03 Chemical Bonding and Structure

Set A **Answer key**

A From the lesson

26 MARKS

1 **C** $Al_2(SO_4)_3$ **[1]**

Al^{3+} and SO_4^{2-}: two Al^{3+} (+6) balance three SO_4^{2-} (−6).

Brackets keep the sulfate ion together when more than one is needed.

2 **B** MgO **[1]**

Mg^{2+} and O^{2-} both carry a charge of 2 and are small, so the attraction between them is the strongest.

The other compounds are all made of +1 and −1 ions.

3 **B** 5 σ, 1 π **[1]**

The four C–H single bonds are 4 σ bonds.

The C=C double bond is one σ bond and one π bond.

4 **D** $CHCl_3$ **[1]**

In $CHCl_3$ one C–H bond replaces a C–Cl bond, so the bond dipoles of the tetrahedral molecule no longer cancel.

CCl_4, BF_3 and CO_2 are symmetrical, so their dipoles cancel.

5 **C** H_2O **[1]**

Water forms 2 hydrogen bonds per molecule: it has 2 H atoms on O and 2 lone pairs on O.

NH_3 and HF form only 1 per molecule on average, and CH_4 forms none.

6 **(a)** Period 3, Group 2: three shells and 2 valence electrons (2.8.2). **[1]**

(b) Period 3, Group 16: three shells and 6 valence electrons (2.8.6). **[1]**

(c) By losing: calcium is in Group 2, so it has 2 valence electrons.
Losing two is far easier than gaining six, so it forms Ca^{2+}. **[2]**

7 K_2O, $FeCl_3$ and $(NH_4)_2SO_4$ [3]

8 NaF. Both are made of ions with charges of 1+ and 1–, but Na^+ and F^- are smaller than Cs^+ and Cl^-.

So the attraction between the ions in NaF is stronger, and more energy is needed to overcome it. [2]

9 **(a)** O in the centre shares one pair with each H atom, and has two lone pairs. [1]

(b) The two N atoms share three pairs (a triple bond), and each N has one lone pair. [1]

10 **(a)** Trigonal planar, 120° (3 bond pairs) [1]

(b) Bent, 104.5° (2 bond pairs, 2 lone pairs) [1]

(c) Octahedral, 90° (6 bond pairs) [1]

(d) Square planar, 90° (4 bond pairs, 2 lone pairs opposite each other) [1]

11 **(a)** C–F: fluorine is more electronegative than chlorine. [1]

(b) It is tetrahedral and symmetrical, so the four bond dipoles cancel. [1]

12 **(a)** CH_3OH and NH_3: each has H bonded to O or N, and a lone pair on O or N. [1]

(b) $Cl_2 < Br_2 < I_2$: the number of electrons increases, so the instantaneous dipole–induced dipole forces get stronger. [1]

13 SiO_2 is giant covalent: melting it breaks many strong covalent bonds.

CO_2 is simple molecular: boiling it overcomes only weak instantaneous dipole–induced dipole forces between molecules. [2]

B Practice

17 MARKS

14 **A** It is a compound of sodium and chlorine. [1]

Sodium and chlorine react and are chemically combined, so sodium chloride is a compound with properties unlike either element.

A mixture or an alloy forms with no reaction, and sodium chloride contains two elements, so it is not an element.

15 **B** X forms ionic bonds with Y. [1]

X (2.1) is lithium, a metal. Y (1) is hydrogen and Z (2.8.7) is chlorine, both non-metals. A metal and a non-metal form ionic bonds, so X bonds ionically with Y.

X with Z is also ionic, not covalent. Hydrogen and chlorine are both non-metals, so they share electrons: Y forms covalent bonds with Z.

16 **D** X 2.8.8.2, Y 2.8.7 [1]

In XY_2, one X ion balances two Y ions, so X forms X^{2+} and Y forms Y^-.

X loses 2 electrons (2.8.8.2, calcium) and Y gains 1 (2.8.7, chlorine): $CaCl_2$.

17 **B** row B [1]

X (2.8.3, aluminium) loses 3 electrons to form X^{3+}. Y (2.6, oxygen) gains 2 to form Y^{2-}.

