Hydrogen bonding and methane

A Level

Part A Effects of intermolecular hydrogen bonding

Which of the following statements describes a phenomenon which can be explained by intermolecular hydrogen-bonding?

- CH_3OCH_3 (M_r = 46) has a higher boiling point than $CH_3CH_2CH_3$ (M_r = 44).
- The melting points of the Group 1 hydroxides increase with increasing relative molecular mass (M_r)
- The boiling points of the alkanes increase with increasing relative molecular mass.
- Hydrogen chloride forms an acidic solution when dissolved in water.
- Ice has a lower density than water at $0\,^\circ C$.

Part B Condensed methane

The Voyager 2 probe has shown that the surface of Triton, a moon of the planet Neptune, contains condensed methane which flows rapidly.

Which statement explains the flow within the condensed methane?

- Methane molecules have a tetrahedral structure.
- Condensed methane has a metallic structure.
- The intermolecular forces between methane molecules are weak.
- Methane molecules contain strong $C-H$ bonds.

Part A adapted with permission from UCLES, A-Level Chemistry, November 1990, Paper 1, Question 4;
Part B adapted with permission from UCLES, A-Level Chemistry, November 1996, Paper 4, Question 4

Hydration and solubility

A Level

Part A Enthalpy of hydration

For which of the following ions is the enthalpy change of hydration likely to be the most exothermic?

ion	ionic radius / nm	charge on ion
A	0.065	+2
B	0.095	+1
C	0.135	+2
D	0.169	+1
E	0.181	−1

- A
- B
- C
- D
- E

Part B Solubility in water

Which of the following compounds is **least** soluble in water?

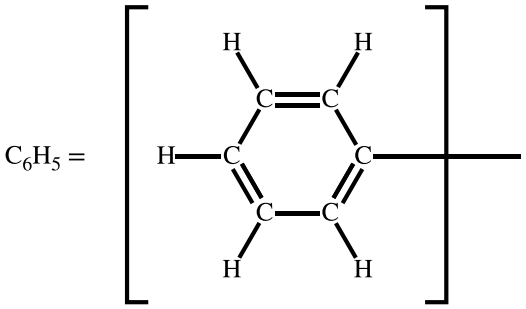


Figure 1: C_6H_5 group

- $CH_3CH(NH_2)CO_2H$
- $CH_3CH(OH)CH_3$
- $CH_3CH_2CH_2NH_2$
- $C_6H_5CO_2Na$
- $C_6H_5NH_2$

Part A adapted with permission from UCLES, A-Level Chemistry, November 1991, Paper 1, Question 8;
Part B adapted with permission from UCLES, A-Level Chemistry, June 1993, Paper 4, Question 5

Ammonia

A Level

P P P

Part A Lone pair on ammonia

Which of the following does **not** involve the lone pair of electrons on the nitrogen atom of the ammonia molecule?

- the dissolving of silver chloride in aqueous ammonia
- the hydrogen bonding that occurs between molecules of ammonia
- the formation of NH_4^+ ions in aqueous ammonia
- the formation of NH_2^- ions during the reaction of ammonia with sodium

Part B Ammonia in water

Which combination of molecules and ions exists in a solution of ammonia in water?

- ions only
- simple molecules and ions only
- hydrogen-bonded molecules and ions only
- simple molecules and hydrogen-bonded molecules only

Part A adapted with permission from UCLES, A-Level Chemistry, November 1995, Paper 4, Question 18;
Part B adapted with permission from UCLES, A-Level Chemistry, November 1998, Paper 3, Question 18

Breaking hydrogen bonds

A Level

Part A Hydrogen bonding between same molecules

Which of the following molecules will **not** form a hydrogen bond with another of its own molecules?

- CH_4
- H_2O
- CH_3OH
- NH_3

Part B Breaking hydrogen bonds

In which of the following processes will hydrogen bonds be broken?

- $H_2\,(l) \longrightarrow H_2\,(g)$
- $H_2\,(g) \longrightarrow 2\,H\,(g)$
- $NH_3\,(l) \longrightarrow NH_3\,(g)$
- $C_2H_5OC_2H_5\,(l) \longrightarrow C_2H_5OC_2H_5\,(g)$
- $2\,HI\,(g) \longrightarrow H_2\,(g) + I_2\,(g)$

Part A adapted with permission from UCLES, A-Level Chemistry, June 1994, Paper 4, Question 8;
Part B adapted with permission from OCSEB, A-Level Chemistry, June 1995, Paper 1, Question 5

Dissolving salts

A Level

Part A Barium and magnesium sulfates

Barium sulfate occurs naturally as barite, which is a solid ore. Magnesium sulfate, however, occurs mainly in solution,

Why is this?

- Magnesium sulfate is hydrolysed by naturally acidic solutions, but barium sulfate is not.
- Barium sulfate is more resistant to oxidation than magnesium sulfate.
- Barium ions are less readily hydrated than magnesium ions.
- Barium sulfate has a stronger crystalline lattice.

Part B Dissolving ammonium nitrate

Which of the following statements correctly explains why the temperature falls when ammonium nitrate dissolves in water?

- The vapour pressure over a salt solution is always less than that of the pure solvent.
- The lattice enthalpy of the salt is greater in magnitude than the enthalpy of solvation of the ions.
- Six bonds have to be broken in the crystal and only one is formed in solution.
- The lattice enthalpy of the salt has a negative value.
- The strength of the bonding between ammonium and nitrate ions in the crystal is greater than that between ammonium and hydroxide ions in solution.

