Chapter 1

1 number of protons in (the nucleus of) an atom [1]

2 (a) proton: relative mass = 1 and relative charge = +1
   (b) electron: relative mass = \( \frac{1}{1840} \) and
       relative charge = −1
   (c) neutron: relative mass = 1 and relative charge = 0

3 Atoms of the same element/with the same number of protons [1] but with a different mass number/different number of neutrons [1].

4 Atoms contain the same number of protons and electrons

5 (a) 2,8,5
   (b) 2,1
   (c) 2,6
   (d) 2,8,8,1
   (e) 2,8,8
   (f) 2
   (g) 2,8,3
   (h) 2,8,1

6 (a) 2,8
   (b) 2,8

7 (a) \( \text{Al}^{3+} \)  \( \text{O}^{2−} \)  \( \text{F}^{−} \)
   (b) \( \text{Al}^{3+} \)
   (c) \( \text{Cl}^{−} \)
   (d) hydride ion

8 A positive sphere [1] with electrons embedded in it [1]

9 Chadwick [1] — no charge so more difficult to detect [1]

10 (a) 3−
    (b) phosphorus
    (c) phosphide

    20 electrons [1] arranged 2,8,8,2 [1]

12 0.056 nm

13 (a) \( \frac{0.23 \text{nm}}{2.3 \times 10^{−16} \text{m}} \) [1]
   (b) \( \frac{2.3 \times 10^{−10}}{24730} \) [1] = 9.3 \times 10^{−15} \text{ m} [1]

14

<table>
<thead>
<tr>
<th>Particle</th>
<th>Atomic number</th>
<th>Mass number</th>
<th>Number of protons</th>
<th>Number of neutrons</th>
<th>Number of electrons</th>
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<td>8</td>
<td>16</td>
<td>8</td>
<td>8</td>
<td>10</td>
<td>2,8</td>
</tr>
</tbody>
</table>

15 relative atomic mass = \( \frac{(5.8 \times 54) + (91.8 \times 56) + (2.2 \times 57) + (0.2 \times 58)}{100} \) [1] = \( \frac{5591}{100} \) = 55.91 [1] = 55.9 [1] to 1 decimal place

Chapter 2

1 A mixture of two or more elements, at least one of which is a metal [1] and the resulting mixture has metallic properties [1].

2 any two from: conducts electricity/light/faster recharge/less required [2]

3 21 [1]

4 attraction [1] between oppositely charged ions [1]

5 (a) ionic [1]
   (b) covalent [1]
   (c) metallic [1]

6 (a) top unbonded pair of electrons labelled [1]
    (b) covalent [1]
    (c) van der Waals’ forces of attraction [1]
    (d) \( \text{NH}_3 \) [1]

7 pair of electrons [1] shared between two atoms [1]

8 (a) [1]
9 The van der Waals’ [1] forces of attraction between the molecules are weak [1] and require little energy to break [1].
11 Delocalised electrons [1] can move and carry charge [1].
12 0.075 [1]
13 A regular arrangement/lattice [1] consisting of layers of positive ions/cations [1] held together by metallic bonding, which is the attraction [1] between the positive ions and the delocalised electrons [1].
14 (a) sodium and iron [1]
   (b) sodium, graphene and iron [1]
   (c) ammonia, hydrogen and carbon dioxide [1]
15 (a) In sodium chloride solution the ions [1] are free to move and carry charge [1] but in solid sodium chloride the ions cannot move [1].
   (b) ionic lattice
   (c) Strong ionic bonds [1] require substantial energy to break [1].

