

**1. Explain why metals are malleable whilst salts such as sodium chloride (NaCl) are brittle. (6 marks)**

**Metals**

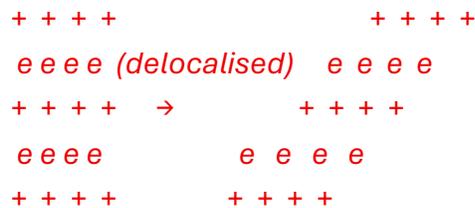
Metals consist of a lattice of positive metal ions surrounded by a “sea” of delocalised electrons. 1-----mark- must state the word delocalised

Metallic bonds are **non-directional**, so when layers of metal atoms slide over one another the metallic bonding remains intact because the delocalised electrons continue to hold the positive ions together. As a result, the layers of atoms can move without the structure breaking, making metals **malleable and ductile**. 1-----mark

**Diagram (metal)** 1-----mark diagram must show + ions in a sea of electrons before and after force still having a significant force of attraction between the cations and sea of delocalised electrons.

Before force:

After force:



**Ionic solids (NaCl)**

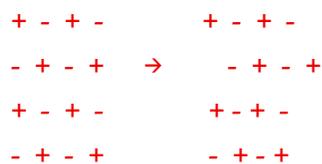
Ionic solids consist of a lattice of alternating positive and negative ions held together by strong directional electrostatic forces of attractions. 1-----mark – must mention directional

When a force is applied and the layers shift, ions of the same charge become aligned next to each other. The strong repulsion between like charges causes the lattice to fracture, so ionic compounds are brittle. 1-----mark

**Diagram (ionic):**

Before force:

After force:



1-----mark showing like charges aligned

## 2. Properties of compounds

First identify the atoms.

A:  $1s^2 2s^2 2p^5 \rightarrow$  **Fluorine (F)**

B:  $\dots 4s^1 \rightarrow$  **Potassium (K)**

C:  $\dots 3p^4 \rightarrow$  **Sulfur (S)**

D:  $\dots 4s^2 3d^2 \rightarrow$  **Titanium (Ti)**

### a. Compound between A and B

$K + F \rightarrow KF$

i. Formula:  $KF$                       1-----mark

ii. BP: High                              1-----mark

iii. Conducts electricity:

in liquid state                              1-----mark – both states must be correctly stated.

in aqueous state

(ionic compounds do not conduct when solid)

### b. Compound between A and C

$F + S \rightarrow SF_2$

i. Formula:  $SF_2$                       1-----mark

ii. BP: Low                                1-----mark

iii. Conducts electricity:

does not conduct                        1-----mark

(Simple molecular covalent compound)

### c. Substance made of atom D (Titanium – metal)

i. Electronic configuration of particles in solid:

$Ti^{2+}$  ions with delocalised electrons                      1-----mark

(or positive metal ions in a sea of delocalised electrons)

ii. BP: High                                1-----mark

iii. Conducts electricity:                      1-----mark

*solid state*  
*liquid state*

*1-----mark for both*

### 3. Match the property with the structural feature (10 marks)

Property	Structural Feature
i. Electrical conductivity in solid state	<i>A and C and E</i>
ii. High melting point	<i>A, D</i>
iii. Brittleness	<i>D</i>
iv. Malleability	<i>E and A</i>
v. Electrical conductivity of graphite	<i>C</i>
vi. Lustrous	<i>A and E</i>
vii. Sublimes at very high temperatures	<i>F and C</i>
viii. Conducts electricity only liquid and aqueous states	<i>B</i>
ix. Low BP and MP	<i>G and H</i>
x. Gas at room temperature	<i>H and H</i>

### 4a. Order of increasing melting temperature

Lowest → Highest



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### 4b. Explanation (6 marks)

*Mercury is a liquid metal at room temperature. 1-----mark*

*The other three substances are ionic compounds, which have strong electrostatic attractions between oppositely charged ions in a crystal lattice, giving them high melting temperatures. 1-----mark*

Potassium oxide ( $K_2O$ ) contains  $K^+$  ions, which have a +1 charge and relatively large ionic radius. This results in weaker ionic attraction compared with MgO and  $Al_2O_3$ . 1-----mark

Magnesium oxide (MgO) contains  $Mg^{2+}$  ions, which have a higher charge and smaller ionic radius than  $K^+$ , leading to stronger electrostatic attractions and therefore a higher melting point. 1-----mark

Aluminium oxide ( $Al_2O_3$ ) contains  $Al^{3+}$  ions, which have the highest charge and very strong electrostatic attraction to  $O^{2-}$  ions. This results in the strongest ionic bonding and the highest melting temperature. 1-----mark

1-----mark for mentioning the ionic radius and the impact it has on the electrostatic force of attraction.

## 5. Properties the metallic bonding model cannot explain

Circle:

i. Density

ii. Reactivity

vi. Magnetism

ix. Why mercury is liquid at room temperature

1-----mark each

The metallic bonding model does explain:

- conductivity
- malleability
- ductility
- lustre
- high melting temperatures (generally)