IB · DP · Chemistry

2 hours 13 questions

Structured Questions: Paper 2

4.3 Intermolecular Forces & Metallic Bonding

4.3.1 Types of Intermolecular Forces / 4.3.2 Deducing Intermolecular Forces / 4.3.3 Properties of Covalent Compounds / 4.3.4 Metallic Bonding / 4.3.5 Trends in Melting Points of Metals / 4.3.6 Alloys & their Properties

Easy (4 questions)	/36
Medium (5 questions)	/51
Hard (4 questions)	/53
Total Marks	**/140**

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Easy Questions

1 (a) There are a number of different types of intermolecular force possible between molecules.

Which types of forces can be classified as 'van der Waals' forces?

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(2 marks)

(b) Methanol, CH_3OH, is a small alcohol molecule that forms hydrogen bonds with water.

Sketch 2 different hydrogen bonding interactions between methanol and water.

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(2 marks)

(c) Methanol, CH_3OH can be oxidised to methanal, CH_2O and then to methanoic acid, HCOOH.

Identify the strongest type of intermolecular force between:

i) Methanal molecules

ii) Methanoic acid molecules

iii) Water and methanal

iv) Water and methanoic acid

[4]

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(4 marks)

(d) Methanoic acid reacts with sodium hydroxide to form sodium methanoate:

$$HCOOH + NaOH \rightarrow HCOONa + H_2O$$

Explain why sodium methanoate is a solid at room temperature and methanoic acid is a liquid.

(3 marks)

2 (a) Group 17 of the Periodic Table contain non-metals that are often referred to as the halogens.

Iodine, I_2, is one of these halogens. At room temperature and pressure it exists as a grey-black solid.

Describe the bonding and forces present in I_2 in the solid state.

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(2 marks)

(b) The state of the halogens changes down the group, with fluorine being a gas and astatine being a solid.

Explain why the melting point of the halogens increases down the group.

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(2 marks)

(c) The halogens are all diatomic covalent molecules.

Predict the most probable physical properties shown by all of the elements in Group 17.

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(3 marks)

(d) The halogens can also form interhalogen compounds, such as iodine monochloride, ICl.

Predict the state of iodine monochloride at room temperature and pressure, and explain your answer with reference to the intermolecular forces present.

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(3 marks)

3 (a) Describe the bonding in solid sodium.

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(2 marks)

(b) Potassium has a lower melting point than sodium does.

Explain why.

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(2 marks)

(c) Magnesium is in the same period as sodium, but has a much higher melting point.

Explain why.

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(2 marks)

(d) Predict whether magnesium is harder or softer than sodium and explain why.

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(2 marks)

4 (a) Copper is a common metal used in wiring.

Explain the electrical conductivity of copper.

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(2 marks)

Explain why copper is also very malleable.

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(b) **(2 marks)**

(c) Copper is used in alloys such as brass and bronze.

Outline why copper alloys are usually less malleable than pure copper.

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(1 mark)

(d) Copper is used for water pipes.

Suggest two properties of copper that make it suitable for this use, excluding malleability.

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(2 marks)

Medium Questions

1 (a) Magnesium is a lightweight metal used for the manufacturing of car seats. Describe the structure and bonding present in solid magnesium.

(3 marks)

(b) Magnesium has a considerably higher boiling point than sodium. Explain this difference, despite the fact both elements are in period 3.

(3 marks)

(c) Explain, with reference to bonding, the principal property of a metal that makes it suited to manufacturing shaped objects such as railings.

(3 marks)

(d) Many alloys are harder than their constituent metal elements alone.

Outline the reason for this with reference to the structure of metal alloys.

(2 marks)

2 (a) Based on the type of intermolecular force present, explain why butan-1-ol has a higher boiling point than butanal.

(2 marks)

(b) Ethane, C_2H_6, and disilane, Si_2H_6, are both hydrides of Group 4 elements with similar structures but different chemical properties.

Explain why disilane has a higher boiling point than ethane.

(2 marks)

(c) Put the following molecules in order of increasing boiling point and explain your choice:

CH_3CHO **CH_3CH_2OH** **$CH_3CH_2CH_3$**

(3 marks)

(d) Based on the type of intermolecular force present, explain the difference in solubility in water between ethane and ethanol.

(4 marks)

3 (a) The elements sodium, aluminium, silicon, phosphorus and sulfur are in period 3 of the periodic table.

Describe and explain the general trend in melting points of the metals in period 3.

(4 marks)

(b) Identify, with reasoning, which of the period 3 metals has the highest melting point.

(3 marks)

(c) Explain, by reference to the intermolecular forces, why sulfur has a higher melting point than phosphorus.