**Chapter 4**

1 (a) alkali metals [1]
   (b) alkaline earth metals [1]
   (c) halogens [1]
   (d) noble gases [1]
2 K → K⁺ + e⁻ [2]
3 phosphorus, P [1]
4 Any four from: floats/fizzes/moves about the surface/heat released/colourless solution formed/disappears/lilac flame/crackles or explosion [4]
5 (a) yellow gas [1]
   (b) yellow-green gas [1]
   (c) red-brown liquid [1]
   (d) grey-black solid [1]
   (e) colourless gas [1]
6 (a) Rb⁺ [1]
   (b) I⁻ [1]
   (c) K⁺ [1]
   (d) F⁻ [1]
   (e) 7 group 6 [1]
7 group 6 [1]
8 (a) nitrogen [1]; oxygen [1]; fluorsine [1]; bromine [1]
   (b) carbon/sulfur [1]
   (c) sodium [1]
   (d) iron [1]
   (e) oxygen [1]; nitrogen [1]; fluorsine [1]
9 shiny surface goes dull
10 [a] white [1]; [b] grey-black [1]; [c] black [1];
    [d] blue [1]; [e] green [1]
11 $\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-$ [3]
12 any three from: large trough of water/small piece of sodium/safety screen/gloves/glasses/tongs to handle sodium/remove oil from surface of sodium [3]
13 (a) white [1]; (b) grey-black [1]; (c) black [1]; (d) blue [1]; (e) green [1]
14 (a) $2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2$ [3]
    (b) Sodium is less dense than water. [1]
15 any two from: in order of atomic mass (weight)/no noble gases/no block of transition metals/no atomic number/fewer elements or gaps/no actinides or lanthanides [2]

Chapter 5
1 carbon-12 [1]
2 (a) 98 [1]
    (b) 74 [1]
    (c) 342 [1]
    (d) 138 [1]
    (e) 162.5 [1]
3 (a) 281 [1]
    (b) 238 [1]
4 moles $\text{CaCO}_3 = 5/100 = 0.05$
    moles $\text{CaO} = 0.05$
    mass $\text{CaO} = 0.05 \times 56 = 2.8$ g
5 moles $\text{Mg} = 1.2/24 = 0.05$
    moles $\text{MgO} = 0.05$
    mass $\text{MgO} = 0.05 \times 40 = 2$ g
6 mass of $\text{Al} = 54 000$ g
    moles of aluminium = $54 000/27 = 2000$
    moles of $\text{Fe}_2\text{O}_3 = 1000$
    mass of $\text{Fe}_2\text{O}_3 = 1000 \times 160 = 160000$ g or 160 kg
7 (a) moles of $\text{Fe}_2\text{O}_3 = 40/160 = 0.25$
    (b) moles of $\text{Na} = 46/23 = 2$
    (c) limiting reactant = $\text{Fe}_2\text{O}_3$
    (d) moles of iron = $0.25 \times 2 = 0.5$
    (e) mass of iron = $0.5 \times 56 = 28$ g
8 mass of iron = $100 - 27.6 = 72.4$
    moles of $\text{Fe} = 72.4/56 = 1.293$
    moles of $\text{O} = 27.6/16 = 1.725$
    simplest ratio: 3:4/$\text{Fe}_2\text{O}_3$
9 (a) $36/171 \times 100$ [1] = 21.1% [1]
    (b) $180/286 \times 100$ [1] = 62.9% [1]
10 mass of copper = 3.2 g
    moles of copper = $3.2/64 = 0.05$
    mass of oxygen = 0.8 g
    moles of oxygen = $0.8/16 = 0.05$
    simplest ratio = 1:1/$\text{CuO}$
11 $\text{H}_2\text{O}_2$
12 $\text{CH}_2\text{O}$