Two X atoms give 6 electrons to three Y atoms, forming the ionic compound X_2Y_3 (Al_2O_3).

18 **C** The forces of attraction between K^+ and Cl^- are weaker than those between Ca^{2+} and O^{2-}. [1]

Both are ionic. K^+ and Cl^- carry charges of 1, while Ca^{2+} and O^{2-} carry charges of 2, so the attraction in KCl is weaker and needs less energy to overcome.

Melting a compound has nothing to do with the melting points or reactivity of the metals in it.

19 **D** the ratio of calcium ions to chloride ions is half [1]

$CaCl_2$ has 1 Ca^{2+} to 2 Cl^-, a ratio of 1 : 2. KCl has 1 K^+ to 1 Cl^-, 1 : 1. So the ratio in $CaCl_2$ is half that in KCl.

Ca^{2+} has the greater charge, the ions cannot move in the solid, and ionic compounds have no sea of electrons.

20 **C** R_2S_3, PS_2 [1]

P is carbon, Q magnesium, R aluminium and S oxygen. R (Al^{3+}) and S (O^{2-}) form the ionic compound R_2S_3.

P and S are both non-metals and form the covalent compound PS_2 (CO_2). Q and R are both metals, so Q_3R_2 is not a compound, and S_2 is an element.

21 **C** 10 electrons, 8 neutrons [1]

A hydroxide ion is OH^-. Oxygen-16 has 8 protons, 8 electrons and 8 neutrons. Hydrogen-1 has 1 proton, 1 electron and no neutrons.

Electrons = 8 + 1 + 1 for the charge = 10. Neutrons = 8 + 0 = 8.

22 **A** ammonium chloride [1]

Ammonium chloride is made of NH_4^+ and Cl^- ions held by ionic bonds, and the atoms inside NH_4^+ are joined by covalent bonds.

Hydrogen chloride and silicon dioxide are covalent only. Lithium oxide is ionic only.

23 **B** iron [1]

A metal has a high melting point, conducts through its delocalised electrons and is malleable because its layers of ions slide.

Graphite conducts but is not malleable. Potassium chloride and silicon dioxide do not conduct as solids.

24 **D** The zinc atoms disrupt the orderly arrangement of copper atoms. [1]

Zinc atoms are a different size from copper atoms, so they disrupt the regular layers.

The layers can no longer slide over one another easily, so brass is harder. More zinc disrupts the layers more.

25 **C** Electrons in a metal move randomly through the giant metallic lattice. [1]

The delocalised electrons are not tied to any one ion and move throughout the lattice.

The lattice is made of positive ions, not atoms. Some metals, such as sodium (98 °C), melt at low temperatures. Metals are malleable because layers of ions slide, while the ions stay in their layers.

26 **B** row B [1]

Each shared pair is 2 electrons. NH_3 has 3 shared pairs (6), CO_2 two double bonds (8), F_2 one single bond (2) and N_2 a triple bond (6).

Lone pairs are not used in bonding, so they are not counted.

27 **B** a high melting point [1]

Melting silicon dioxide means breaking many strong covalent bonds throughout the structure, which needs a lot of energy.

It has no mobile electrons or ions, so it does not conduct, and a giant covalent substance is insoluble in water.

28

B Both substances have different covalent structures. [1]

Carbon dioxide is simple molecular: only weak forces between molecules must be overcome. Silicon dioxide is giant covalent: many strong covalent bonds must be broken.

Silicon dioxide has no ions, and the strength of the covalent bonds inside CO_2 molecules does not decide its boiling point.

29

A diamond and silicon dioxide [1]

In diamond each C is bonded to 4 others in a tetrahedral arrangement. In silicon dioxide each Si is bonded to 4 O in the same tetrahedral network.

Graphite is in flat layers, and carbon dioxide is made of separate linear molecules.

30

C 2 and 3 only [1]

A giant covalent substance does not conduct in any state (graphite is the exception, and it conducts as a solid), and it is insoluble, so 1 is wrong.

Simple molecular substances have low melting points and no mobile charges (2). Metals conduct as solid and liquid through delocalised electrons, and their melting points vary (3).