1.3 Bonding structure and electrolysis

Name: _____ Class: _____ Date: _____ **Total: 32 marks**

Objective

Build the skills to answer exam questions on **bonding, structure and electrolysis** 、 : ionic, covalent and metallic bonding, the properties of giant and simple structures, and electrolysis of molten and aqueous compounds.

You must be able to:

- write formulae of ionic compounds
- link structure and bonding to melting point and conductivity
- predict products of electrolysis and write half-equations
- compare the properties of different structures

1 Key knowledge and worked examples

■ Structure and electrolysis

structure	bonding	properties
giant ionic, e.g. NaCl	metal ions + non-metal ions, held by strong attraction	high melting point; conducts when molten or dissolved
simple molecular, e.g. Cl_2	shared pairs of electrons; weak forces between molecules	low melting point; does not conduct
giant covalent, e.g. diamond	many strong covalent bonds	very high melting point
metallic	positive ions in a sea of delocalised electrons	conducts as a solid; malleable
electrolysis	cathode (−): positive ions gain electrons; anode (+): negative ions lose electrons	

Worked example 1: an ionic formula. Find the formula of aluminium oxide.

1. Known: Al^{3+} and O^{2-}.
2. Rule: total positive charge = total negative charge.
3. Numbers: $2 \times (+3) = +6$; $3 \times (-2) = -6$.
4. Result: $\mathbf{Al_2O_3}$.

Worked example 2: a half-equation. Write the half-equation at the cathode when molten lead(II) bromide is electrolysed.

1. Known: Pb^{2+} goes to the cathode.
2. Rule: positive ions gain electrons.
3. Numbers: 2 electrons for a 2+ ion.
4. Result: $\mathbf{Pb^{2+}} + 2e^- \rightarrow \mathbf{Pb}$.

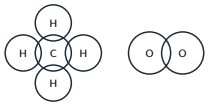
Answer shapes: link the property to the particles: what has to be broken, and how strong it is.

2 Practice

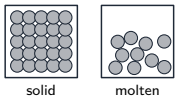
2.1 Write the formulae of magnesium chloride and calcium oxide. [2]

Mg^{2+} Cl^- Ca^{2+} O^{2-}

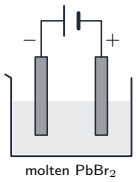
2.2 State the number of shared pairs of electrons in a molecule of methane, CH_4, and in a molecule of oxygen, O_2. [2]



2.3 Explain why sodium chloride conducts electricity when molten but not when solid. [2]



2.4 Molten lead(II) bromide is electrolysed. Name the product at the cathode and at the anode. [2]



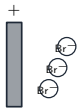
2.5 Explain why graphite conducts electricity. [2]

3 Exam-style questions

3.1 Explain why diamond has a very high melting point. [3]

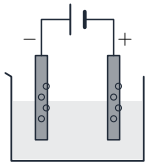


3.2 Write the half-equation for the reaction of bromide ions at the anode, and explain whether it is oxidation or reduction. [3]



3.3 Concentrated sodium chloride solution (brine) is electrolysed using inert electrodes. A gas is made at each electrode, and the solution left becomes alkaline.

(a) Name the product at the cathode, the product at the anode, and the substance left in solution. [3]



(b) Explain why hydrogen, and not sodium, is produced at the cathode. Include a half-equation. [4]

(c) Describe a test for each gas and give the result. [3]

(d) Sodium chloride melts at 801 °C; chlorine boils at −34 °C. Explain this difference, and the difference in electrical conductivity of solid sodium chloride and liquid chlorine, in terms of structure and bonding. [6]

Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

- $MgCl_2$
- CaO

2.2

- methane: 4
- oxygen: 2 (a double bond)

2.3

- in the solid the ions are fixed in place
- when molten the ions are free to move and carry charge

2.4

- cathode: lead
- anode: bromine

2.5

- each carbon atom forms only three bonds, so one electron per atom is delocalised
- these electrons move along the layers and carry charge

3.1

- diamond is a giant covalent structure
- each carbon atom is joined to four others by strong covalent bonds
- a lot of energy is needed to break these many strong bonds

3.2

- $2Br^- \rightarrow Br_2 + 2e^-$
- oxidation, because the bromide ions lose electrons

3.3

(a) cathode: hydrogen; anode: chlorine; solution: sodium hydroxide

(b) the solution contains Na^+ ions and H^+ ions from water; hydrogen is less reactive than sodium, so H^+ ions gain electrons more easily; $2H^+ + 2e^- \rightarrow H_2$

(c) hydrogen: a lit splint gives a squeaky pop; chlorine: damp blue litmus paper turns red and then white (bleached)

(d) points to include:

- sodium chloride is a giant ionic lattice with strong attraction between oppositely charged ions in all directions (K)
- a lot of energy is needed to overcome these, so its melting point is high (An)
- chlorine is a simple molecular substance: strong covalent bonds inside each molecule, but weak forces between molecules (K)
- little energy is needed to separate the molecules, so its boiling point is low (An)
- solid sodium chloride does not conduct, because its ions cannot move (An)
- liquid chlorine does not conduct, because it has no ions and no free electrons (An)

Levels: **5–6** a full, logical answer with correct chemistry and correct terms; **3–4** several correct points, partly linked; **1–2** one or two relevant points.