Chapter 6
1 a soluble base [1]
2 any two from: copper(ii) oxide/copper(ii) carbonate/copper(ii) hydroxide [2]
3 Pipette [1] a measured volume/25 cm$^3$ of sodium hydroxide solution into a conical flask [1]. Add 5 drops of phenolphthalein [1]; changes to pink [1]. Add sulfuric acid from a burette [1] until the indicator changes to colourless [1]; record the volume and repeat using the same volumes without the indicator [1]. Heat to reduce the volume by half [1]; leave aside to cool and crystallise [1]. Filter off the crystals [1]; dry between two sheets of filter paper/in a low-temperature oven/in a desiccator [1]. [max. 8]
4 (a) purple/dark blue [1]; 12–14 [1]
    (b) red [1]; 0–2 [1]
    (c) blue [1]; 9–11[1]
    (d) yellow or orange [1]; 3–6 [1]
    (e) green [1]; 7 [1]
5 $\text{H}^+$ [1]
6 Any metal oxide or metal hydroxide, such as magnesium oxide, copper(ii) oxide, sodium hydroxide etc. [max. 2]
7 0.5 mol/dm$^3$ [1]
8 $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(l)$ [3]
9 (a) colourless [1]
    (b) colourless
    (c) pink [1]
10 (a) $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$ [3]
    (b) $\text{Mg(OH)}_2 + 2\text{HCl} \rightarrow \text{MgCl}_2 + 2\text{H}_2\text{O}$ [3]
    (c) $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O}$ [3]
11 (a) heat released [1]; bubbles of gas [1]; solid disappears [1]; colourless solution [1] [max. 3]
    (b) bubbles of gas [1]; green solid disappears [1]; solution changes from colourless to blue [1]; heat released [1] [max. 3]
Exam practice answers

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12 sodium chloride
13 (a) red
(b) red
(c) orange
(d) colourless
(e) red
14 hydrogen [1]; hold a lit splint at the mouth of a tube of it [1]; listen for pop [1]
15 (a) residue
(b) filtrate
(c) Filter [1] to remove crystals and dry between two sheets of filter paper or in a desiccator or in a low-temperature oven [1].
(d) labelled diagram of filter funnel [1] in conical flask [1]; filter paper [1]; residue and filtrate correctly labelled [1]

Chapter 7
1 filtration [1]; sedimentation [1]; chlorination [1]
2 (a) solid that dissolves in a solvent [1]
(b) liquid in which the solute dissolves [1]
(c) mixture of the solute dissolved in the solvent [1]
3 Add water [1] then filter through filter paper [1]. Sand is the residue [1]; water is the filtrate [1].
4 fractional distillation [1]
5 (a) 3
(b) water or other suitable solvent [1]
(c) 2
(d) 1 and 4
(e) 1
(f) not soluble [1]
(g) solvent front [1]
6 (a) B = filter paper [1]; C = filter funnel [1]; D = conical flask [1]
(b) residue [1]
(c) filtrate [1]
(d) sand mixed with water [1]
7 white to blue [1]
9 (a) iron(III) hydroxide [1]
(b) barium sulfate [1]
(c) zinc hydroxide [1]
10 (a) 3NaOH + FeCl₃ → Fe(OH)₃ + 3NaCl [3]
(b) BaCl₂ + MgSO₄ → BaSO₄ + MgCl₂ [2]
(c) 2NaOH + Zn(NO₃)₂ → Zn(OH)₂ + 2NaNO₃ [3]
11 (a) Fe³⁺ + 3OH⁻ → Fe(OH)₃ [3]
(b) Ba²⁺ + SO₄²⁻ → BaSO₄ [2]
(c) Zn²⁺ + 2OH⁻ → Zn(OH)₂ [3]
12 (a) brown ppt [1]
(b) white ppt [1]
(c) white ppt [1]
13 (a) Mg²⁺ [1]
(b) I⁻ [1]
(c) magnesium iodide [1]
14 Ag⁺(aq) + Cl⁻(aq) → AgCl(s) [3]
15 A solid [1] that may form on mixing two solutions [1]

