Bonding, Polarity & Intermolecular Forces

Question Paper 1

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Application of Core Principles of Chemistry
Sub Topic	Bonding, Polarity & Intermolecular Forces
Booklet	Question Paper 1

Time Allowed: **54 minutes**

Score: **/45**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 Which describes the polarity of the C—Cl bond and the polarity of the molecule trichloromethane, $CHCl_3$?

	Polarity of C—Cl bond	Polarity of molecule
☒ **A**	non-polar	non-polar
☒ **B**	non-polar	polar
☒ **C**	polar	non-polar
☒ **D**	polar	polar

(Total for Question 1 = 1 mark)

2 Which isomer, with the formula C_7H_{16}, will have the **lowest** boiling temperature?

☒ **A** $CH_3CH_2CH_2CH_2CH_2CH_2CH_3$

☒ **B** $(CH_3)_2CHCH_2CH_2CH_2CH_3$

☒ **C** $CH_3CH_2C(CH_3)_2CH_2CH_3$

☒ **D** $(CH_3)_2CHC(CH_3)_3$

(Total for Question 2 = 1 mark)

3 Which of these molecules is polar?

☒ **A** CO_2

☒ **B** NH_3

☒ **C** CCl_4

☒ **D** CH_4

(Total for Question 3 = 1 mark)

4 Which of the following compounds has hydrogen bonding in the **liquid** state?

☒ **A** Hydrogen bromide, HBr

☒ **B** Hydrogen sulfide, H_2S

☒ **C** Silane, SiH_4

☒ **D** Ammonia, NH_3

(Total for Question 4 = 1 mark)

5 Which of the following elements has the greatest attraction for bond pairs of electrons in a covalent bond?

☒ **A** Beryllium

☒ **B** Boron

☒ **C** Bromine

☒ **D** Chlorine

(Total for Question 5 = 1 mark)

6 In a molecule of hydrogen, the two hydrogen atoms are held together by

☒ **A** a hydrogen bond.

☒ **B** a polar covalent bond.

☒ **C** a non-polar covalent bond.

☒ **D** London forces.

(Total for Question 6 = 1 mark)

7 Which of the following bonds is likely to be the most polar?

    ☒ **A**   H—F

    ☒ **B**   P—O

    ☒ **C**   N—Cl

    ☒ **D**   C—S

(Total for Question 7 = 1 mark)

8 Which of the following has the longest bond length?

    ☒ **A**   Cl—Cl

    ☒ **B**   H—Cl

    ☒ **C**   O=O

    ☒ **D**   N≡N

(Total for Question 8 = 1 mark)

