

PART 01:

Group 1: Writing and Balancing Chemical Equations

1. Write the chemical equations for these reactions:
 - (a) Hydrogen reacts with copper oxide to form copper and water.
 - (b) Carbon reacts with carbon dioxide to produce carbon monoxide.
 - (c) Carbon combines with oxygen to yield carbon dioxide.
 - (d) Magnesium reacts with sulfuric acid to produce hydrogen and magnesium sulfate.
 - (e) Copper reacts with chlorine to form copper(II) chloride.
2. Write balanced chemical equations for the following reactions:
 - (a) Calcium reacts with water to produce hydrogen and calcium hydroxide solution.
 - (b) Copper combines with oxygen to form copper(II) oxide.
 - (c) Sodium reacts with oxygen to produce sodium oxide.
 - (d) Iron reacts with hydrochloric acid to form iron(II) chloride solution and hydrogen.
 - (e) Iron reacts with chlorine to produce iron(III) chloride.
3. Balance the following chemical equations:
 - (a) $\text{Na}_2\text{O}(\text{s}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{NaOH}(\text{aq})$
 - (b) $\text{KClO}_3(\text{s}) \rightarrow \text{KCl}(\text{s}) + \text{O}_2(\text{g})$
 - (c) $\text{H}_2\text{O}_2(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$
 - (d) $\text{Fe}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{Fe}_3\text{O}_4(\text{s})$
 - (e) $\text{Mg}(\text{s}) + \text{N}_2(\text{g}) \rightarrow \text{Mg}_3\text{N}_2(\text{s})$
 - (f) $\text{NH}_3(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{N}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$
 - (g) $\text{Fe}(\text{s}) + \text{H}_2\text{O}(\text{g}) \rightarrow \text{Fe}_3\text{O}_4(\text{s}) + \text{H}_2(\text{g})$
 - (h) $\text{H}_2\text{S}(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{g}) + \text{SO}_2(\text{g})$
 - (i) $\text{H}_2\text{S}(\text{g}) + \text{SO}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{S}(\text{s})$

Group 2: Relative Formula Mass Calculations

1. Determine the relative formula masses of these compounds:
 - (a) $\text{Mg}(\text{OH})_2$ (b) NaOH (c) KNO_3 (d) MgCO_3 (e) PbCl_2 (f) MgCl_2 (g) $\text{Mg}(\text{NO}_3)_2$ (h) $\text{Zn}(\text{OH})_2$, (i) ZnSO_4 (j) H_2SO_4 (k) HNO_3 (l) $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ (m) CaSO_4 (n) Pb_3O_4 (o) P_2O_5 (p) Na_2CO_3 , (r) $\text{Ca}(\text{OH})_2$ (s) CuCO_3 (t) CuSO_4 (u) $\text{Ca}(\text{HCO}_3)_2$ (v) $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ (w) $\text{Al}_2(\text{SO}_4)_3$, (x) $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ (y) $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ (z) KClO_3
2. Find the relative formula masses of these compounds: carbon dioxide, sulfuric acid, hydrogen chloride, and sodium hydroxide. Then calculate:
 - (a) The mass of 1 mole of carbon dioxide.
 - (b) The mass of 1 mole of sulfuric acid.
 - (c) The mass of 1 mole of hydrogen chloride.
 - (d) The mass of 1 mole of sodium hydroxide.
3. Calculate the relative formula masses of these compounds and determine:
 - (a) The mass of 1 mole of sodium chloride.
 - (b) The mass of 0.5 mole of potassium hydroxide.
 - (c) The mass of 4 moles of iron(II) chloride.
 - (d) The mass of 2.5 moles of sodium carbonate.
 - (e) The mass of 0.1 mole of zinc chloride.
4. For each compound below, calculate the relative formula mass, then find: (a) the mass of 1 mole and (b) the mass of 0.25 mole:
calcium chloride, copper carbonate, barium hydroxide, sodium nitrate.

5. Calculate the relative molecular masses of the following gases based on the given data:

- 2.2 g of gas A occupies 1.12 dm³ at s.t.p.
- 8.0 g of gas B occupies 2.8 dm³ at s.t.p.
- 4.0 g of gas C occupies 560 cm³ at s.t.p.
- 1.0 g of gas D occupies 1.4 dm³ at s.t.p.
- 4.0 g of gas E occupies 3.2 dm³ at s.t.p.
- 1.7 g of gas F occupies 2.24 dm³ at s.t.p.