Chapter 8
1 decreases [1]
2 increases [1]
3 units: g/100 g water [1]
4 (a) 34.7 (allow 34–35) g/100 g water
(b) Yes it is saturated because solubility at 20°C = 33 g/100 g water, so 16.5 g are required to saturate 50 g of water [1].
(c) solubility at 33°C = 37 g/100 g water; mass required to saturate 200 g of water = 37 × 2 = 74 g [1]
(d) solubility at 43°C = 40 g/100 g water; solubility at 23°C = 34 g/100 g water difference in solubility = 40 − 34 = 6 g [1]
per 50 g of water = 6/2 = 3 g [1]
5 9.1 × 5 = 45.5 g/100 g water [1]
6 (210/100) × 40 = 84 g [1]
7 25 × 3 = 75 g [1]
8 0.14 × 10 = 1.4 g needed to saturate 1 kg of water [1]; mass remaining = 2.0 − 1.4 = 0.6 g [1]
9 2.2 × 20 = 44 g/100 g water [1]
10 (a) solubility at 80°C = 148 g/100 g water;
solubility at 30°C = 96 g/100 g water [1]
148 − 96 = 52 g [1]
52/10 = 5.2 g [1] deposited
(b) Mixture A is saturated (200 g of water at 60°C requires 248 g of solid and 250 g are present). Mixture B is not saturated (20 g of water at 30°C requires 19.2 g of solid and 19 g are present). Mixture C is saturated (12.5 g of water at 20°C requires 11 g of solid and 12 g are present). So mixtures A and C are saturated. [1]
(c) solubility at 70°C = 135 g/100 g water;
solubility at 40°C = 105 g/100 g water [1]
135 − 105 = 30 g [1]
mass of water = (12/30) × 100 = 40 g [1] of water

Chapter 9
1 hydrogen [1]
2 any four of: floats/moves about the surface/fizzes/lilac flame/eventually disappears/expLOdes or crackles/heat released/colourless solution formed [4]
3 2K + 2H₂O → 2KOH + H₂ [3]
any three from: red-brown solid appears/blue solution/fades to colourless/heat released

By heating [1] damp mineral wool [1].

6 (a) Cu + 2AgNO₃ → Cu(NO₃)₂ + 2Ag
(b) nitrate ion / NO₃⁻
(c) Cu + 2Ag⁺ → Cu²⁺ + 2Ag

7 Aluminium has a protective oxide layer.

8 Grey solid [1] burns with a bright white light [1], forming a white solid [1].

any two of: painting/oiling/greasing/plastic coating/suitable metal plating or galvanising

any two of: water/moisture [1]; air/oxygen [1]; soil conditions and growth/seasonal

Magnesium reacts first [1].

Magnesium is more reactive than iron [1], so magnesium reacts first [1].

Chapter 10

1 Nitrogen gains hydrogen [1] and gain of hydrogen is reduction [1].

2 (a) hydrogen
(b) oxygen

3 haematite/iron ore [1]; coke/carbon [1]; limestone/calcium carbonate [1]; hot air [1]

4 magnesium/zinc

5 (a) hydrated iron(III) oxide
(b) Redox is oxidation and reduction occurring simultaneously in the same reaction.

6 oxygen [1]; loss [1]; oxygen [1]; gain [1]

7 (a) Zn → Zn²⁺ + 2e⁻
(b) Cu²⁺ + 2e⁻ → Cu
(c) Zn equation

8 Mg → Mg²⁺ + 2e⁻ [3]; oxidation [1]

9 Magnesium is oxidised [1]; zinc ions are reduced [1].

10 water/moisture [1]; air/oxygen [1]

11 any two of: painting/oiling/greasing/plastic coating/suitable metal plating or galvanising

12 Fe₂O₃ + 3CO → 2Fe + 3CO₂

13 Calcium carbonate undergoes thermal decomposition.

CaCO₃ → CaO + CO₂

Calcium oxide reacts with silicon dioxide to form calcium silicate/slag.

CaO + SiO₂ → CaSiO₃

14 (a) Carbon gains oxygen [1] and gain of oxygen is oxidation [1].
(b) CO₂ + C → 2CO

15 Magnesium is more reactive than iron [1], so magnesium reacts first [1].

Chapter 11

1 manganese(tv) oxide
2 sulfur
3 gas syringe
4 2H₂O₂ → 2H₂O + O₂
5 rate increases

6 A substance that increases the rate of a chemical reaction [1] without being used up [1].

7 hydrogen
8 size of solid particles/presence of a catalyst
9 change in mass against time [1]; using a conical flask on a balance[1]; or change in gas volume

10 Hydrogen ions/particles move faster/have more energy [1], so there are more collisions [1] and more successful collisions/more collisions with higher than activation energy [1] in a given period of time [1]; rate increases [1]. [max. 4]

11 (a) 80 seconds
(b) 80 cm³
(c) 25 seconds
(d) starts at (0,0), remains higher and levels off at the same level
(e) starts at (0,0), remains lower and levels off at the same level

Chapter 12

1 H₂ + Br₂ ⇌ 2HBr
2 It is a compromise between achieving a reasonable yield with a fast enough rate of reaction.

3 (a) The position of equilibrium will move to the right.
(b) There are more molecules of gas on the right-hand side (three molecules → five molecules).

