Structure and Bonding of Solids

A Level

Part A Ionic and covalent solids

Which of the following statements about the properties associated with different types of bonding is correct?

- Ionic compounds differ from metals in that ionic compounds do not conduct electricity in the solid state.
- The only covalent compounds with high melting-points are those in which hydrogen bonds occur.
- A covalent compound cannot be an electrolyte.
- Ionic bonds and covalent bonds cannot both occur in the same compound.
- Any covalent compound that contains both oxygen and hydrogen in its molecule forms hydrogen bonds.

Part B Structure of a solid

A solid melts sharply just above $100\,^{\circ}\mathrm{C}$. It does not conduct electricity even when molten. It dissolves in hydrocarbon solvents.

What is the structure of the solid most likely to be?

- a giant ionic structure
- simple molecular
- metallic
- a giant molecular structure
- simple atomic

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 tetrachloromethane, $\mathrm{CCl_4}$?

- 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

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

Sulfates and Detergents

A Level

P P P

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.

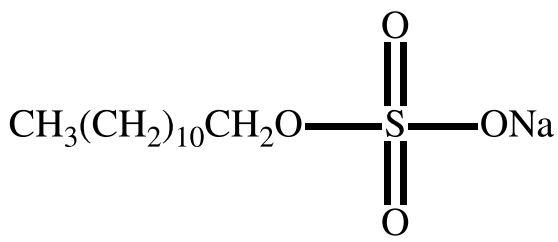

Figure 1: Sodium lauryl sulfate

- **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

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Shapes of Molecules and Ions

A Level

Part A F_2O

By considering the number of lone and bonding pairs of electrons, predict the shape of F_2O.

Part B H_3O^+

By considering the number of lone and bonding pairs of electrons, predict the shape of H_3O^+.

Part C ClF_4^-

By considering the number of lone and bonding pairs of electrons, predict the shape of ClF_4^-.

Part D SbF_5^{n-}

Antimony, Sb, is in group 15 of the Periodic Table. It forms a series of salts which contain the SbF_5^{n-} anion, the structure of which is a square-based pyramid:

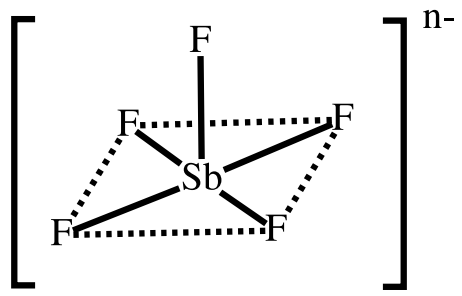

Figure 1: Structure of the SbF_5^{n-} anion

Deduce the total number of electrons around the antimony atom.

Deduce the value of n.

Adapted with permission from UCLES, A-Level Chemistry, June 1991, Paper 3, Question 2

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Shapes of Molecules and Ions Extension

A Level

Antimony, Sb, is in group 15 of the Periodic Table. It forms a series of salts which contain the $\mathrm{SbF_5}^{n-}$ anion, the structure of which is a square-based pyramid:

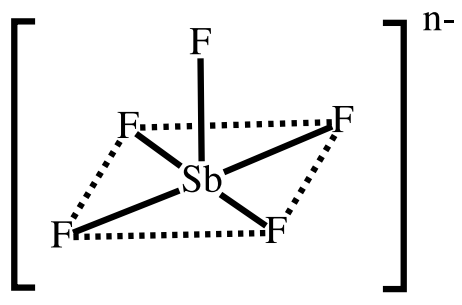

Figure 1: Structure of the $\mathrm{SbF_5}^{n-}$ anion

Deduce the oxidation number of Sb in the $\mathrm{SbF_5}^{n-}$ anion above.

Adapted with permission from UCLES A-Level Chemistry June 1991, Paper 3, Q2

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Shapes of Xenon Compounds

A Level

For each of the following, deduce the shape of the molecules and enter a one to two word answer, using appropriate shape of molecule terminology, e.g. "linear".

Part A $\mathrm{XeF_2}$

Describe the shape of $\mathrm{XeF_2}$.

Part B $\mathrm{XeOF_2}$

Describe the shape of $\mathrm{XeOF_2}$.

Part C $\mathrm{XeO_4}$

Describe the shape of $\mathrm{XeO_4}$.

Part D $\mathrm{XeF_4}$

Describe the shape of $\mathrm{XeF_4}$.

Part E $XeOF_4$

Describe the shape of $XeOF_4$.