Group 3: Percentage Composition by Mass

- Calculate the percentage by mass of calcium, carbon, and oxygen in calcium carbonate.
- Determine the percentage by mass of potassium, hydrogen, carbon, and oxygen in potassium hydrogencarbonate (KHCO₃).
- Find the percentage by mass of:
 - Nitrogen and oxygen in nitrogen monoxide (NO).
 - Carbon and hydrogen in ethane (C₂H₆).
 - Sodium, oxygen, and hydrogen in sodium hydroxide (NaOH).
 - Sulphur and oxygen in sulfur trioxide (SO₃).
 - Carbon and hydrogen in propyne (C₃H₄).
- Determine the percentage by mass of:
 - Carbon and hydrogen in heptane (C₇H₁₆).
 - Magnesium and nitrogen in magnesium nitride (Mg₃N₂).
 - Calcium and bromine in calcium bromide (CaBr₂).
- Calculate the percentage by mass of:
 - Carbon and hydrogen in pentene (C₅H₁₀).
 - Nitrogen, hydrogen, and oxygen in ammonium nitrate.
 - Iron, oxygen, and hydrogen in iron(II) hydroxide.
 - Carbon, hydrogen, and oxygen in ethanedioic acid (H₂C₂O₄).
- Find the percentage by mass of:
 - Iron, sulfur, and oxygen in iron(III) sulphate.
 - Carbon, hydrogen, and oxygen in propanol (C₃H₇OH).
 - Carbon, hydrogen, and oxygen in ethanoic acid (CH₃COOH).
- Determine the percentage of nitrogen in pure ammonium nitrate (NH₄NO₃).
- Identify which compound has the largest percentage by mass of nitrogen:
 - Ammonium chloride (NH₄Cl)
 - Ammonium nitrate (NH₄NO₃)
 - Ammonium sulphate ((NH₄)₂SO₄)
 - Ammonia (NH₃)
- If ammonium sulfate ((NH₄)₂SO₄) and sodium nitrate (NaNO₃) cost the same per ton, determine which is the cheaper source of nitrogen.

Group 4: Mole and Mass Calculations for Elements

- Find the relative atomic masses of sodium, magnesium, and lead, and calculate the mass of 1 mole of:
 - Sodium

(b) Magnesium
(c) Lead

2. Determine the relative atomic masses of barium, chromium, and tin, and calculate the mass of:
(a) 0.1 mole of barium
(b) 0.1 mole of chromium
(c) 0.1 mole of tin

3. Using relative atomic masses, calculate the mass of:
(a) 2 moles of iodine molecules
(b) 2 moles of silver
(c) 2 moles of aluminum
(d) 2 moles of mercury

4. Calculate the mass of 0.25 mole of each element:
(a) Silver
(b) Sulfur
(c) Magnesium
(d) Calcium
(e) Neon

5. Using relative atomic masses, determine the number of moles in:
(a) 54 g of aluminum
(b) 1.6 g of sulfur
(c) 42 g of iron
(d) 54 g of silver
(e) 13 g of zinc

6. Calculate the mass of:
(a) 0.5 mole of chromium
(b) $1/7$ mole of iron
(c) $1/3$ mole of carbon
(d) $1/4$ mole of magnesium
(e) $1/7$ mole of nitrogen molecules
(f) $1/4$ mole of oxygen molecules (Note: Nitrogen and oxygen exist as N_2 and O_2 .)

7. Find the number of moles in:
(a) 46 g of sodium
(b) 130 g of zinc
(c) 10 g of calcium
(d) 2.4 g of magnesium
(e) 8 g of sulfur

8. Calculate the mass of:
(a) 1 mole of sodium atoms
(b) $1/2$ mole of nitrogen atoms
(c) $1/2$ mole of nitrogen molecules
(d) $1/4$ mole of sulfur atoms
(e) 0.2 mole of bromine atoms
(f) 0.2 mole of bromine molecules

9. Determine the number of moles of atoms in:
(a) 23 g of sodium
(b) 64 g of sulfur
(c) 9 g of aluminum
(d) 120 g of calcium

(e) 12 g of magnesium
(f) 7 g of iron

10. Calculate the mass of:
(a) 10 moles of lead
(b) 1/6 mole of copper
(c) 0.1 mole of iodine molecules
(d) 10 moles of hydrogen molecules
(e) 0.25 mole of calcium
(f) 0.25 mole of bromine molecules
(g) 3/4 mole of iron
(h) 0.20 mole of zinc
(i) 1/2 mole of chlorine molecules
(j) 0.1 mole of neon

Group 5: Mole and Mass Calculations for Compounds

1. Calculate the number of moles in:
(a) 58.5 g of sodium chloride
(b) 26.5 g of anhydrous sodium carbonate
(c) 50.0 g of calcium carbonate
(d) 15.9 g of copper(II) oxide
(e) 8.0 g of sodium hydroxide
(f) 303 g of potassium nitrate
(g) 9.8 g of sulfuric acid
(h) 499 g of copper sulfate-5-water

Group 6: Stoichiometry and Mass of Reactants/Products

1. Calculate the mass of magnesium oxide produced from the complete combustion of 24 g of magnesium. Write the equation and use relative atomic masses.
2. Determine the mass of magnesium oxide formed from the complete combustion of 6 g of magnesium. Write the equation, use relative atomic masses, and apply a ratio calculation.
3. Find the mass of carbon dioxide produced by the complete combustion of 12 g of carbon. Write the equation and use relative atomic masses.
4. Calculate the mass of carbon dioxide formed from the complete combustion of 4 g of carbon. Write the equation, use relative atomic masses, and use a ratio calculation.
5. Determine the mass of sulfur needed to produce 64 g of sulfur dioxide. Write the equation and use relative atomic masses.
6. Calculate the mass of sulfur required to produce 8 g of sulfur dioxide.
7. Find the mass of sulfur needed to produce 100 g of sulfur dioxide.
8. For the reaction $\text{CuO(s)} + \text{H}_2\text{(g)} \rightarrow \text{Cu(s)} + \text{H}_2\text{O(g)}$, calculate the mass of copper obtained from:
(a) 79.5 g of copper(II) oxide
(b) 15.9 g of copper(II) oxide
Use relative atomic masses in the equation.
9. Calculate the mass of carbon dioxide produced by heating 10 g of calcium carbonate. Write the equation, use relative atomic masses, and apply a ratio calculation.