The position of equilibrium moves to the left to minimise the increase in pressure.

4 (a) All reactants and products are in the same state.
(b) The forward reaction is exothermic.

The position of equilibrium moves in the direction of the reverse endothermic reaction to absorb the heat.

5 (a) The rate of the forward reaction is equal to the rate of the reverse reaction.
(b) The forward reaction is endothermic.

The position of equilibrium moves in the direction of the forward endothermic reaction to absorb the heat.

(c) The position of equilibrium moves to the left.
There are fewer molecules of gas on the left to minimise the effect of the increase in pressure. [1]

6 (a) There are fewer molecules of gas on the right-hand side (three molecules → two molecules). [1]

The position of equilibrium moves to the right to minimise the increase in pressure. [1]

(b) The position of equilibrium moves to the right to absorb the heat. [1]

More NO2, so darker colour. [1]

7 (a) C and D [1]

(b) C and D [1]

(c) A and B [1]

8 (a) The yield of hydrogen would decrease. [1]

The position of equilibrium would move to the left. [1]

There are fewer molecules of gas on left/two molecules on the left and four molecules on the right. [1]

(b) The position of equilibrium would move to the right to remove the added hydrogen [1].

9 (a) The position of equilibrium moves to the left. [1]

There are fewer gas molecules on the left/nine molecules on the left and ten molecules on right. [1]

(b) The position of equilibrium moves to the left. In the direction of the reverse endothermic reaction, to absorb the heat. [1]

10 (a) The lower temperature moves the position of equilibrium in the direction of the forward exothermic reaction. [1]

(b) compromise temperature [1]; reasonable yield with fast rate [1]

Chapter 13

1 (a) \( \text{C}_2\text{H}_6 \) [1]

(b) \( \text{C}_3\text{H}_4 \) [1]

(c) \( \text{C}_4\text{H}_{10} \) [1]

(d) \( \text{CH}_4 \) [1]

2 orange/brown solution changes to colourless [1]

3 compounds containing only carbon and hydrogen [1]

4 (a) propane [1]

(b) but–2–ene [1]

(c) propan–1–ol [1]

5 \( \text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O} \) [3]

6 ethane [1]

7 fractional distillation [1]

8 orange to green [1]

9 2\( \text{CH}_3\text{COOH} + \text{Mg} \rightarrow (\text{CH}_3\text{COO})_2\text{Mg} + \text{H}_2 \) [3]

10 A family of organic compounds with the same general formula [1], which differ by a \( \text{CH}_2 \) unit [1]. They show a gradation in their physical properties [1] and similar chemical properties [1]. [max. 3]

11 (a) polythene [1]

(b) PVC [1]

12 climate change/rising sea levels/melting of polar ice caps/flooding of low-lying areas/global warming [3]

13 carbon monoxide [1], soot [1] and water [1]

14 \( 2\text{C}_2\text{H}_3\text{COOH} + \text{Na}_2\text{CO}_3 \rightarrow 2\text{C}_2\text{H}_4\text{COONa} + \text{CO}_2 + \text{H}_2\text{O} \) [3]

sodium butanoate, carbon dioxide, water [1]

15 \( \text{C}_2\text{H}_2\text{O}_{2v+2} \) [1]

Chapter 14

1 Rinse with deionised water [1]; rinse with the solution being used in the burette [1]; fill with the solution, ensuring no air bubbles/jet is filled [1]; read the volume from the bottom of the meniscus [1]. [max. 3]

2 Equal volumes of gases under the same conditions of temperature and pressure [1] contain the same number of particles [1]. [1 mark awarded if the colour change is the wrong way round]

3 yellow [1] to red [1] [1 mark awarded if the colour change is the wrong way round]