Part A adapted with permission from OCR, STEP Chemistry, June 1999, Question 5

Gameboard:

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Essential Pre-Uni Chemistry K2.1

A Level

Complete and balance the following half-equations (assume all are in aqueous solution):

Part A Fe^{2+}

Complete and balance the half equation

$$\mathrm{Fe}^{2+} \longrightarrow \mathrm{Fe}^{3+} + \_\_\_\_\_$$

Part B Cu^{2+}

Complete and balance the half equation

$$\mathrm{Cu}^{2+} + \_\_\_\_\_ \longrightarrow \mathrm{Cu}$$

Please **click on and drag** the pre-loaded species in the equation editor to create your chemical equation.

Part C $\mathrm{MnO_4}^-$

Complete and balance the half equation

$$\mathrm{MnO_4}^- + \_\_\_\_\_ \longrightarrow \mathrm{Mn}^{2+} + \_\_\_\_\_$$

Please **click on and drag** the pre-loaded species in the equation editor to create your chemical equation.

Part D H_2O_2

Complete and balance the half equation

$$H_2O_2 + \_\_\_\_\_ \longrightarrow 2\,OH^-$$

Please **click on and drag** the pre-loaded species in the equation editor to create your chemical equation.

Part E H_2O_2 ii

Complete and balance the half equation

$$H_2O_2 \longrightarrow O_2 + 2\,H^+ + \_\_\_\_\_$$

Part F NH_3

Complete and balance the half equation

$$NH_3 + \_\_\_\_\_ \longrightarrow NO + \_\_\_\_\_$$

Please **click on and drag** the pre-loaded species in the equation editor to create your chemical equation.

Part G Br^-

Complete and balance the half equation

$$Br^- + \_\_\_\_\_ \longrightarrow BrO_3{}^- + \_\_\_\_\_$$

Please **click on and drag** the pre-loaded species in the equation editor to create your chemical equation.

Part H NO_3^-

Complete and balance the half equation

$$NO_3^- + \_\_\_\_\_ \longrightarrow N_2 + \_\_\_\_\_$$

Please **click on and drag** the pre-loaded species in the equation editor to create your chemical equation.

Gameboard:

STEM SMART Chemistry Week 16

Essential Pre-Uni Chemistry D3.1

A Level

There are trends evident in atomic and ionic radii. Ionisation energies also show trends. Complete the sentences below with the words 'increase' or 'decrease', to indicate what happens to the radii and ionisation energy of the atoms or ions [(a)–(f)], or to the ionisation energies [(g)–(i)].

Part A Along a period, L-R

Going along a period from left to right, the atomic radii...

- increase
- decrease

Part B Down a group

Going down a group, the atomic radii...

- increase
- decrease

Part C Electrons removed

As successive electrons are removed from the same atom/ion, the radii...

- increase
- decrease

Part D Same charge, down a group

The radii of ions of the same charge, on descending a group...

- decrease
- increase

Part E Adding electrons

As successive electrons are added to one atom to make increasingly negative ions, the radii...

- increase
- decrease

Part F Along period, L-R

Along a period from left to right, the radii of isoelectronic species generally...

- ○ increase
- ○ decrease

Part G Along period, L-R

Along a period from left to right, the first ionisation energies generally...

- ○ increase
- ○ decrease

Part H Down a group

Going down a group, the first ionisation energies...

- ○ decrease
- ○ increase

Part I Ionisation energies

Successive ionisation energies for the same element...

- ○ decrease
- ○ increase

Gameboard:

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Ionisation of Elements

A Level

The table below shows the first five ionisation energies of five elements in the same group of the Periodic Table.

		Element	Ionisation Energy / $\mathrm{kJ\,mol^{-1}}$				
			1st	2nd	3rd	4th	5th
Increasing proton (atomic) number	↓	A	1090	2350	4610	6220	37830
		B	786	1580	3230	4360	16090
		C	762	1540	3300	4390	6970
		D	707	1410	2940	3930	6970
		E	716	1450	3080	4080	6640

Part A Group

In which group of the Periodic Table are the elements found?

Part B Ionisation of Na

Write an equation, with state symbols, to define the first ionisation energy of Na.

Part C Decrease in ionisation energy

Why does the first ionisation energy of the element tend to show a decrease down the table?

- Electronegativity decreases.
- Electron affinity decreases.
- Hydration energy decreases.
- Electrons are being removed from higher energy shells.
- Lattice energy decreases.
- The effective nuclear change experienced by the electron decreases down the group.

Part D A^{2+}

Calculate the energy change of:

$$A\,(\mathrm{g}) \longrightarrow A^{2+}\,(\mathrm{g}) + 2\,\mathrm{e}^{-}\,(\mathrm{g})$$

Part E E^{2+}

Calculate the energy change of:

$$E\,(\mathrm{g}) \longrightarrow E^{2+}\,(\mathrm{g}) + 2\,\mathrm{e}^{-}\,(\mathrm{g})$$

Part F A bonding

What sorts of bond would you expect A to form?

Adapted with permission from UCLES, A-Level Chemistry, December 1995, Paper 3, Question 3.