

Metallic Bonding and Types of Solids

Answer key with explanations

A. Metallic bonding

1. Metallic bonding.

(a) The attraction between **positive metal ions** in a regular lattice and a **sea of delocalized electrons**. (b) The delocalized electrons are **free to move**, so they carry a current. The layers of ions can **slide** over each other while the electron sea keeps holding them together, so the metal changes shape without breaking.

2. Magnesium and sodium.

Magnesium gives **two** electrons per atom to the sea (forming Mg^{2+}), sodium only one (Na^+). Magnesium ions are also **smaller** and more highly charged, so the attraction between the ions and the electron sea is **stronger**, and more energy is needed to melt it.

3. Alloys.

(a) A mixture of a metal with other elements (usually metals).
(b) Tin atoms are a different size from copper atoms, so they **disrupt the layers**, which can no longer slide easily: the alloy is harder.

$$(c) m_{\text{Cu}} = \frac{88.0}{100} \times 40.0 \text{ g} = \mathbf{35.2 \text{ g}} \text{ and } m_{\text{Sn}} = 40.0 \text{ g} - 35.2 \text{ g} = \mathbf{4.8 \text{ g}}$$

B. Types of solid

4. Classify.

P: **metallic** (conducts as a solid: mobile electrons). Q: **molecular** (low melting point, no conduction). R: **ionic** (conducts only when the ions are free to move). S: **covalent network** (strong covalent bonds throughout, no mobile charges).

5. Explanations.

(a) In solid KCl the ions are fixed in the lattice. In solution they are **free to move** and carry charge. (b) Iodine is a **molecular** solid. Melting only overcomes the weak **forces between** I_2 molecules; the I-I covalent bonds are not broken.

C. Diamond and graphite

6. Diamond and graphite.

(a) In diamond every carbon is covalently bonded to **four** others in a rigid 3D network; many strong bonds must be broken to scratch or break it. (b) In graphite each carbon bonds to **three** others in flat layers; the fourth outer electron is **delocalized** along the layer and can move, carrying a current. (c) The layers are held together only by **weak forces**, so they slide off onto the paper.

D. Comparing structures

7. Bend or shatter.

In the metal, layers of positive ions slide over each other but stay surrounded by the electron sea, so the bonding is not broken: it **bends**. In salt, a slight shift brings ions of the **same charge** next to each other; they repel and the crystal **shatters**.

E. Challenge

8. SiO_2 and CO_2 .

CO_2 is **molecular**: separate small molecules held together only by weak forces, which are overcome far below room temperature. SiO_2 is a **covalent network**: each Si is bonded to four O atoms and each O to two Si atoms in a giant 3D structure, so melting requires breaking many strong **covalent bonds**. The formula SiO_2 gives only the ratio of atoms, not a molecule.