Intermolecular Forces, Electronegativity & Bond Properties

Question Paper

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Chemical Bonding
Sub-Topic	Intermolecular forces, electronegativity & bond properties
Paper Type	Theory
Booklet	Question Paper

Time Allowed: **68 minutes**

Score: **/56**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 **(a)** Complete the electronic configurations of the following atoms.

fluorine: $1s^2$.....

sulfur: $1s^2$.....

[1]

(b) Write an equation to show the thermal decomposition of HC*l*.

..... [1]

(ii) Using all relevant bond energy values from the *Data Booklet*, explain why the thermal stability of HF is **much** more than that of HC*l*.

.....

.....

..... [1]

(c) Explain what is meant by the term *electronegativity*, and how it relates to the concept of *bond polarity*.

.....

.....

.....

..... [2]

(d) Sulfur and fluorinereacttogethertogivethecovalentcompoundSF_4.

(i) Draw a 'dot-and-cross' diagram to show the bonding in SF_4. Include **all** outer shell electrons in your diagram.

[2]

(ii) State whether a molecule of SF_4 has a dipole moment. Explain your answer.

.....

..... [1]

(e) Suggest a reason why sulfur can form both SF_4 and SF_6 whereas oxygen can only form OF_2.

.....

..... [1]

(f) State a major source of atmospheric sulfur dioxide.

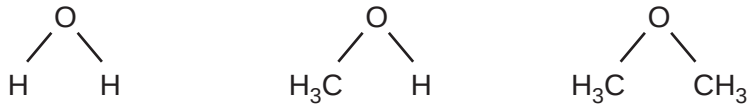
..... [1]

(ii) State **one** environmental consequence of atmospheric sulfur dioxide.

..... [1]

[Total: 11]

2 The structural formulae of water, methanol and methoxymethane, CH_3OCH_3, are given below.



(a) **(i)** How many lone pairs of electrons are there around the oxygen atom in methoxymethane?

.....

(ii) Suggest the size of the C–O–C bond angle in methoxymethane.

.....
[2]

The physical properties of a covalent compound, such as its melting point, boiling point, vapour pressure, or solubility, are related to the strength of attractive forces between the molecules of that compound.

These relatively weak attractive forces are called intermolecular forces. They differ in their strength and include the following.

A interactions involving permanent dipoles

B interactions involving temporary or induced dipoles

C hydrogen bonds

(b) By using the letters **A**, **B**, or **C**, state the **strongest** intermolecular force present in **each** of the following compounds.
For each compound, write the answer on the dotted line.

ethanal	CH_3CHO	.....
ethanol	CH_3CH_2OH	.....
methoxymethane	CH_3OCH_3	.....
2-methylpropane	$_3)_2CHCH_3$	.....

[4]

(c) Methanol and water are completely soluble in each other.

(i) Which intermolecular force exists between methanol molecules and water molecules that makes these two liquids soluble in each other?

.....

(ii) Draw a diagram that clearly shows this intermolecular force. Your diagram should show any lone pairs or dipoles present on either molecule that you consider to be important.

[4]

(d) When equal volumes of ethoxyethane, $C_2H_5OC_2H_5$, and water are mixed, shaken, and then allowed to stand, two layers are formed.

Suggest why ethoxyethane does not fully dissolve in water. Explain your answer.

.....

.....

.....

.....[2]

[Total: 12]

3 **(a)** Describe and explain the trend in the volatilities of the halogens Cl_2, Br_2 and I_2.

.....

.....

.....

..... [3]

(b) For each of the following pairs of compounds, predict which compound has the higher boiling point, and explain the reasons behind your choice.
Use diagrams in your answers where appropriate.

(i) H_2O and H_2S

(ii) $CH_3-CH_2-CH_3$ and CH_3-O-CH_3

[4]

(c) Briefly explain the shape of the SF_6 molecule, drawing a diagram to illustrate your answer.

[2]

[Total: 9]

4 The kinetic theory of gases is used to explain the large scale (macroscopic) properties of gases by considering how individual molecules behave.

(a) State **two** basic assumptions of the kinetic theory as applied to an ideal gas.

(i) .....

.....