10. Determine the mass of hydrogen produced by reacting 12 g of magnesium with excess dilute sulfuric acid. Write the equation, use relative atomic masses, and apply a ratio calculation.
11. Calculate the mass of carbon that can be completely burned in 32 g of oxygen. Follow the three-step process.
12. Find the mass of iron needed to produce 4.4 g of iron(II) sulfide when heated with excess sulfur. Use the three-step process.
13. Calculate the mass of carbon required to reduce 15.9 g of copper(II) oxide to copper in the reaction $\text{CuO(s)} + \text{C(s)} \rightarrow \text{Cu(s)} + \text{CO(g)}$.
14. For the reaction $2\text{Fe(s)} + 3\text{Cl}_2\text{(g)} \rightarrow 2\text{FeCl}_3\text{(s)}$, determine the mass of iron(III) chloride produced from 8 g of iron.
15. In a mixture of 8 g of iron and 4 g of sulfur heated to form iron(II) sulfide (FeS), calculate how much iron remains unreacted.
16. Calculate the mass of lead(II) oxide produced by heating 33.1 g of lead(II) nitrate in the reaction $2\text{Pb(NO}_3)_2\text{(s)} \rightarrow 2\text{PbO(s)} + 4\text{NO}_2\text{(g)} + \text{O}_2\text{(g)}$.
17. Determine the mass of carbon dioxide produced from 15 g of calcium carbonate reacting with acid in the reaction $\text{CaCO}_3\text{(s)} + 2\text{HCl(aq)} \rightarrow \text{CO}_2\text{(g)} + \text{CaCl}_2\text{(aq)} + \text{H}_2\text{O(l)}$.
18. Calculate the mass of sodium hydroxide needed to neutralize a solution containing 7.3 g of hydrogen chloride in the reaction $\text{NaOH(aq)} + \text{HCl(aq)} \rightarrow \text{NaCl(aq)} + \text{H}_2\text{O(l)}$.
19. Find the mass of sodium sulfate formed when 49 g of sulfuric acid is neutralized by sodium hydroxide in the reaction $\text{H}_2\text{SO}_4\text{(aq)} + 2\text{NaOH(aq)} \rightarrow \text{Na}_2\text{SO}_4\text{(aq)} + 2\text{H}_2\text{O(l)}$.
20. Calculate the mass of zinc chloride formed when 13 g of zinc is completely converted to chloride.
21. Determine the mass of potassium chloride produced when a solution containing 8 g of potassium hydroxide is neutralized with hydrochloric acid in the reaction $\text{KOH(aq)} + \text{HCl(aq)} \rightarrow \text{KCl(aq)} + \text{H}_2\text{O(l)}$.
22. Calculate the mass of sodium nitrate needed to produce 126 g of nitric acid in the reaction $\text{NaNO}_3\text{(s)} + \text{H}_2\text{SO}_4\text{(l)} \rightarrow \text{HNO}_3\text{(l)} + \text{NaHSO}_4\text{(s)}$.
23. Calculate the mass of copper(II) sulfate crystals ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) theoretically obtainable from 8.0 g of copper(II) oxide.
24. Determine the theoretical yield of hydrated zinc sulfate crystals ($\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$) from 4.05 g of zinc oxide. Describe the preparation process starting from zinc oxide.
25. Calculate the mass of copper(II) oxide required to theoretically produce 1000 g of copper(II) sulfate crystals ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$). ($\text{Cu} = 64$)
26. For the reaction $4\text{NH}_3 + 6\text{NO} \rightarrow 5\text{N}_2 + 6\text{H}_2\text{O}$, calculate the mass of ammonia needed to react with 1.8 g of NO emitted per mile by a car traveling 10,000 miles in one year.
27. For a power station burning 48,000 tons of fossil carbon ($\text{C} + \text{O}_2 \rightarrow \text{CO}_2$), calculate the daily tonnage of carbon dioxide added to the atmosphere.
28. A motorist drives 20 miles daily for 250 days, with a car consuming 20 miles/gallon and petrol containing 2 g/gallon of lead. Calculate the total lead discharged into the environment.
29. When 25.0 g of a mixture of sodium carbonate and sodium hydrogencarbonate is heated ($2\text{NaHCO}_3 \rightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O} + \text{CO}_2$) and loses 6.2 g, calculate the mass of each salt in the original mixture.