Part A adapted with permission from OCR, A-Level Chemistry, November 1999, Paper 3, Question 14;
Part B adapted with permission from OCSEB, A-Level Chemistry, June 1999, Paper 1, Question 7

Dipoles

A Level

P P P

Part A Dipoles 1

Which of the following molecules has **no** permanent dipole?

- $CHCl_3$
- C_2H_5Cl
- CCl_2F_2
- C_2Cl_4

Part B Dipoles 2

In which pair of molecules is the permanent dipole in molecule **I** greater than that in molecule **II**?

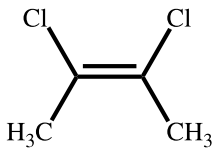
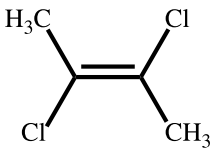
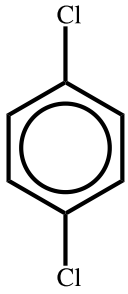
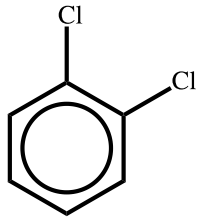
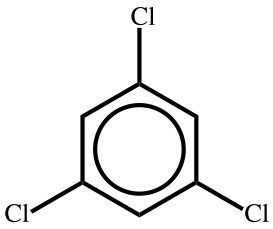
	I	II
A		
B	CH_3CH_2Cl	CH_3CHCl_2
C		
D		

Figure 1: Dipoles.

- A
- B
- C
- D

Part A adapted with permission from UCLES, A-Level Chemistry, June 1994, Paper 4, Question 9;
Part B adapted with permission from UCLES, A-Level Chemistry, June 1999, Paper 3, Question 18

Van der Waals and paraffin wax

A Level

Part A Van der Waals forces

Which of the following compounds in their solid states consist of atoms or molecules held together only by van der Waals forces (due to some form of dipole-dipole interaction)?

- H_2O
- CO_2
- MgO
- Cu
- SiO_2

Part B Melting point of paraffin wax

The melting point of paraffin wax (a mixture of saturated hydrocarbons which have high relative molar mass) is determined by

- covalent bonds within hydrocarbon molecules
- covalent bonds between hydrogen carbon molecules
- ionic bonds between molecules
- hydrogen bonds between molecules
- van der Waals (London dispersion) forces between the molecules

Part A adapted with permission from UCLES, A-Level Chemistry, November 1990, Paper 1, Question 1;
Part B adapted with permission from OCSEB, A-Level Chemistry, June 1994, Paper 1, Question 3

Hydrogen bonding

A Level

Which of the following contain hydrogen bonds?

1 $NH_4Cl\,(s)$
2 $NH_3\,(l)$
3 $HNO_3\,(l)$

- **1, 2** and **3**
- **1** and **2** only
- **2** and **3** only
- **1** only
- **3** only

Adapted with permission from UCLES, A-Level Chemistry, November 1998, Paper 3, Question 31

Dry ice and carbon tetrachloride

A Level

Part A Interactions in dry ice

Solid carbon dioxide, $\mathrm{CO_2\,(s)}$, (dry ice) is used as a refrigerating agent because it readily changes directly from the solid into vapour state at a low temperature.

What does this indicate the main intermolecular interactions in $\mathrm{CO_2\,(s)}$ to be?

- covalent bonding
- hydrogen bonding
- ionic bonding
- van der Waals' forces

Part B Liquid tetrachloromethane

Which type of interaction is responsible for intermolecular forces in liquid tetrachlomethane, $\mathrm{CCl_4}$?

- covalent bonding
- hydrogen bonding
- induced dipole - dipole attractions
- permanent dipole - dipole attractions

Part A adapted with permission from OCR, A-Level Chemistry, June 1998, Paper 3, Question 7;
Part B adapted with permission from UCLES, A-Level Chemistry, June 1998, Paper 3, Question 5

Sulfates and detergents

A Level

Part A Solubility of sulfates

Which of the following factors helps to explain the differing solubility in water of magnesium sulfate compared with that of barium sulfate?

1 Barium sulfate has a numerically (in terms of magnitude) larger lattice energy than magnesium sulfate.

2 The enthalpy change of hydration of magnesium ions is more exothermic than that of barium ions.

3 The charge density of magnesium ions is greater than that of barium ions.

- **1, 2** and **3** are correct
- **1** and **2** only are correct
- **2** and **3** only are correct
- **1** only is correct
- **3** only is correct

Part B Detergents

Long-chain alkanes are converted on an industrial scale into alkyl sulfates for use as detergents, e.g. sodium lauryl sulfate.

Which of the following are properties of this substance?

1 It possesses both a water-attracting and a water-repelling part.
2 The sulfate group is anionic in aqueous solutions.
3 The alkyl chain is soluble in oil droplets.

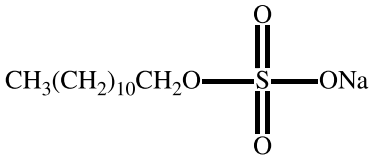


Figure 1: Sodium lauryl sulfate

- **1, 2** and **3** are correct
- **1** and **2** only are correct
- **2** and **3** only are correct
- **1** only is correct
- **3** only is correct

Part A adapted with permission from UCLES, A-Level Chemistry, November 1995, Paper 4, Question 35;
Part B adapted with permission from UCLES, A-Level Chemistry, November 1990, Paper 1, Question 32