Exam Papers Practice

4.3 Intermolecular Forces & Metallic Bonding

Mark Schemes

Course	DP IB Chemistry
Section	4. Chemical Bonding & Structure
Topic	4.3 Intermolecular Forces & Metallic Bonding
Difficulty	Medium

To be used by all students preparing for DP IB Chemistry HL
Students of other boards may also find this useful

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The correct answer is **C** because:

- The melting point of a metal depends on the strength of the metallic bonds present
- The strength of a metallic bond depends on the charge of the ions and the radius of the metal ion
- The higher the charge, the greater the number of valence electrons which increases the strength of the metallic bonding
- The smaller the atomic radius the stronger the metallic bonding
- Since Al is a group 3 element, the cation will be Al^{3+} so it will have the strongest metallic bonding and highest melting point

A is incorrect as	sodium forms a +1 ion and will be larger than Al^{3+} ions
B is incorrect as	magnesium forms a +2 ion and will be larger than Al^{3+} ions
D is incorrect as	potassium forms a +1 ion and will be larger than Al^{3+} ions. Since potassium is below sodium in Group I, it will have larger atoms and a lower melting point than sodium

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The correct answer is **C** because:

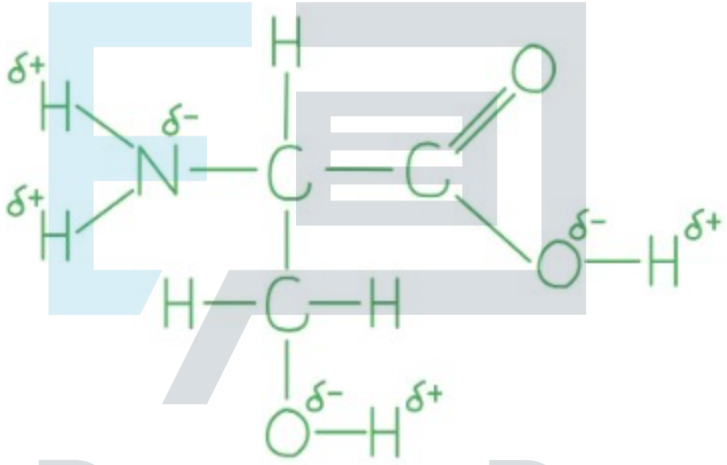
- The increasing strength of intermolecular forces is
  - London dispersion forces < permanent dipole dipole forces < hydrogen bonding
- Butane, C_4H_{10}, only has London dispersion forces between the molecules
- 1–chlorobutane, $CH_3CH_2CH_2CH_2Cl$, contains a polar bond due to the difference in electronegativity between the C and Cl atoms
- This creates a δ+ C atom and δ- Cl atom
- Butan-1–ol has hydrogen bonds between the molecules
- In order to have hydrogen bonding a **hydrogen atom must be directly bonded to one of oxygen, nitrogen or fluorine atoms**
- Alcohols can exhibit hydrogen bonding

A is incorrect as	permanent dipole dipole forces in 1–chlorobutane are stronger than the van der Waals forces in butane
B & **D** are incorrect as	the hydrogen forces in butan-1–ol are the strongest type of intermolecular force and this is listed first

3

The correct answer is **C** because:

- In order to have hydrogen bonding a **hydrogen atom must be directly bonded to one of oxygen, nitrogen or fluorine atoms**
- Hydrogen bonding only occurs with these atoms, as they have a very high electronegativity
- In a molecule of serine there are O-H bonds and N-H bonds
- This allows for interaction between the side chain of the amino acid and another serine molecule which contributes to the shape of proteins



- The interaction of the side chains by different molecules of serine (and other amino acids) is a very important part of the formation of different protein structures
- As we can see, serine contains an -OH group in the side chain.
    - A hydrogen bond is set up between two serine residues in different parts of a folded chain

A & **B** are incorrect as	these are bonds between oxygen and hydrogen on the side chain of the amino acid which will allow hydrogen bonding to occur
D is incorrect as	covalent bonding is not a type of intermolecular force

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The correct answer is **D** because:

- Hexane is a nonpolar molecule and therefore can not exhibit permanent dipole permanent dipole intermolecular forces

A is incorrect as	hexane molecules can pack closely together as there are no branches therefore there are stronger interactions between them
B is incorrect as	the methyl groups branching from the main carbon skeleton in 2,2-dimethylbutane don't allow the molecules to pack close to one another
C is incorrect as	2,2-dimethylbutane does only contain London dispersion forces as there are no polar bonds present

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The correct answer is **D** because:

- Graphite is a giant macromolecular substance.
- These substances such as graphite and diamond have high melting and boiling points because the atoms are bonded throughout by strong covalent bonds, which require a lot of energy to break these bonds

A is incorrect as	magnesium has a metallic structure and although these structures generally have high melting and boiling points due to the strong electrostatic forces of attraction between cations and delocalised electrons, magnesium has a lower melting point than a giant macromolecular structure like graphite
B is incorrect as	sodium oxide is an ionic structure and although these structures have high melting and boiling points due to the large amount of energy needed to overcome the strong electrostatic attraction between oppositely charged ions, sodium oxide has a lower melting point than a giant macromolecular structure like graphite
C is incorrect as	oxygen is a simple covalent substance and is a gas at room temperature and pressure, as it is relatively easy to overcome the weak intermolecular forces to separate one molecule from another in simple covalent substances

