



- (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)**

- (e) The boiling points of fluorine and hydrogen fluoride are  $-188\text{ }^{\circ}\text{C}$  and  $19.5\text{ }^{\circ}\text{C}$  respectively. Explain, in terms of bonding, why the boiling point of fluorine is very low.

---

---

---

**(2)**

**(Total 15 marks)**