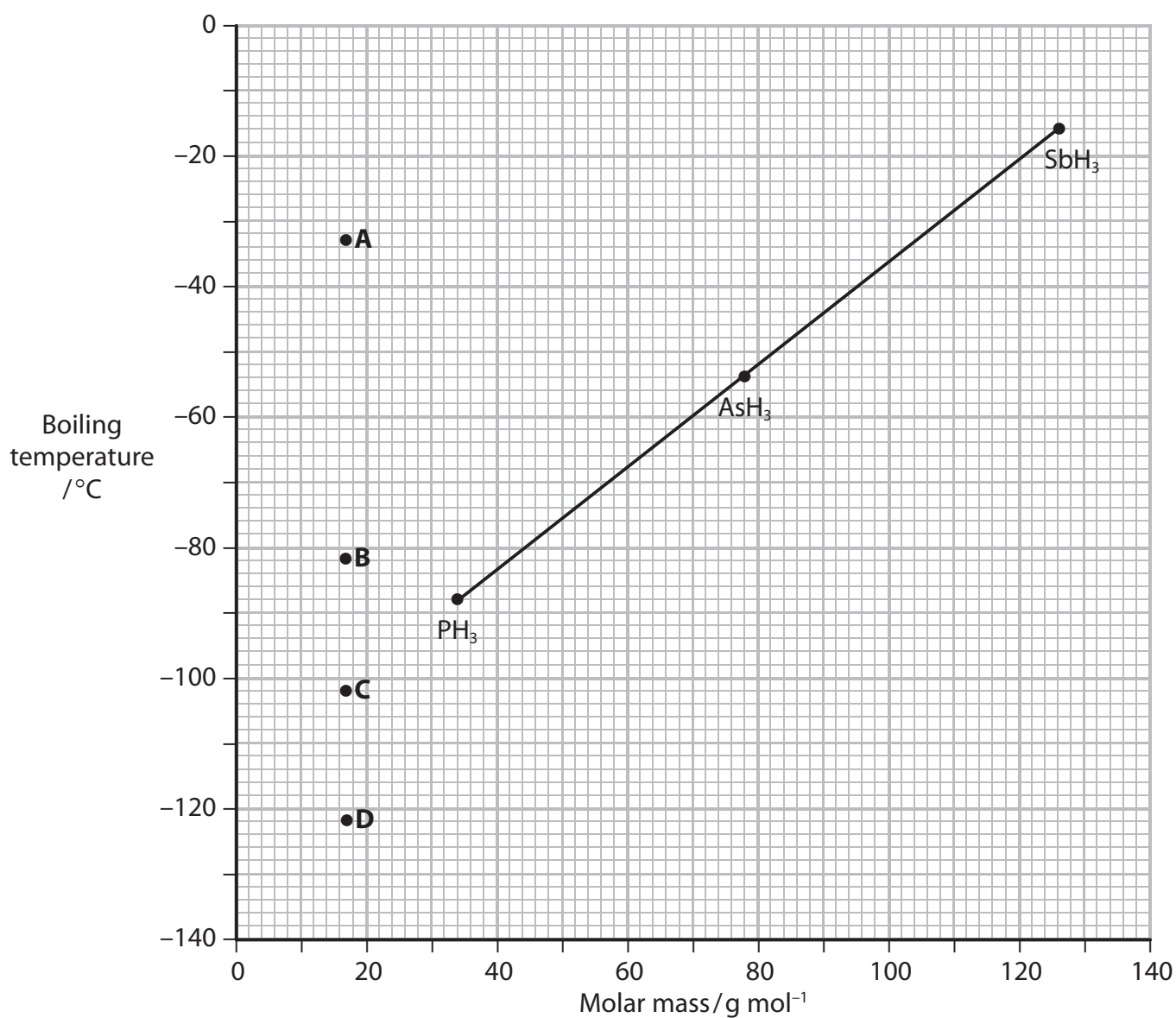**9** (a) The strongest intermolecular forces in liquid ammonia are

(1)

☒ **A** covalent bonds.

☒ **B** hydrogen bonds.

☒ **C** London forces.

☒ **D** permanent dipole-dipole forces.

(b) The graph below shows the boiling temperatures for the Group 5 hydrides. Select the most likely boiling temperature for ammonia.
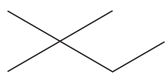
(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 2 marks)

10 Which of the following isomers of C_6H_{14} has the **lowest** boiling temperature?
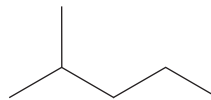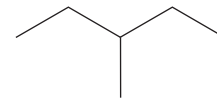
       A   B   C   D

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 10 = 1 mark)

11 Which of the following compounds has the **highest** boiling temperature?

M_r = relative molecular mass

☒ **A** cyclopentane $M_r = 70$

☒ **B** pentane $M_r = 72$

☒ **C** butan-1-ol $_r = 74$

☒ **D** ethane-1,2-diol $M_r = 62$

(Total for Question 11 = 1 mark)

12 Microwave energy can only be used for heating reactions involving polar reactants.

Which of the following reactions **cannot** be heated with microwave energy?

☒ **A** C_5H_{12} + Cl_2 → $C_5H_{11}Cl$ + HCl

☒ **B** C_2H_5OH + HBr → C_2H_5Br + H_2O

☒ **C** C_2H_5I + KOH → C_2H_5OH + KI

☒ **D** CH_3CHO + $\frac{1}{2}O_2$ → CH_3COOH
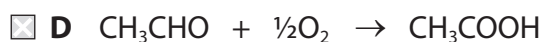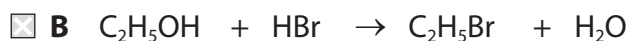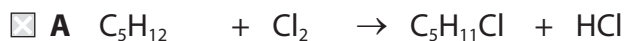
(Total for Question 12 = 1 mark)

13 An experiment to determine the effect of an electrostatic force on a jet of liquid is carried out using the apparatus as shown.