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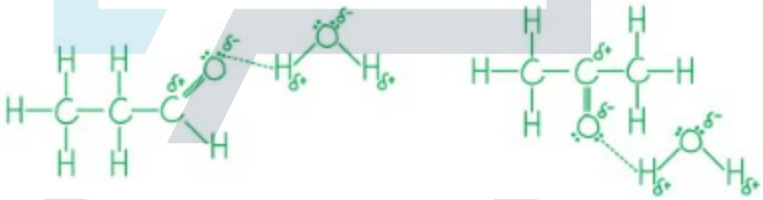
The correct answer is **C** because:

- Statement I is incorrect
  - Hydrogen bonding can not occur in these compounds as there is no O-H bond
  - The hydrogen must be bonded to either a O, N or F atom in order for hydrogen bonding to occur
- Statement II is correct
  - The C-O bond is polar due to the difference in electronegativity (a δ+ C atom and δ- O atom)
  - Therefore, a permanent dipole permanent dipole force will occur between each molecule
- Statement III is correct
  - Given that each molecule is polar, it can interact with water molecules as shown below



A, **B** & **D** are incorrect as	these are not the correct combination of statements

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The correct answer is **C** because:

- $CH_3CH_2CH_3$ is propane and therefore an alkane
- It is a nonpolar molecule and will only have weak London dispersion forces between the molecules
- CH_3CH_2CHO (A), $CH_3CH_2CH_2Cl$ (B) and CH_3CH_2COOH (C) all are polar due to the difference in electronegativity of the C atom and the atom to which they are bonded
    - O and Cl are more electronegative than C
- As well as this, molecule D is a carboxylic acid
    - Carboxylic acids have an O-H bond in, so CH_3CH_2COOH will be able to form hydrogen bonds
- Therefore, these substances will have permanent dipole permanent dipole forces between the molecules which are stronger than London dispersion forces
- The boiling point is therefore higher

A, **B** & **D** are incorrect as	these molecules have a higher boiling point than propane, $CH_3CH_2CH_3$

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The correct answer is **D** because:

- The species listed are as follows:
  - $1s^2\ 2s^2\ 2p^6\ 3s^1$ = Na
  - $1s^2\ 2s^2\ 2p^6\ 3s^2$ = Mg
  - $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$ = Al
  - $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$ = Si
- As you go across period 3 in the periodic table, the melting point of the elements increases from Na to Si
- Na, Mg and Al, have metallic structures and Si has a giant covalent / macromolecular / network covalent structure
- Therefore, Si has the highest melting point

A, **B** & **C** are incorrect as	these elements exhibit metallic bonding which is not as strong as covalent bonding within silicon's giant covalent lattice

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The correct answer is **D** because:

- A covalent bond occurs between two nonmetals and involves the electrostatic attraction between nuclei of the two atoms and the electrons of their outer shells
- These electrons are shared between the atoms
- It can be easy to get confused between the descriptions of the different types of bonding as they all involve electrostatic attraction, but the clue here is the 'sharing of electrons'
  - This is unique to covalent bonding

A is incorrect as	hydrogen bonding is a special type of intermolecular force, not a type of bonding
B is incorrect as	ionic bonding is the result of electrostatic attraction between oppositely charged ions and occurs by the transfer of electrons
C is incorrect as	metallic bonding is the result of electrostatic attraction between positive ions and delocalised electrons

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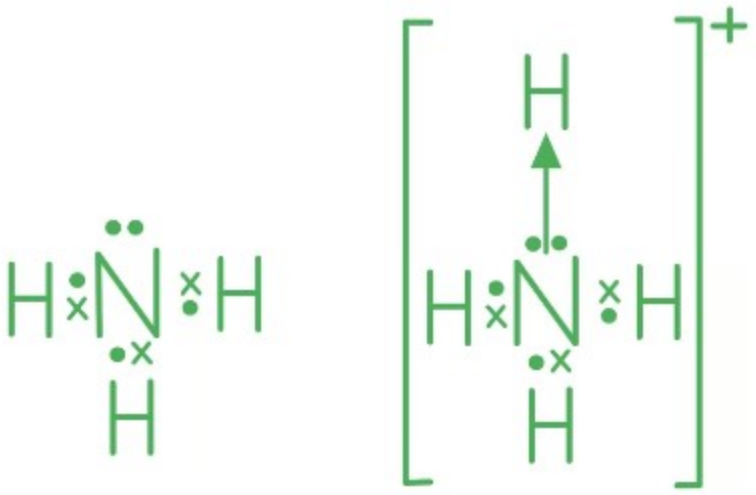
The correct answer is **D** because:

- This is incorrect as the number of valence electron pairs is four, not bonding pairs
  - 1 N atom = 1 x 5 = 5 electrons, 3 H atoms = 3 x 1 = 3 electrons
  - Total number of valence electrons = 8
  - Therefore there are 4 pairs of valence electrons
- The NH_3 molecule only has three bonds, therefore there is one lone pair of electrons
- This lone pair can form a coordinate bond with an incoming proton to form an ammonium ion. NH_4^+



A is incorrect as	the lone pair of electrons on the nitrogen atom in NH_3 can form a coordinate bond
B is incorrect as	the bond angle in a molecule of NH_3 is 107° as there are 4 electron pairs, 3 of which are bonding pairs and 1 is a lone pair
C is incorrect as	NH_3 molecules can form hydrogen bonds between them as shown: