Unit 10

Answers: Inorganic Materials

Quick checks

1 c Red litmus turning blue means an alkali, and alkalis come from **basic oxides**, the oxides of metals: $CaO + H_2O \rightarrow Ca(OH)_2$. Sulphur, carbon and phosphorus are non-metals: their oxides are acidic and would turn blue litmus red.

2 c Chlorine bleaches by forming hypochlorous acid with water, which gives nascent oxygen that oxidizes the dyes. Without water, no hypochlorous acid forms, so dry chlorine doesn't bleach.

3 c Copper is below hydrogen in the reactivity series, so it can't displace hydrogen from the acid. Zinc gives hydrogen, marble (a carbonate) gives carbon dioxide, and sodium hydroxide is neutralized.

4 b Copper hydroxide, $Cu(OH)_2$, is blue. Iron(II) hydroxide is dirty green and iron(III) hydroxide reddish brown; sodium chloride gives no precipitate, since sodium hydroxide doesn't react with it.

5 b In steel, small carbon atoms fit into the gaps between iron atoms (interstitial). In brass, zinc atoms, close to copper's size, take copper's places (substitutional). Bronze and solder are substitutional too.

1 a. **c** Zinc oxide reacts with acids ($ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$) and with bases ($ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$). CaO is basic, SO_2 acidic and CO neutral.

1 b. **b** $Fe + 2HCl \rightarrow FeCl_2 + H_2$. The acid takes iron only to valency 2; chlorine gas would give $FeCl_3$.

1 c. **c** A heating coil must turn current into heat (high resistance) and survive glowing in air for years without burning away (no oxidation at high temperature). Nichrome does both.

2 a. Chlorine bleaches through hypochlorous acid, which it forms only with water: $Cl_2 + H_2O \rightleftharpoons HCl + HOCl$. Hypochlorous acid gives nascent oxygen, $HOCl \rightarrow HCl + [O]$, which oxidizes the colored matter into colorless matter. Dry chlorine forms no hypochlorous acid, so it can't bleach.

2 b. Mercury reacts with sulphur even at room temperature to form mercury sulphide: $Hg + S \rightarrow HgS$. Mercury droplets give off poisonous vapor; mercury sulphide is a solid that doesn't, so it can be swept up safely.

2 c. Pure metals are often too soft (gold, aluminium), rust easily (iron) or melt at an unsuitable temperature. Mixing in a little of another element makes an alloy harder and stronger (the different-sized atoms stop the rows sliding), often resistant to corrosion (stainless steel), and gives it the melting point, color, resistance or magnetism a job needs (solder, brass, nichrome, alnico).

3 i.

Acidic oxide	Basic oxide
Usually the oxide of a non-metal.	The oxide of a metal.
Dissolves in water to give an acid, which turns blue litmus red.	If it dissolves, gives an alkali, which turns red litmus blue.
Reacts with bases to give a salt and water.	Reacts with acids to give a salt and water.
Examples: CO_2, SO_2, P_2O_5.	Examples: Na_2O, CaO, MgO.

3 ii.

Substitutional alloy	Interstitial alloy
The added atoms take the places of some of the main metal's atoms.	The added atoms fit into the gaps between the main metal's atoms.
The added atoms are about the same size as the main metal's.	The added atoms are much smaller (C, N, H).
Example: brass (Zn in Cu), bronze (Sn in Cu).	Example: steel (C in Fe).

4 a.

i. $H_2 + Cl_2 \rightarrow 2HCl$ (in sunlight)

ii. $2Fe + 3Cl_2 \rightarrow 2FeCl_3$

iii. $Cl_2 + 2NaOH \rightarrow NaCl + NaOCl + H_2O$

iv. $Ca(OH)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$

v. $Cl_2 + 2KI \rightarrow 2KCl + I_2$

4 b.

i. $Zn + 2HCl \rightarrow ZnCl_2 + H_2$: fizzing; the gas burns with a pop.

ii. $Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$: brisk fizzing; the gas turns lime water milky.

iii. $CuO + 2HCl \rightarrow CuCl_2 + H_2O$: the black powder dissolves, giving a blue-green solution.

iv. $AgNO_3 + HCl \rightarrow AgCl + HNO_3$: a white precipitate, which darkens in sunlight.

4 c.

i. $Zn + S \rightarrow ZnS$ (zinc sulphide).

ii. $2Na + 2H_2O \rightarrow 2NaOH + H_2$ (sodium hydroxide and hydrogen).

iii. $CaO + H_2O \rightarrow Ca(OH)_2$ (calcium hydroxide, slaked lime).

iv. $NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$ (sodium hydrogen sulphate and hydrogen chloride gas).

v. $NH_4Cl + NaOH \rightarrow NaCl + NH_3 + H_2O$ (sodium chloride, ammonia and water).

vi. $2NaCl + 2H_2O \rightarrow 2NaOH + H_2 + Cl_2$ (sodium hydroxide, left in the solution; hydrogen at the cathode; chlorine at the anode).

4 d. An **alloy** is a homogeneous mixture of a metal with one or more other metals or a non-metal, made by melting them together.

- **Brass:** copper and zinc; gagri, taps, screws.
- **Bronze:** copper and tin; statues, bells, medals.
- **Stainless steel:** iron with chromium (and nickel); kitchen utensils, surgical instruments.
- **Solder:** tin and lead (or tin with a little silver and copper); joining wires.
- **Duralumin:** aluminium with copper, magnesium and manganese; aircraft bodies.

An **amalgam** is an alloy of mercury with another metal: dental amalgam (mercury with silver, tin and copper) fills teeth.

5 a.

$$= \frac{18}{24} \times 35 \; = 26.25$$

About 26.3 g of gold (75%).

5 b. Total mass = 3.9 + 1.1 = 5.0 kg.

$$= \frac{3.9}{5.0} \times 100\% = 78\% \qquad = 22\%$$

78% copper and 22% tin: bell metal, the bronze with extra tin that rings well, just right for a bell.

5 c. **No.** Both have 0.5 g of calcium carbonate and plenty of acid, so both give the **same volume** of carbon dioxide in the end ($CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$). The powder has a much larger surface area, so more acid particles hit it each second and its gas comes out much faster; the chips give the same gas more slowly, over a longer time. A longer fizz means a slower reaction, not more product.