Group 7: Gas Volume Calculations

1. Calculate the volume of carbon dioxide (at s.t.p.) produced by combusting 12 g of carbon. Write the equation and determine:
 - (a) Moles of CO_2 from 1 mole of carbon.
 - (b) Volume of CO_2 from 1 mole of carbon.
 - (c) Moles of carbon in 12 g.
 - (d) Volume of CO_2 produced.
2. Determine the volume of hydrogen (at s.t.p.) produced when 12 g of magnesium reacts with excess acid. Write the equation and calculate:
 - (a) Moles of H_2 from 1 mole of Mg.
 - (b) Volume of H_2 from 1 mole.
 - (c) Moles of Mg in 12 g.
 - (d) Volume of H_2 produced.
3. Find the volume of hydrogen (at s.t.p.) produced when 6.5 g of zinc reacts with excess acid. Write the equation and calculate:
 - (a) Moles of H_2 from 1 mole of Zn.
 - (b) Volume of H_2 from 1 mole.
 - (c) Moles of Zn in 6.5 g.
 - (d) Volume of H_2 produced.
4. Calculate the volume of carbon dioxide (at s.t.p.) produced by heating 10 g of calcium carbonate. Write the equation and determine:
 - (a) Moles of CO_2 from 1 mole of CaCO_3 .
 - (b) Volume of CO_2 from 1 mole.
 - (c) Moles of CaCO_3 in 10 g.
 - (d) Volume of CO_2 produced.
5. Determine the volume of oxygen (at s.t.p.) needed for the complete combustion of 125 cm^3 of methane, and the volume of carbon dioxide produced. Write the equation and calculate:
 - (a) Moles of O_2 per mole of CH_4 .
 - (b) Volumes of O_2 per volume of CH_4 .
 - (c) Volume of O_2 for 125 cm^3 of CH_4 .
 - (d) Moles of CO_2 per mole of CH_4 .
 - (e) Volumes of CO_2 per volume of CH_4 .
 - (f) Volume of CO_2 produced.
6. Calculate the volume of oxygen (at s.t.p.) reacting with 10 g of carbon and the volume of carbon dioxide formed.
7. For the reaction $\text{CaCO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$, calculate the mass of marble needed to produce 10.00 g of CO_2 and the volume of CO_2 at s.t.p.
8. For $\text{Zn}(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{H}_2(\text{g}) + \text{ZnCl}_2(\text{aq})$, determine the mass of zinc needed to produce 100 g of hydrogen and the volume of H_2 at (a) s.t.p. and (b) room temperature and 1 atm.
9. For $\text{PbO}(\text{s}) + \text{H}_2(\text{g}) \rightarrow \text{Pb}(\text{s}) + \text{H}_2\text{O}(\text{g})$, calculate the volume of hydrogen (at s.t.p.) needed to reduce 4.46 g of lead(II) oxide and the mass of lead formed.
10. For $2\text{Pb}(\text{NO}_3)_2(\text{s}) \rightarrow 2\text{PbO}(\text{s}) + 4\text{NO}_2(\text{g}) + \text{O}_2(\text{g})$, calculate the volume of oxygen (at s.t.p.) from decomposing 3.31 g of lead(II) nitrate.
11. For $2\text{H}_2\text{O}_2(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$, calculate the volume of oxygen (at s.t.p.) from decomposing 1.7 g of hydrogen peroxide.
12. For $2\text{KClO}_3(\text{s}) \rightarrow 2\text{KCl}(\text{s}) + 3\text{O}_2(\text{g})$, determine the mass of potassium chlorate(V) needed to produce 112 cm^3 of oxygen at s.t.p.
13. Calculate the volume of oxygen needed to convert 123 cm^3 of hydrogen into water via explosion.

14. For $\text{C}_3\text{H}_8(\text{g}) + 5\text{O}_2(\text{g}) \rightarrow 3\text{CO}_2(\text{g}) + 4\text{H}_2\text{O}(\text{g})$, calculate the volume of oxygen (at s.t.p.) needed to combust 44 g of propane and the volume of CO_2 formed.

15. For $2\text{NaHCO}_3(\text{s}) \rightarrow \text{Na}_2\text{CO}_3(\text{s}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$, calculate the volume of CO_2 (at s.t.p.) from heating 4.20 g of sodium hydrogencarbonate, and from reacting 4.2 g with excess HCl.

16. Calculate the volume of hydrogen (at s.t.p.) needed to reduce 250 cm^3 of propene (C_3H_6) to propane (C_3H_8).

17. Calculate the volume of carbon dioxide (at s.t.p.) from combusting 250 cm^3 of butane (C_4H_{10}) at s.t.p.

18. Calculate the volume of oxygen (at s.t.p.) from 50 cm^3 of hydrogen peroxide solution (68 g/L).

19. Determine (a) the volume of 17.0 g of ammonia at s.t.p., and (b) the volume of 17.0 g of a 1:3 nitrogen-hydrogen mixture at s.t.p.

20. For $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$:

- How many moles are in 64 g of methane?
- How many moles of oxygen are needed to burn 64 g of methane?

