

Metals by reactivity and how we extract them

Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Worksheet answers

Each answer gives the chemical reasoning as well as the result. For equations, check the balancing last; for redox, always say which substance gains or loses oxygen or electrons.

Level: Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** GCSE C4

Problem 1 Put them in order

1. **Potassium, magnesium, zinc, iron, copper, gold.**
2. **Potassium** reacts with cold water, violently.
3. **Copper and gold.**

Problem 2 Metals and dilute acid

1. **Magnesium, zinc, iron**, and copper does not fizz at all.
2. **Magnesium + hydrochloric acid → magnesium chloride + hydrogen.**
3. A lighted splint gives a **squeaky pop**.

Problem 3 Will it react?

1. **Reaction:** zinc sulfate and copper.
2. **No reaction:** copper is less reactive than zinc.
3. **Reaction:** magnesium sulfate and iron.
4. **No reaction:** iron is below magnesium.

Problem 4 Vocabulary of redox

1. **Oxidation is gain of oxygen.**
2. **Reduction is gain of electrons.**
3. Hydrogen gains oxygen, so **H₂ is oxidised**; copper oxide loses oxygen, so **CuO is reduced**.
4. **Oxidation Is Loss, Reduction Is Gain** (of electrons).

Problem 5 Choose the method

1. **Electrolysis.**
2. **Heating with carbon.**
3. **Found uncombined.**
4. **Electrolysis.**
5. **Heating with carbon.**

Problem 6 Inside a blast furnace

1. Coke is carbon: it **burns to give heat and forms carbon monoxide**.
2. **Carbon monoxide**.
3. Limestone removes sandy impurities as **slag**: $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$, then $\text{CaO} + \text{SiO}_2 \rightarrow \text{CaSiO}_3$.

Problem 7 Balance the equations

1. $2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2$.
2. $2\text{Al} + 6\text{HCl} \rightarrow 2\text{AlCl}_3 + 3\text{H}_2$.
3. $\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$.
4. Already balanced: $\text{ZnO} + \text{C} \rightarrow \text{Zn} + \text{CO}$.

Problem 8 Ionic equation and half-equations

1. $\text{Zn} + \text{Cu}^{2+} \rightarrow \text{Zn}^{2+} + \text{Cu}$.
2. $\text{Zn} \rightarrow \text{Zn}^{2+} + 2\text{e}^-$: **oxidation**.
3. $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$ (reduction). The spectator is the **sulfate ion, SO_4^{2-}** .

Problem 9 Redox spotting

1. Mg is **oxidised**, O_2 is reduced; reducing agent **Mg**.
2. CO is **oxidised**, Fe_2O_3 is **reduced**; reducing agent **CO**.
3. Fe is **oxidised** ($\text{Fe} \rightarrow \text{Fe}^{2+}$), Cu^{2+} is reduced; reducing agent **Fe**.
4. H_2 is **oxidised**, CuO is reduced; reducing agent **H_2** .

Problem 10 Deduce the order

1. W displaces X, Y and Z, and Y displaces X and Z, X displaces only Z. The order is **$\text{W} > \text{Y} > \text{X} > \text{Z}$** .
2. **Z**, because it displaces nothing.
3. **No reaction**, because Y is less reactive than W.

Problem 11 Welding rails

1. Aluminium is **more reactive than iron**, so it displaces iron from its oxide.
2. $n = 5400 \div 27 = \mathbf{200 \text{ mol}}$.
3. $n(\text{Fe}) = 200 \text{ mol}$, $m = 200 \times 56 = \mathbf{11.2 \text{ kg}}$. $n(\text{Fe}_2\text{O}_3) = 100 \text{ mol}$, $m = 100 \times 160 = \mathbf{16 \text{ kg}}$.

Problem 12 Galvanised roofs

1. Area = 20 000 cm²; $V = 20\,000 \times 0.0020 = \mathbf{40 \text{ cm}^3}$.
2. $m = 40 \times 7.1 = \mathbf{284 \text{ g}}$.
3. Zinc is **more reactive than iron**, so it loses electrons first and corrodes instead of the

iron (sacrificial protection).