charged rod
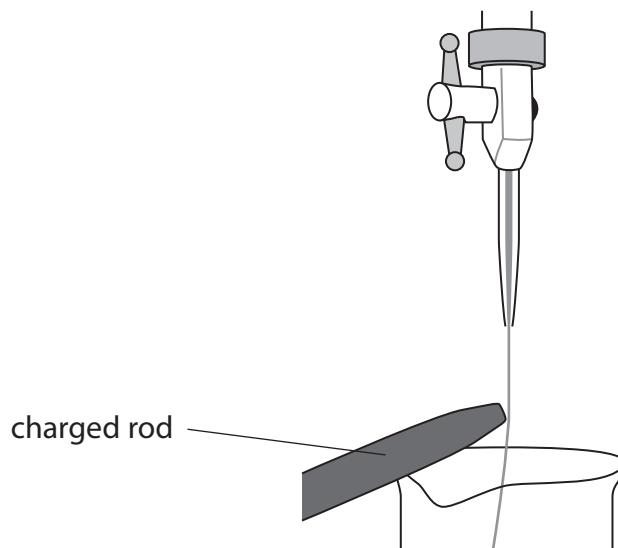
Which of the following liquids would **not** be significantly deflected by the electrostatic force applied?

☒ **A** CH_3OH

☒ **B** CCl_4

☒ **C** $CHCl_3$

☒ **D** H_2O

(Total for Question 13 = 1 mark)

14 Although they have similar relative molecular masses, the boiling temperatures of pentane (36°C) and butan-1-ol (117°C) are significantly different. The reason for this is that, in comparison with pentane,

☒ **A** the intermolecular forces between the alcohol molecules are much stronger.

☒ **B** the covalent bonds in the alcohol are stronger.

☒ **C** there are more covalent bonds in the alcohol and so it requires more energy to break all of them.

☒ **D** the molecular shape of the alcohol allows it to form stronger interactions between molecules.

(Total for Question 14 = 1 mark)

15 Compounds such as sodium chloride dissolve in water because the ions interact with the water molecules. The interactions are

☒ **A** dipole-dipole.

☒ **B** ion-dipole.

☒ **C** hydrogen bonds.

☒ **D** London forces.

(Total for Question 15 = 1 mark)

16 The term **electronegativity** is best described as the ability of an atom to

☒ **A** attract the electrons within a covalent bond.

☒ **B** repel the electrons within a covalent bond.

☒ **C** attract the electrons within an ionic bond.

☒ **D** repel the electrons within an ionic bond.

(Total for Question 16 = 1 mark)

17 Graphite is made up of hexagonal rings of carbon atoms in a layered arrangement.
The carbon atoms in the same layer are 0.14 nm apart.
What is the distance between adjacent layers of carbon atoms?

☒ **A** 0.04 nm

☒ **B** 0.13 nm

☒ **C** 0.15 nm

☒ **D** 0.34 nm

(Total for Question 17 = 1 mark)

18 Some ionic solids, such as sodium chloride, are soluble in water because

☒ **A** there are only weak ionic bonds within the lattice.

☒ **B** there are strong London forces created on dissolving.

☒ **C** the ions are strongly hydrated by the water molecules.

☒ **D** strong hydrogen bonds are formed with the water molecules.

(Total for Question 18 = 1 mark)

19 This question concerns the halogens and some of their compounds.

(a) A halogen dissolves in water to form a yellow solution, and in cyclohexane to form a purple solution.

Name the halogen.

(1)

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(b) Oxygen difluoride, OF_2, is produced in the reaction between fluorine and cold, dilute sodium hydroxide solution.

$$2F_2 \quad + \quad 2OH^- \quad \rightarrow \quad OF_2 \quad + \quad 2F^- \quad + \quad H_2O$$

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Give the oxidation numbers of fluorine and oxygen in all of the species in the equation above and use them to explain why this is a redox reaction.

(3)

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(c) Chlorine oxidises thiosulfate ions, $S_2O_3^{2-}$, to sulfate(VI) ions.

The ionic half-equations for the reaction are

$$Cl_2 + 2e^- \rightarrow 2Cl^-$$

$$S_2O_3^{2-} + 5H_2O \rightarrow 2SO_4^{2-} + 10H^+ + 8e^-$$
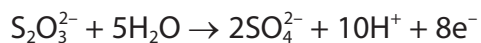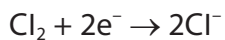
Write the overall equation for the reaction.

(1)

(d) The boiling temperatures of the hydrogen halides are shown.

Hydrogen halide	Boiling temperature / K
HF	293
HCl	188
HBr	206
HI	238

*(i) London forces are present in **all** of these compounds.

Describe how these forces arise.

(2)

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(ii) State why the London forces are greater in hydrogen iodide than in hydrogen bromide.