(2 marks)

(d) Although the molar masses of IC*l* and Br_2 are very similar, the boiling point of IC*l* is 97.4 °C and that of Br_2 is 58.8 °C.

Explain the difference in these boiling points in terms of the intermolecular forces present in each liquid.

(2 marks)

4 (a) The melting points of some Group 1 elements are listed in **Table 1**.

Table 1

	Na	K	Rb
Melting point / °C	98	63	

Predict, with a reason, the melting point of Rb.

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(3 marks)

(b) Explain why ammonia, NH_3, is a gas at room temperature.

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(2 marks)

(c) Phosphine (IUPAC name phosphane) is a hydride of phosphorus, with the formula PH_3. Phosphine has a much greater molar mass than ammonia.

Explain why phosphine has a significantly lower boiling point than ammonia.

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(3 marks)

(d) Identify the type of interaction that must be overcome when liquid hydrazine, N_2H_4, vaporizes. Suggest, with a reason, whether hydrazine has a lower or higher boiling point than diimide, N_2H_2.

(2 marks)

5 (a) Copper is a transition metal. Describe the bonding in metals.

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(2 marks)

(b) Aluminium and copper can be used to make the alloy duralumin.

Explain why an aluminium-copper alloy is harder than pure aluminium.

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(2 marks)

(c) This question is about the chlorides of copper and aluminium.

(i) State the type of bonding present in copper(II) chloride which melts at 771 K.

(ii) The chloride of aluminium, $AlCl_3$, melts 465 K. Suggest why the melting point is so much lower than that of $CuCl_2$.

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(2 marks)

(d) Both copper and benzene have delocalised electrons. Explain why both structures have delocalised electrons, copper conducts electricity, but benzene does not.

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(2 marks)

Hard Questions

1 (a) Explain why methanol is soluble in water.

(3 marks)

(b) Methanol, ethanol and propan-1-ol are all primary alcohols. Describe and explain the trend in their melting points shown below.

Alcohol	Methanol CH_3OH	Ethanol C_2H_5OH	Propan-1-ol C_3H_7OH
Melting point / °C	-97	-114	-126

(4 marks)

(c) These longer primary alcohols have the following melting points:

Alcohol	C_4H_9OH	$C_5H_{11}OH$	$C_6H_{13}OH$	$C_7H_{15}OH$	$C_8H_{17}OH$	$C_9H_{19}OH$	$C_{10}H_{21}OH$
Melting point / °C	-90	-79	-52	-34	-16	-6	6

Describe and explain this trend.

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(4 marks)

(d) Predict, with a reason, whether ethanol or ethane-1,2-diol will have the higher melting point?

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(2 marks)

2 (a) C_2H_6, C_4H_{10} and C_3H_8 are alkanes.

i) Put them in order of increasing boiling point and explain your answer.

[3]

ii) Put them in order of increasing volatility and explain your answer.

[3]

(6 marks)

Predict, with a reason, whether the alkanes are soluble in water and propanone.

(5 marks)

(b)

(c) Pentane can exist as isomers, including pentane, $CH_3CH_2CH_2CH_2CH_3$ and 2,2-dimethylpropane, $CH_3C(CH_3)_2CH_3$.

i) Draw skeletal formula for each isomer shown above.

[2]

ii) Predict and explain which isomer of pentane would have the greater volatility.

[3]

(5 marks)

(d) There are two isomers possible with the molecular formula C_2H_6O.

i) Draw the skeletal formulae of both isomers

[2]

ii) Identify the strongest type of intermolecular force present in each isomer

[2]

iii) Predict which isomer would have the higher melting point

[1]

(5 marks)

3 (a) Explain why transition metals, such as iron, alloy best with other transition metals, such as nickel.

(2 marks)

(b) State the name of the most common type of iron alloy and the element it is alloyed with.

(2 marks)

(c) Describe and explain the trend in the melting points of all the Group 1 metals as you descend the group.

Use page 7 of the Data book.

(3 marks)

(d) Describe and explain the trend in melting points across the Period 3 metals of sodium, magnesium and aluminium.

Use page 7 of the Data book.

(3 marks)

Explain why pure gold is not often used to make jewellery.

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4 (a) **(2 marks)**

(b) b) Gold is often alloyed with other metals.

i) Suggest why alloying gold is useful.

[2]

ii) Give some examples of metals that are commonly alloyed with gold.

[2]

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(4 marks)

(c) c) Silver is the best metal electrical conductor.

i) Explain how silver conducts electricity so well.

[2]

ii) Explain why copper is often used instead of silver in wiring.

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(3 marks)