21. For $2\text{C}_4\text{H}_{10} + 13\text{O}_2 \rightarrow 8\text{CO}_2 + 10\text{H}_2\text{O}$:

- Calculate the volume of oxygen used and CO_2 produced from burning 100 cm^3 of butane at room temperature and pressure (adjusted to original conditions).
- Calculate (i) the number of molecules in 5600 cm^3 of hydrogen at s.t.p., and (ii) the number of atoms in 20 g of calcium. (1 mole = 22400 cm^3 at s.t.p.; Avogadro's constant = 6.02×10^{23})

22. For $2\text{C}_2\text{H}_6 + 7\text{O}_2 \rightarrow 4\text{CO}_2 + 6\text{H}_2\text{O}$, calculate the volume of residual gases after exploding 20 cm^3 of ethane with 100 cm^3 of oxygen, adjusted to original room temperature and pressure.

23. For $2\text{Ca}(\text{NO}_3)_2 \rightarrow 2\text{CaO} + 4\text{NO}_2 + \text{O}_2$, calculate the volume at s.t.p. of (a) nitrogen dioxide and (b) oxygen from heating 16.4 g of calcium nitrate ($M_r = 164$).

24. For $(\text{NH}_4)_2\text{SO}_4 + \text{Ca}(\text{OH})_2 \rightarrow \text{CaSO}_4 + 2\text{NH}_3 + 2\text{H}_2\text{O}$, calculate the volume of ammonia at room temperature and pressure from 0.1 mol of ammonium sulfate.

25. For $2\text{NaHCO}_3 \rightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O} + \text{CO}_2$, calculate (a) the mass and (b) the volume at s.t.p. of CO_2 from decomposing 4.20 g of sodium hydrogencarbonate.

26. For $2\text{Ag}_2\text{CO}_3 \rightarrow 4\text{Ag} + 2\text{CO}_2 + \text{O}_2$, calculate (a) the volume of oxygen at room temperature and pressure and (b) the mass of silver from decomposing 0.01 mol of silver carbonate. ($\text{Ag} = 108$; 1 mole = 24 dm^3 at RTP)

Group 8: Empirical and Molecular Formula Calculations

- Determine the empirical formulas of compounds with these compositions:
 - 50% sulfur, 50% oxygen
 - 40% sulfur, 60% oxygen
 - 47% nitrogen, 53% oxygen
 - 30.5% nitrogen, 69.5% oxygen
 - 75% carbon, 25% hydrogen
 - 85.7% carbon, 14.3% hydrogen
- Calculate the empirical formulas for compounds formed from:
 - 0.62 g phosphorus and 0.48 g oxygen
 - 1.4 g nitrogen and 0.30 g hydrogen
 - 0.62 g lead and 0.064 g oxygen
 - 3.5 g silicon and 4.0 g oxygen
 - 1.10 g manganese and 0.64 g oxygen

(f) 4.2 g nitrogen and 12.0 g oxygen
(g) 2.6 g chromium and 5.3 g chlorine

3. Find the empirical formulas of compounds formed when:
(a) 0.69 g sodium forms 0.93 g of sodium oxide
(b) 10.35 g lead forms 11.41 g of lead oxide
(c) 0.035 g nitrogen forms 0.115 g of nitrogen oxide
(d) 2.54 g copper forms 2.86 g of copper oxide
(e) 11.2 g iron forms 25.4 g of iron chloride
(f) 14.0 g iron combines with 26.6 g chlorine

4. Determine the empirical formulas of compounds formed when:
(a) 0.24 g carbon combines with 0.64 g oxygen
(b) 20.7 g lead forms 23.9 g of lead oxide
(c) 15.9 g copper combines with 17.7 g chlorine
(d) 6 g magnesium combines with 4 g oxygen
(e) 1.8 g magnesium forms 2.5 g of magnesium nitride
(f) 9 g aluminum forms 89 g of aluminum bromide

5. Calculate the empirical formulas of these hydrates:
(a) Magnesium sulfate crystals: 48.8% MgSO_4 , 51.2% water
(b) Copper sulfate crystals: 63.9% CuSO_4 , 36.1% water
(c) Chromium(III) nitrate crystals: 59.5% $\text{Cr}(\text{NO}_3)_3$, 40.5% water

6. Determine the empirical formulas of compounds with these compositions:
(a) 20% magnesium, 26.6% sulfur, 53.3% oxygen
(b) 35% nitrogen, 5% hydrogen, 60% oxygen
(c) 60% carbon, 13.3% hydrogen, 26.7% oxygen
(d) 40% carbon, 6.7% hydrogen, 53.3% oxygen

7. A hydrocarbon with 80% carbon and a relative molecular mass of 30: Calculate its empirical formula, and write (a) its molecular formula and (b) a structural formula.

8. For 1.23 g of hydrated magnesium sulfate losing 0.63 g on heating, calculate the empirical formula of the crystals.

9. Butane has an empirical formula of C_2H_5 and a relative molecular mass of 58. Find its molecular formula and one possible structural formula. For benzene (empirical formula CH , $M_r = 78$), determine its molecular formula and a possible structural formula.

10. A hydrocarbon with 85.7% carbon and a relative molecular mass of 28: Calculate its empirical formula, (a) molecular formula, and (b) structural formula.

11. Two oxides of metal M ($A_r = 207$) contain 7.18% and 13.4% oxygen. Calculate their empirical formulas.

12. For 0.61 g of $\text{BaCl}_2 \cdot x\text{H}_2\text{O}$ losing water to leave 0.52 g of anhydrous BaCl_2 , calculate the empirical formula of the crystals.