(1)

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(iii) Explain why the boiling temperature of hydrogen fluoride is higher than that of hydrogen chloride.

(2)

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(e) In the solid state, phosphorus(V) chloride exists as $[PCl_4]^+$ and $[PCl_6]^-$ ions.

Predict the shapes of these ions. Fully justify your answers.

(4)

Shape $[PCl_4]^+$ ....

Shape $[PCl_6]^-$ ....

Justification

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(Total for Question 19 = 14 marks)

20 Potassium bromate(V), $KBrO_3$, is a primary standard, meaning that it can be obtained as a pure substance and used to accurately determine the concentrations of solutions of other chemicals, such as sodium thiosulfate, $Na_2S_2O_3$.

(a) (i) Complete the dot and cross diagram for the bromate(V) ion. Show only the outer shell electrons.

In this ion, the bromine expands its outer shell to accommodate 12 electrons.

Use **x** for bromine electrons and • for oxygen electrons. The symbol * on the diagram represents the extra electron which gives the ion its charge.

(2)
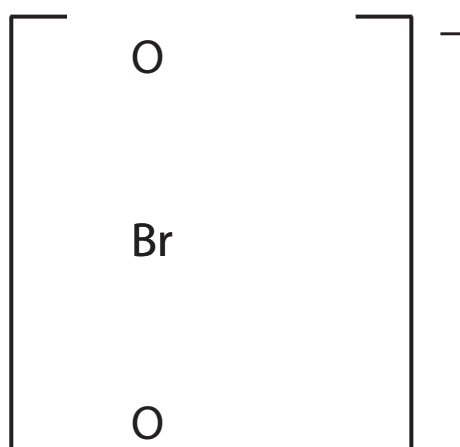
(ii) Suggest how elements in Period 3 and higher can accommodate more than eight electrons in their outer shell.

(1)

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(b) Four chemistry students were given a solution of sodium thiosulfate with a concentration of **approximately** 0.1 mol dm^{-3} and asked to determine its **exact** concentration.

They were each given separate tasks to carry out, as described below.

(i) The first student was given the task of making up a potassium bromate(V) solution. A mass of 8.35 g of $KBrO_3$ was weighed out, dissolved in deionized water, the volume made up to 250 cm^3 in a volumetric flask and the mixture shaken.

Calculate the concentration of this potassium bromate(V) solution, in mol dm^{-3}.

(2)

(ii) The second student was asked to determine a suitable mass of potassium iodide to add to 0.0025 mol of potassium bromate(V) to ensure complete reaction. The equation for the reaction is

$$BrO_3^-(aq) \ + \ 6H^+(aq) \ + \ 6I^-(aq) \ \rightarrow \ Br^-(aq) \ + \ 3I_2(aq) \ + \ 3H_2O(l)$$

Calculate the minimum mass of potassium iodide, KI, required and hence suggest a suitable mass to use if the potassium iodide is to be in excess.

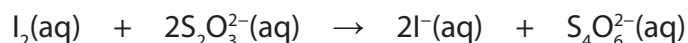You **must** show your working and your mass should be reasonable.

(3)

Minimum mass required .... g

Suitable mass to use .... g

(iii) The third student was given the following equation.

$$I_2(aq) \ + \ 2S_2O_3^{2-}(aq) \ \rightarrow \ 2I^-(aq) \ + \ S_4O_6^{2-}(aq)$$

This student was asked to estimate the titration reading.

Calculate the volume of 0.1 mol dm^{-3} of sodium thiosulfate solution, in cm^3, that would be needed to react with 0.00100 mol of iodine present in the conical flask.

(2)

(iv) The fourth student carried out an alternative method for determining the concentration of the sodium thiosulfate solution. A known mass of solid potassium bromate(V) was dissolved in water in a conical flask. An excess of potassium iodide and acid were added and the mixture titrated with the sodium thiosulfate solution. The following measurements were obtained.

Mass of KBrO$_3$	0.07 g
Volume of water	25 cm^3
Volume of Na$_2$S$_2$O$_3$(aq)	26.85 cm^3

The student calculated the concentration of the sodium thiosulfate, Na$_2$S$_2$O$_3$, to be 0.0937 mol dm^{-3}.

There is uncertainty in the value of the calculated concentration of the sodium thiosulfate. Which measurement, given in the table, has the greatest effect on the uncertainty of this value? Justify your answer.

No calculation is required for this answer.

(2)

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(Total for Question 20 = 12 marks)