Problem 13 Recycling aluminium

- $1000 \times 15 \text{ g} = 15\,000 \text{ g} = \mathbf{15 \text{ kg}}$.
- Extraction: $15 \times 50 = 750 \text{ MJ}$; recycling: $15 \times 2.5 = 37.5 \text{ MJ}$; saving = **712.5 MJ**.
- $712.5 \div 750 \times 100 = \mathbf{95\%}$. Recycling only melts the metal, whereas extraction requires **electrolysis of molten aluminium oxide** at high temperature.

Problem 14 How much iron in the ore?

- $112 \div 160 \times 100 = \mathbf{70.0\%}$.
- $\text{Fe}_2\text{O}_3 = 0.80 \times 50 = 40 \text{ t}$; iron = $0.700 \times 40 = \mathbf{28 \text{ t}}$.
- $0.92 \times 28 = \mathbf{25.8 \text{ t}}$ (25.76 t).

Problem 15 Reactions with water

- Sodium > calcium > magnesium**.
- Sodium loses **one outer electron** very easily ($\text{Na} \rightarrow \text{Na}^+ + \text{e}^-$), whereas magnesium must lose two electrons, which takes more energy.
- $2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2$** .

Problem 16 Smelting copper oxide

- $M(\text{CuO}) = 79.5$, so $n = 159 \div 79.5 = \mathbf{2.00 \text{ mol}}$; $n(\text{C}) = 6.0 \div 12 = \mathbf{0.50 \text{ mol}}$.
- 2.00 mol CuO needs 1.00 mol C, so **carbon is limiting**.
- 0.50 mol C reacts with 1.00 mol CuO and forms 1.00 mol Cu: $m = \mathbf{63.5 \text{ g}}$. CuO left = $1.00 \text{ mol} \times 79.5 = \mathbf{79.5 \text{ g}}$.

Problem 17 Zinc in copper sulfate

- $n(\text{Zn}) = 3.25 \div 65 = \mathbf{0.0500 \text{ mol}}$; $n(\text{CuSO}_4) = 0.400 \times 0.100 = \mathbf{0.0400 \text{ mol}}$.
- Ratio 1 : 1, so **copper sulfate is limiting**; $n(\text{Cu}) = 0.0400 \text{ mol}$, $m = \mathbf{2.54 \text{ g}}$.
- Zinc left = $0.0100 \text{ mol} \times 65 = \mathbf{0.65 \text{ g}}$. $c(\text{ZnSO}_4) = 0.0400 \div 0.100 = \mathbf{0.400 \text{ mol/dm}^3}$.

Problem 18 Spot the errors

- (a) Cost is irrelevant; carbon is **less reactive** than aluminium. (b) Use as coins depends on resisting corrosion, which shows copper is **less reactive**. (c) Sodium reacts with the **water** first.
- (a) Carbon cannot displace aluminium because aluminium is more reactive than carbon. (b) Copper is less reactive than iron. (c) Sodium reacts with water in the solution.
- $2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2$, and the NaOH then forms a **blue precipitate of copper(II) hydroxide**, not copper metal.

Problem 19 Aluminium electrolysis

1. $1000 \div 27 = \mathbf{37.0 \text{ kmol}}$ (37.04).
2. $n(\text{Al}_2\text{O}_3) = 37.04 \div 2 = 18.52 \text{ kmol}$; $M = 102$; $m = \mathbf{1890 \text{ kg}}$ (1889 kg).
3. $n(\text{O}_2) = 37.04 \times 3/4 = 27.78 \text{ kmol}$; $m = \mathbf{889 \text{ kg}}$ (check: $1000 + 889 = 1889$). The oxygen **burns the carbon anodes away** to form carbon dioxide.

Problem 20 Which metal is M?

1. M is **below iron and above copper**, and above hydrogen because it reacts with acid.
2. $\mathbf{M + Cu^{2+} \rightarrow M^{2+} + Cu}$.
3. $n(\text{Cu}) = 6.35 \div 63.5 = 0.100 \text{ mol} = n(\text{M})$; $A_r = 5.90 \div 0.100 = \mathbf{59.0}$, which is **nickel**.
4. M is below carbon, so its oxide can be **reduced by heating with carbon**.