13. A hydrocarbon with 7.7% hydrogen: Calculate its empirical formula and suggest a structural formula.

14. For 4.17 g of a phosphorus chloride containing 3.55 g chlorine ($A_r(\text{P}) = 31$, $A_r(\text{Cl}) = 35.5$), find its empirical formula.

15. For an oxide (A) of chromium: (a) 5 g yields 2.6 g Cr on reduction ($A_r(\text{Cr}) = 52$, $A_r(\text{O}) = 16$); find its empirical formula. (b) Oxide (A) forms oxide (B) with 24 g oxygen per molar mass of Cr; find oxide (B)'s empirical formula. (c) Write the equation for oxide (B) formation from oxide (A).

16. A compound ($M_r = 28$) with 85.7% carbon and 14.3% hydrogen: Determine (a) empirical formula, (b) molecular formula, (c) structural formula, (d) name, and (e) series.

17. A polymer with 85.7% carbon and 14.3% hydrogen: Calculate its empirical formula.

18. For 2.7 g aluminum producing 13.35 g aluminum chloride, find the empirical formula.
19. Two saturated hydrocarbons ($M_r = 58$, 82.8% carbon): For each, determine (a) molecular formula and (b) structural formula.
20. A compound with 29.4% calcium, 23.5% sulfur, 47.1% oxygen: Calculate its empirical formula.
21. For 3.22 g of $M_2SO_4 \cdot 10H_2O$ losing mass to 1.42 g, calculate the relative atomic mass of M.
22. For 7 g of hydrocarbon X producing 22 g CO_2 and 9 g H_2O , with 21 g occupying 11.2 dm^3 at s.t.p.: Find (a) grams of H and C in 7 g, (b) empirical formula, (c) M_r , and (d) molecular formula.
23. For compound A (empirical formula C_2H_6O), 4.6 g vaporizes to 2.24 dm^3 at s.t.p.: Find its molecular formula.
24. For liquid B (empirical formula C_2H_4O), 4.4 g vaporizes to 1.12 dm^3 : Determine its molecular formula.

Group 9: Avogadro's Constant and Number of Particles

1. Using Avogadro's constant ($6 \times 10^{23} \text{ mol}^{-1}$), calculate the number of atoms in:
 - (a) 35.5 g chlorine
 - (b) 27 g aluminum
 - (c) 3.1 g phosphorus
 - (d) 336 g iron
 - (e) 48 g magnesium
 - (f) 1.6 g oxygen
 - (g) 0.4 g oxygen
 - (h) 216 g silver
2. Calculate the mass of zinc containing:
 - (a) 6×10^{23} atoms
 - (b) 6×10^{20} atoms
3. Determine the mass of aluminum containing:
 - (a) 2×10^{23} atoms
 - (b) 6×10^{20} atoms
4. Find the mass of carbon containing:
 - (a) 6×10^{23} atoms
 - (b) 2×10^{21} atoms
5. Calculate:
 - (a) The mass of calcium with the same number of atoms as 12 g magnesium
 - (b) The mass of silver with the same number of atoms as 3 g aluminum
 - (c) The mass of zinc with the same number of atoms as 1 g helium
 - (d) The mass of sodium with 5 times the number of atoms in 39 g potassium
6. Identify which contains the same number of atoms as 7 g iron:
 - (a) 4 g aluminum
 - (b) 4 g magnesium
 - (c) 4 g sulfur
 - (d) 3 g carbon
 - (e) 4 g calcium
7. Identify which contains the same number of atoms as 10 g calcium:
 - (a) 6 g sodium
 - (b) 13 g chromium
 - (c) 8 g magnesium
 - (d) 26 g silver
 - (e) 7 g aluminum
8. For 7 g nitrogen and 11 g hydrocarbon X occupying the same volume at s.t.p.:
 - (a) How many moles of N_2 are in 7 g nitrogen?
 - (b) What is the relative molecular mass of X?

9. Given 1 mole = 6×10^{23} particles, calculate:
(a) The number of molecules in 3.4 g ammonia
(b) The mass of copper deposited from CuSO_4 by 2×10^{23} electrons

Group 10: Preparation of Compounds and Related Calculations

1. (a) Describe how to prepare dry hydrated copper(II) sulfate crystals ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) from copper(II) oxide and dilute sulfuric acid. Calculate the mass of crystals from 0.01 mole of CuO .
(b) Describe what happens when the crystals are heated until no mass change occurs, and calculate the percentage change in mass.
2. (a) Describe how to prepare dry hydrated sodium sulfate crystals ($\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$) from dilute sodium hydroxide and sulfuric acid.
(b) Calculate the mass of crystals from 0.05 mole of NaOH .
3. (a) Describe how to prepare dry hydrated zinc sulfate crystals ($\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$) from zinc oxide and dilute sulfuric acid.
(b) Calculate the mass of crystals from 0.05 mole of ZnO .
(c) For 0.01 mole of ZnSO_4 crystals dissolved and treated with excess BaCl_2 , describe observations, write the ionic equation, and calculate the mass of the dry solid product.
4. Describe how to prepare reasonably dry hydrated zinc sulfate crystals ($\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$) from zinc oxide, and calculate the theoretical yield from 4.05 g of ZnO .
5. (a) Draw a labeled diagram of an apparatus to determine the formula of water by reducing dry copper(II) oxide with dry hydrogen.
(b) Using results (CuO before = 15.80 g, Cu after = 12.60 g, water collector before = 65.06 g, after = 68.66 g), determine the formula of water.
(c) Suggest why early work deduced H and O relative atomic masses as 1 and 8.