(ii) .....

.....

[2]

(b) State **two** conditions under which the behaviour of a real gas approaches that of an ideal gas.

(i) .....

(ii) .....

[2]

(c) Place the following gases in decreasing order of ideal behaviour.

ammonia, neon, nitrogen

most ideal ..... **least ideal**

Explain your answer.

.....

.....

[3]

(d) By using the kinetic-molecular model, explain why a liquid eventually becomes a gas as the temperature is increased.

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.....

.....

.....[2]

(e) Ethane, CH_3CH_3, and fluoromethane, CH_3F are *iso*-electronic, that is they have the same total number of electrons in their molecules.

Calculate the **total** number of electrons in one molecule of CH_3F.

[1]

(f) The boiling points of these two compounds are given below.

compound	bp / K
CH_3CH_3	184.5
CH_3F	194.7

Suggest explanations for the following.

(i) the close similarity of the boiling points of the two compounds

.....

.....

(ii) the slightly higher boiling point of CH_3F

.....

.....

[2]

[Total: 12]

5 All the Group IV elements form chlorides with the formula MCl_4.

(a) Describe the bonding in, and the shape of, these chlorides.

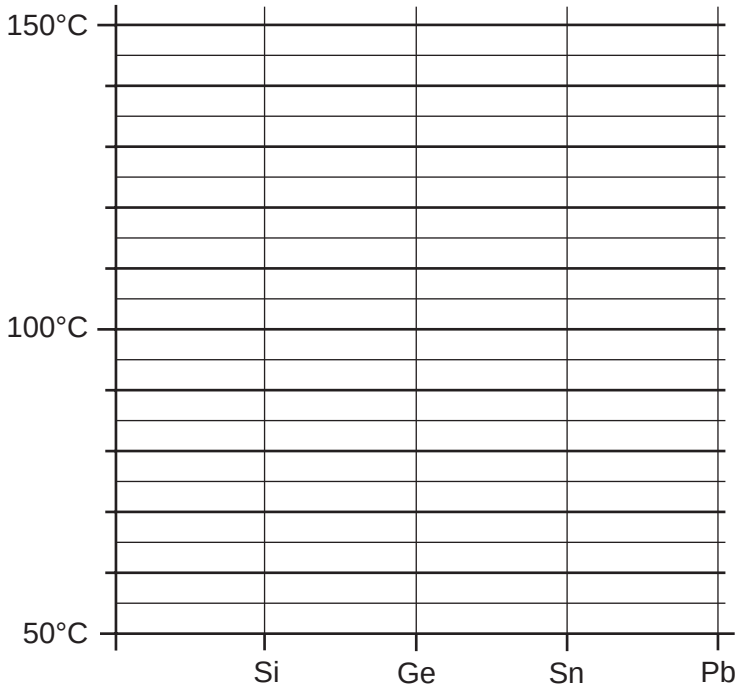
(i) bonding .....

(ii) shape .....[2]

The boiling point of lead(IV) chloride cannot be measured directly because it decomposes on heating. The following table lists the boiling points of three Group IV chlorides.

chloride	b.p. / °C
$SiCl_4$	58
$GeCl_4$	83
$SnCl_4$	114

(b) **(i)** Plot these data on the following axes and extrapolate your graph to predict what the boiling point of $PbCl_4$ would be if it did not decompose.



(ii) Suggest why the boiling points vary in this way.

.....

.....

.....[4]

(c) $SiCl_4$ reacts vigorously with water whereas CCl_4 is inert.

(i) Suggest a reason for this difference in reactivity.

.....

(ii) Write an equation for the reaction between $SiCl_4$ and water.

.....

(iii) Suggest, with a reason, whether you would expect $GeCl_4$ to react with water.

.....

.....

[3]

(d) $SiCl_4$ is used to make high-purity silicon for the semiconductor industry. After it has been purified by several fractional distillations, it is reduced to silicon by heating with pure zinc.

(i) Suggest an equation for the reduction of $SiCl_4$ by zinc.

.....

(ii) Use your equation to calculate what mass of zinc is needed to produce 250 g of pure silicon by this method.

mass of zinc = ... g [3]

[Total: 12]