4 moles of \( \text{Mg} = 0.6/24 = 0.025 \text{mol} \) [1]

moles \( \text{H}_2\text{SO}_4 = 0.025 \text{mol} \) [1]; volume of \( \text{H}_2\text{SO}_4 = (0.025/2) \times 1000 = 12.5 \text{cm}^3 \) [1]

5 moles \( \text{KMnO}_4 = 3.95/158 = 0.025 \text{mol} \) [1]

moles of \( \text{O}_2 = 0.025/2 = 0.0125 \text{mol} \) [1]

volume of oxygen = 0.0125 × 24000 = 300 cm³ [1]

6 Rinse with deionised water [1]; rinse with the solution being used in the burette [1] using a pipette filler [1]; draw up the solution until the bottom of the meniscus is on the line [1]; release into a conical flask and touch the tip of the pipette on the surface of the solution [1]. [max. 4]

7 (a) \((19.5 \times 0.25)/1000 = 0.004875 \text{mol} \) [1]

(b) ratio \( \text{KOH}:\text{H}_2\text{SO}_4 \) is 2:1, so moles \( \text{KOH} = 0.004875 \times 2 = 0.00975 \text{mol} \) [1]

(c) concentration of \( \text{KOH} = (0.00975 \times 1000)/25 = 0.39 \text{mol/dm}^3 \) [1]

8 (a) \((17.5 \times 0.2)/1000 = 0.0035 \text{mol} \) [1]

(b) 1:1 ratio, so moles \( \text{MOH} = 0.0035 \text{mol} \) [1]

(c) in 100 cm³, so moles \( \text{MOH} = 0.0035 \times 4 = 0.014 \text{mol} \) [1]

(d) \( M = 0.56/0.014 = 40 \) [1]

(e) \( A = 40 - 16 = 24 \) [1]

(f) sodium/Na [1]

9 (a) \((20.7 \times 0.05)/1000 = 0.001035 \text{mol} \) [1]

(b) 1:1 ratio, so moles \( \text{KOH} = 0.001035 \text{mol} \) [1]

(c) \(0.001035 \times 1000/25 = 0.0414 \text{mol/dm}^3 \) [1]
Exam practice answers

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(d) dilution factor = 250/10 = 25 [1]; so concentration = 0.0414 \times 25 = 1.035 \text{ mol/dm}^3 [1]

(e) M_o of KOH = 56, so concentration = 1.035 \times 56 = 57.96 [1] g/dm^3

10 (a) atom economy = \frac{\text{mass of desired product}}{\text{total mass of products}} \times 100
mass of desired product (2N_2) = 56 [1]
total mass of products = 164 [1]
atom economy = \frac{56}{164} \times 100 = 34.1\% [1]

(b) (50/2) \times 3 [1] = 75 \text{ cm}^3 [1]

11 (a) 35.1 and 34.9 [1]

(b) 35.0/35 \text{ cm}^3 [2]; use of the rough titre = [1]

(c) \frac{(35 \times 0.2)}{1000} = 0.007 \text{ mol} [1]

d) ratio of Ba(OH)_2:HCl = 1:2, so moles of Ba(OH)_2 = 0.007/2 = 0.0035 \text{ mol} [1]

e) moles of Ba(OH)_2 in 100 \text{ cm}^3 = 0.0035 \times 4 = 0.014 \text{ mol} [1]

(f) M_r = 4.41/0.014 = 315 [1]

g) 315 − 137 − (2 \times 17) = 144 [1]

144/18 = 8 [1]

Chapter 15

1 decomposition (of a liquid electrolyte) using a direct current of electricity [1]


3 2\text{CF} \rightarrow \text{Cl}_2 + 2\text{e}^− [3]

4 (a) positive electrode [1]

(b) negative electrode [1]

5 liquid/solution that conducts electricity [1] and is decomposed by it [1]

6 unreactive [1]; good conductor of electricity [1]

7 Ions [1] can move and carry charge [1]

8 anode: oxygen [1]; cathode: hydrogen [1]

9 4\text{OH}^− \rightarrow \text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^− [3]

10 bauxite [1]

11 lowers operating temperature [1]; increases conductivity [1]

12 carbon/graphite [1]

13 Carbon reacts with oxygen [1], forming carbon dioxide gas [1].

\text{or}

\text{C} + \text{O}_2 \rightarrow \text{CO}_2 [2]

14 \text{Al}^{3+} + 3\text{e}^− \rightarrow \text{Al} [3]

15 2\text{O}^{2−} \rightarrow \text{O}_2 + 4\text{e}^− [3]

The oxide ion loses electrons [1] and the loss of electrons is oxidation [1].