Group 11: Electrolysis and Charge Calculations

1. Which requires the largest quantity of electricity for discharge at an electrode?
(a) 1 mole of Zn^{2+}
(b) 2 moles of Fe^{3+}
(c) 3 moles of OH^-
(d) 4 moles of Cl^-
(e) 5 moles of Ag^+
2. Calculate the number of coulombs required to liberate:
(a) 54 g aluminum
(b) 54 g silver
(Faraday constant = 96500 coulombs/mole)

Group 12: Concentration and Titration Calculations

1. A sodium hydroxide solution contains 8.0 g dm^{-3} . 25.0 cm^3 of this neutralizes 35.0 cm^3 of nitric acid. Calculate:
(a) Concentration of NaOH in mol dm^{-3}
(b) Concentration of HNO_3 in mol dm^{-3}
(c) Concentration of HNO_3 in g dm^{-3}
2. Calculate the volume of 1.5 mol dm^{-3} sulfuric acid needed to react with 7.95 g of copper(II) oxide.

3. For $2\text{Na(s)} + 2\text{H}_2\text{O(l)} \rightarrow 2\text{NaOH(aq)} + \text{H}_2\text{g}$, find the volume of 0.25 mol dm^{-3} HCl needed to neutralize the NaOH from 0.23 g of sodium.
4. In a titration, 25.0 cm^3 of HCl neutralizes 20.0 cm^3 of 0.25 mol dm^{-3} Na_2CO_3 . Calculate:
 - (a) Moles of Na_2CO_3 used
 - (b) Moles of HCl used
 - (c) Concentration of HCl in mol dm^{-3}
5. For 2.1 g of NaHCO_3 reacting with HCl, calculate the volume of 0.50 mol dm^{-3} HCl needed to liberate maximum CO_2 , and the volume of CO_2 at s.t.p.
6. A solution of Na_2CO_3 contains 53.0 g in 250 cm^3 . Calculate:
 - (a) Concentration in mol dm^{-3}
 - (b) Volume of 0.25 mol dm^{-3} HCl needed to neutralize 25.0 cm^3 of the solution

PART 02

Exercise 1:

Calculation of the Molar Mass of Compounds

Calculate the molar mass of the following compounds

1. H_2O
2. CO_2
3. NH_3
4. $\text{C}_2\text{H}_5\text{OH}$
5. C_2H_4
6. SO_2
7. SO_3
8. HBr
9. H_2SO_4
10. HNO_3
11. NaCl
12. NaNO_3
13. Na_2CO_3
14. NaOH
15. Na_2SO_4
16. KMnO_4
17. K_2CrO_4
18. KHCO_3

19. KI
20. CsNO₃
21. CaCl₂
22. Ca(NO₃)₂
23. Ca(OH)₂
24. CaSO₄
25. BaCl₂
26. AlCl₃
27. Al(NO₃)₃
28. Al₂(SO₄)₃
29. FeSO₄
30. FeCl₂
31. FeCl₃
32. Fe₂(SO₄)₃
33. PbO
34. PbO₂
35. Pb₃O₄
36. Pb(NO₃)₂
37. PbCl₂
38. PbSO₄
39. CuCl
40. CuCl₂
41. CuSO₄
42. ZnCl₂
43. AgNO₃
44. NH₄Cl
45. (NH₄)₂SO₄
46. NH₄VO₃
47. KClO₃
48. KIO₃
49. NaClO
50. NaNO₂

51. $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$
52. $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$
53. $(\text{NH}_4)_2\text{SO}_4 \cdot \text{Fe}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$
54. $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$
55. $(\text{COOH})_2 \cdot 2\text{H}_2\text{O}$
56. $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$
57. $\text{Cu}(\text{NH}_3)_4\text{SO}_4 \cdot 2\text{H}_2\text{O}$
58. $\text{CH}_3\text{CO}_2\text{H}$
59. CH_3COCH_3
60. $\text{C}_6\text{H}_5\text{CO}_2\text{H}$

Exercise 2: Writing Formulae from Names

1. Sodium chloride
2. Sodium hydroxide
3. Sodium carbonate
4. Sodium sulphate
5. Sodium phosphate
6. Potassium chloride
7. Potassium bromide
8. Potassium iodide
9. Potassium hydrogencarbonate
10. Potassium nitrite
11. Magnesium chloride
12. Magnesium nitrate
13. Magnesium hydroxide
14. Magnesium oxide
15. Magnesium carbonate
16. Calcium oxide
17. Calcium chloride
18. Calcium sulphate
19. Calcium carbonate
20. Barium chloride
21. Barium sulphate

