8.1 The metallic model

Name: _____ Class: _____ Date: _____ **Total: 25 marks**

KEY WORDS metallic bond • delocalized electrons • cation • malleable • ductile • transition element

Objective

Build the skills to answer exam questions on **the metallic model** : metallic bonding, the properties of metals and what makes a metallic bond strong.

You must be able to:

- describe metallic bonding as cations in a sea of delocalized electrons
- explain electrical and thermal conductivity, malleability and ductility
- explain trends in melting point using ion charge, ion radius and the number of delocalized electrons
- explain the high melting points and conductivity of transition elements using delocalized d electrons

1 Key knowledge and worked examples

■ Metallic bonding

A metal is a lattice of **cations** in a "sea" of **delocalized electrons**. The **metallic bond** is the electrostatic attraction between the cations and the delocalized electrons.

property	reason
conducts electricity	delocalized electrons move through the lattice when a voltage is applied
conducts heat	delocalized electrons (and vibrating cations) pass on kinetic energy
malleable and ductile	layers of cations can slide; the delocalized electrons still hold them together
high melting point (usually)	strong attraction between cations and electrons in all directions

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Bond strength rises with a higher cation charge (more delocalized electrons) and a smaller cation radius.

metal	**Na**	**Mg**	**Al**	**K**
melting point / °C	98	650	660	63

Transition elements (HL): both 4s and 3d electrons can be delocalized, so there are many delocalized electrons per atom: high melting points and good conductivity.

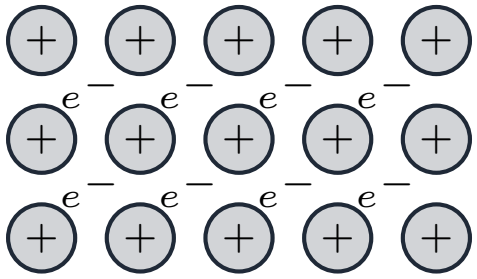
Worked example 1: size. Li (181 °C) melts higher than Na (98 °C): Li^+ is **smaller**, so its delocalized electrons are closer and attracted more strongly.

Worked example 2: a use. Copper is used for wires because it is **ductile** and a **very good conductor**.

Answer shapes: link each property to the delocalized electrons or to the cations.

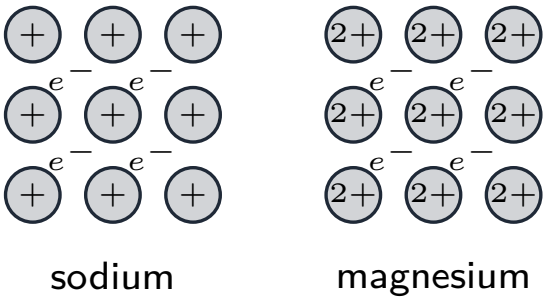
2 Practice

2.1 Describe the bonding in a metal. [2]

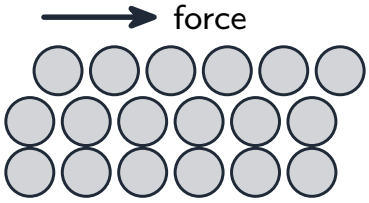


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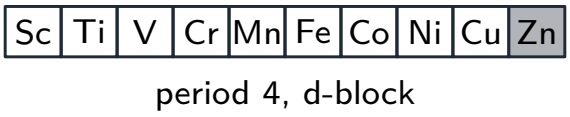
2.2 Magnesium melts at 650 °C and sodium at 98 °C. Explain the difference. [3]



2.3 Explain why copper can be drawn into wires, and why it conducts electricity. [3]

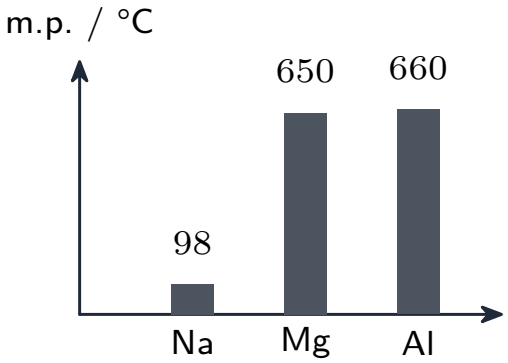


2.4 Explain why zinc is not a transition element, although it is in the d-block. [2]



3 Exam-style questions

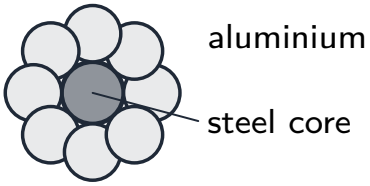
3.1 The graph shows the melting points of sodium, magnesium and aluminium.



(a) Describe and explain the trend from sodium to aluminium. [3]

(b) Potassium melts at 63 °C. Explain why it melts at a lower temperature than sodium. [2]

3.2 Overhead power cables are made of aluminium around a steel core. House wiring is made of copper.



(a) State two properties of aluminium that make it suitable for overhead cables. [2]

(b) Explain, in terms of bonding, why aluminium conducts electricity. [2]

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(c) Suggest why aluminium, not copper, is used for overhead cables. [1]

(d) Explain why metals are good conductors of heat. [2]

(e) Chromium melts at 1907 °C and calcium at 842 °C. Both are in period 4. Explain the difference. [3]

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Solutions

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

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

2.1

a lattice of positive ions / cations and delocalized electrons; held by electrostatic attraction between them

2.2

Mg^{2+} has a higher charge than Na^{+} and gives two delocalized electrons per atom; Mg^{2+} is smaller; so the attraction between ions and delocalized electrons is stronger and more energy is needed to break it

2.3

the layers of cations can slide over each other; the delocalized electrons still hold the ions together, so the metal does not break; delocalized electrons are free to move through the structure and carry charge

2.4

a transition element has an incomplete d sublevel in at least one of its ions; Zn is $[Ar]3d^{10}4s^{2}$ and Zn^{2+} is $[Ar]3d^{10}$: the 3d sublevel is always full

3.1

(a) melting point rises from Na to Al; the cation charge rises (+1, +2, +3), so there are more delocalized electrons; and the cations get smaller, so the attraction is stronger

(b) K^{+} is larger than Na^{+} (an extra electron shell); the delocalized electrons are further from the nuclei, so the attraction is weaker

3.2

(a) good electrical conductor; low density / does not corrode / ductile

(b) it has delocalized electrons; which move through the lattice when a potential difference is applied

(c) aluminium has a much lower density, so the cables are lighter

(d) delocalized electrons gain kinetic energy and move quickly through the metal; they pass on energy by collisions with ions / the vibrating ions also pass it on

(e) calcium delocalizes only its two 4s electrons; chromium can also delocalize its 3d electrons, so there are more delocalized electrons per atom; the metallic bonding is much stronger

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