Chapter 16

1 (a) gives out heat [1]

(b) takes in heat [1]

2 The minimum energy needed for a reaction to occur [1]

3 (a) Exothermic, because the energy change is negative.

(b) +192 \text{ kJ} [1]

4 The energy required to break the bonds in hydrogen and chlorine [1] is less [1] than the energy released when bonds are formed in hydrogen chloride [1].

5 (a) activation energy [1]; reaction pathway [1]; energy change [1]

(b) Endothermic, because the energy change is positive/products are at a higher energy than the reactants. [1]

6 exothermic = B and D [1]; endothermic = A and C [1]

7 total energy used to break bonds = \(2 \times 436\) + 496 = 1368 \text{ kJ} [1]
total energy released when bonds form = 4 \times 463 = 1852 \text{ kJ} [1]

energy change = 1368 − 1852 = −484 \text{ kJ} [1]

8 (a) The energy required to break the bonds in hydrogen bromide [1] is more [1] than the energy released when bonds are formed in hydrogen and bromine [1].

(b) total energy used to break bonds = 2 \times 362 = 724 \text{ kJ} [1]
total energy released when bonds form = 346 + 190 = 626 \text{ kJ} [1]

energy change = 724 − 626 = +98 \text{ kJ} [1]

(c) positive energy change so endothermic [1]

9 (a) total energy used to break bonds = 916 + (3 \times 436) = 2224 \text{ kJ} [1]
total energy released when bonds form = 6 \times 386 = 2316 \text{ kJ} [1]

energy change = 2224 − 2316 = −92 \text{ kJ} [1]

(b) Exothermic, because energy change is negative. [1]

10 (a) 2\text{C}−\text{C}; 12\text{C}−\text{H}; 7\text{O}−\text{O}; 8\text{C}−\text{O}; 12\text{O}−\text{H} [1]

(b) total energy used to break bonds = (2 \times 348) + (12 \times 412) + (7 \times 496) = 9112 \text{ kJ} [1]
total energy released when bonds form = 8 \times 803 + (12 \times 463) = 11980 \text{ kJ} [1]

energy change = 9112 − 11980 = −2868 \text{ kJ} [1]

Chapter 17

1 nitrogen [1]

2 (a) hydrogen peroxide [1] and manganese(Ⅳ) oxide [1]

(b) calcium carbonate [1] and hydrochloric acid [1]

(c) zinc/magnesium [1] and hydrochloric acid [1]
3  (a) lit splint [1] pop [1]  
   (b) limewater [1] turns from colourless [1] to milky [1]  
   (c) glowing splint [1] relights [1]  
   (d) Use a glass rod [1] dipped in concentrated hydrochloric acid [1]; a white smoke [1] is observed if ammonia is present.

4  The product of combustion is water [1], which is non-polluting [1].

5  in fire extinguishers [1]; in fizzy drinks [1]

6  \[2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)\] [4]

7  in medicine [1]; in welding [1]

8  limewater [1]

9  The strong triple covalent bond/N≡N [1] requires substantial energy to break [1].

10  \[CO_2 + H_2O \rightarrow H_2CO_3\] [2]

11  (a) \[S + O_2 \rightarrow SO_2\] [2]  
   (b) yellow solid melts to a red liquid [1]; blue flame [1]; colourless/misty pungent gas produced [1]

12  \[CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O\] [3]

13  manganese(iv) oxide [1]

14  any two from: colourless/odourless/low solubility in water [2]

15  A = conical flask [1]  
    B = delivery tube [1]  
    C = gas jar [1]  
    D = beehive shelf [1]