3   **a**   83.3 moles   **b** 0.083 moles

    c   3.66 g

Percentage yield and atom economy

1   **a**

$$\frac{\text{Relative formula mass of desired product}}{\text{Sum of relative formula masses of reactants}} \times 100$$

    b   They would understand how much of the desired product is made from the reactants and how much is wasted; it can inform decisions about the sustainability of different methods/percentage yield gives no information about the quantity of wasted atoms.

    c   **1** $\frac{48}{128} \times 100 = 38\%$

          2 $\frac{48}{80} \times 100 = 60\%$

    d   It would increase the atom economy of method to 100%; making method even more favourable.

2   **a** $CaCO_3 = 100$; $CaO = 56$

    b   56%

    c   7g

    d $\frac{6.5}{7} \times 100 = 92.9\%$

Chemical changes

Metal oxides and the reactivity series

1   **a**   Magnesium + oxygen → magnesium oxide

    b $2Mg(s) + O_2(g) → 2MgO(s)$ (correct; balanced)

    c   Oxygen is gained/electrons are lost.

2   **a**   Aluminium + lead chloride → aluminium chloride + lead

    b   Silver + copper oxide → no reaction

    c   Calcium + zinc nitrate → calcium nitrate + zinc

    d   Iron chloride + copper → no reaction

3   **a**   1-Sodium, 2-X, 3-Magnesium, 4-Copper.

    b   Copper

### Extraction of metals and reduction

1   Carbon is less reactive than magnesium ore.

2   It's unreactive/doesn't easily form compounds.

3   **a**   Tin(IV) oxide + carbon → carbon oxide/dioxide + tin

    b   Carbon

4   **a** $2CuO(s) + C(s) → CO_2(g) + 2Cu(s)$ or (l)

    b   Any metal above iron in the reactivity series; Too expensive/metals above carbon extracted by electrolysis so require more energy.

    c   Iron is a liquid.

    d   Carbon is more reactive than iron.

    e   Any metal above iron in the reactivity series; Too expensive/metals above carbon extracted by electrolysis so require more energy.

The blast furnace

1   **a**   Carbon + oxygen → carbon dioxide (1)

    b $C(s) + CO_2(g) → 2CO(g)$ − 1 mark for correct formulae and balancing, 1 mark for state symbols

    c   Reduction/redox (1)

    d $2Fe_2O_3(s) + 3C(s) → 4Fe(l) + 3CO_2(g)$

    e   Iron is a liquid

    f $CaSiO_3$

    g
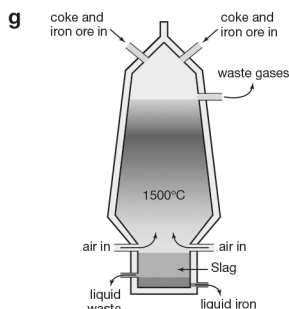
The reactions of acids

1   Both neutralise acid; Bases are insoluble/alkalis are soluble bases/alkalis form hydroxide/OH^- ions ins solution.

2   **a**   Sodium chloride – sodium hydroxide and hydrochloric acid.

    b   Potassium nitrate – potassium carbonate and nitric acid.

    c   Copper sulfate – copper oxide and sulfuric acid.

3   **a**   Solid dissolves/colourless solution forms.

    b   Fizzing occurs with magnesium carbonate.

    c   Magnesium oxide + hydrochloric acid → magnesium chloride + water

    d $MgCO_3$

4   **a** $Mg(s) + 2HCl(aq) → MgCl_2(aq) + H_2(g)$

    b $Li_2O(s) + H_2SO_4(aq) → Li_2SO_4(aq) + H_2O(l)$

    c $CuO(s) + 2HCl(aq) → CuCl_2(aq) + H_2O(l)$

5   **a** $Ca(s) + 2H^+(aq) → Ca^{2+}(aq) + H_2(g)$ (reactants; products; state symbols)

    b   Ca oxidised; H^+/hydrogen reduced.

The preparation of soluble salts

1   **a**   Copper carbonate + sulfuric acid → copper sulfate + water + carbon dioxide

    b   Any two from: Copper carbonate dissolves; Fizzing/bubbles/effervescence; Blue/green solution forms.

    c   To ensure all the acid reacts

    d   Filtration

    e   Copper oxide/copper hydroxide

    f   Any one from: Salt lost from spitting during evaporation; Solution left in container; Not all the solution crystallises.

2   **a** $Ca(s) + 2HNO_3(aq) → Ca(NO_3)_2(aq) + H_2(g)$ (reactants; products; state symbols)

    b   % yield = 2.6/3.0 x 100; 86.7%

3   Possible steps to include: Reactants (zinc/zinc hydroxide/zinc oxide/zinc carbonate) and hydrochloric acid; Correct equation for chosen reactants; Heat acid; Add base until no more reacts/dissolves so the base is in excess; Filter unreacted base; Heat solution on a steam bath until half the water has evaporated; Leave remaining solution to cool so crystals form.

    Equipment list: Bunsen burner; Heatproof mat; Tripod; Gauze; Beaker; Evaporating dish; Funnel; Filter paper; Conical flask; Spatula; Measuring cylinder; Safety glasses.

Oxidation and reduction in terms of electrons

1   **a** $Mg(s) + Cu^{2+}(aq) → Mg^{2+}(aq) + Cu(s)$

    b   Mg is oxidised and Cu is reduced.

2   **a** $Mg(s) + Zn^{2+}(aq) → Mg^{2+}(aq) + Zn(s)$; Mg oxidised, Zn reduced.

    b $2Na(s) + Zn^{2+}(aq) → 2Na^+(aq) + Zn(s)$; Na oxidised, Zn reduced.

    c $Cu(s) + 2Ag^+(aq) → Cu^{2+}(aq) + 2Ag(s)$; Cu oxidised, Zn reduced.

    d $3Ca(s) + 2Fe^{3+}(aq) → 3Ca^{2+}(aq) + 2Fe(s)$; Ca oxidised, Fe reduced.

pH scale and neutralisation

1   Strong acid − pH 2 − Red, Weak acid − pH 5 − Yellow, Strong alkali − pH 13 − Purple, Weak alkali - pH 9 − Blue, Neutral − pH 7 − Green.

2   Hydroxide ion

3 H^+

4   pH1

5   pH12

6   **a**   Potassium hydroxide

    b $2KOH + H_2SO_4 → K_2SO_4 + 2H_2O$

    c $H^+ + OH^- → H_2O$ or $2H^+ + 2OH^- → 2H_2O$

7 OH^- and NH_4^+

Strong and weak acids

1   **a** $HNO_3(aq) → H^+(aq) + NO_3^-(aq)$

    b $HCOOH(aq) → H^+(aq) + COO^-(aq)$

    c $H_2SO_4(aq) → 2H^+(aq) + SO_4^{2-}(aq)$ or $H_2SO_4(aq) → H^+(aq) + HSO_4^-(aq)$

2   Weak acid only partially ionises in solution; Dilute acid has fewer moles of solute dissolved.

3   **a** 1×10^{-3}

    b   Answer is 100 times greater as if pH decreases by 1, H^+ concentration increases by 10; 0.1 (overrides previous mark); 1×10^{-1}