22. Aluminium chloride
23. Aluminium oxide
24. Aluminium hydroxide
25. Aluminium sulphate
26. Copper(II) sulphate
27. Copper(II) oxide
28. Copper(II) chloride
29. Copper(II) nitrate
30. Copper(I) oxide
31. Copper(I) chloride
32. Zinc nitrate
33. Zinc carbonate
34. Zinc oxide
35. Silver chloride
36. Silver bromide
37. Silver iodide
38. Silver nitrate
39. Silver oxide
40. Lead(II) nitrate
41. Lead(II) carbonate
42. Lead(II) oxide
43. Lead(IV) oxide
44. Lead(II) chloride
45. Lead(IV) chloride
46. Lead(II) sulphide
47. Tin(II) chloride
48. Tin(IV) chloride
49. Iron(II) sulphate
50. Iron(II) chloride
51. Iron(III) sulphate
52. Iron(III) chloride
53. Iron(III) hydroxide

54. Iron(II) hydroxide
55. Ammonium chloride
56. Ammonium carbonate
57. Ammonium hydroxide
58. Ammonium nitrate
59. Ammonium sulphate
60. Ammonium phosphate
61. Phosphorus trichloride
62. Phosphorus pentachloride
63. Phosphorus trioxide
64. Phosphorus pentoxide
65. Hydrogen phosphate (Phosphoric acid)
66. Hydrogen sulphate (Sulphuric acid)
67. Hydrogen nitrate (Nitric acid)
68. Hydrogen chloride (Hydrochloric acid)
69. Carbon tetrachloride
70. Silicon tetrachloride
71. Silicon dioxide
72. Sulphur dioxide
73. Sulphur trioxide
74. Hydrogen sulphide
75. Chlorine(I) oxide
76. Nitrogen dioxide
77. Nitrogen monoxide
78. Carbon dioxide
79. Carbon monoxide
80. Hydrogen hydroxide

Exercise 3: Names from Formulae

Provide the names for the following compounds based on their formulae.

1. H_2O
2. CO_2
3. NH_3

4. O₂
5. H₂
6. SO₂
7. SO₃
8. HCl
9. HI
10. HF
11. CH₄
12. H₂S
13. HBr
14. H₂SO₄
15. HNO₃
16. NaCl
17. NaNO₃
18. Na₂CO₃
19. NaOH
20. Na₂SO₄
21. CaCl₂
22. Ca(NO₃)₂
23. Ca(OH)₂
24. CaSO₄
25. BaCl₂
26. AlCl₃
27. Al(NO₃)₃
28. Al₂(SO₄)₃
29. FeSO₄
30. FeCl₂
31. FeCl₃
32. Fe₂(SO₄)₃
33. PbO
34. PbO₂
35. Pb(NO₃)₂

36. PbCl_2
37. PbSO_4
38. $\text{Cu}(\text{NO}_3)_2$
39. CuCl
40. CuCl_2
41. CuSO_4
42. ZnCl_2
43. AgNO_3
44. NH_4Cl
45. $(\text{NH}_4)_2\text{SO}_4$
46. NH_4VO_3
47. KClO_3
48. KIO_3
49. NaClO
50. NaNO_2
51. C_2H_6
52. C_4H_{10}
53. C_8H_{18}
54. $(\text{NH}_4)_2\text{CO}_3$
55. KMnO_4
56. K_2CrO_4
57. KHCO_3
58. KI
59. $\text{Co}(\text{NO}_3)_2$
60. KAt

Exercise 4a: Calculation of the Number of Moles of Material in a Given Mass

Calculate the number of moles in the given mass of each substance.

1. 9 g of H_2O
2. 88 g of CO_2
3. 1.7 g of NH_3
4. 230 g of $\text{C}_2\text{H}_5\text{OH}$
5. 560 g of C_2H_4

6. 0.64 g of SO_2
7. 80 g of SO_3
8. 17.82 g of HBr
9. 0.098 g of H_2SO_4
10. 3.15 g of HNO_3
11. 19.305 g of NaCl
12. 21.25 g of NaNO_3
13. 2.226 g of Na_2CO_3
14. 0.8 g of NaOH
15. 17.75 g of Na_2SO_4
16. 3.16 g of KMnO_4
17. 32.478 g of K_2CrO_4
18. 2.0 g of KHCO_3
19. 3.32 g of KI
20. 3.9 g of CsNO_3
21. 0.111 g of CaCl_2
22. 41 g of $\text{Ca}(\text{NO}_3)_2$
23. 1.48 g of $\text{Ca}(\text{OH})_2$
24. 0.34 g of CaSO_4
25. 41.6 g of BaCl_2
26. 20.8 g of BaCl_2
27. 13.35 g of AlCl_3
28. 1.811 g of $\text{Al}_2(\text{SO}_4)_3$
29. 39.52 g of FeSO_4
30. 13.208 g of FeCl_2
31. 32.5 g of FeCl_3
32. 32.8 g of $\text{Fe}_2(\text{SO}_4)_3$
33. 11.15 g of PbO
34. 319.46 g of PbO_2
35. 17.12 g of Pb_3O_4
36. 67.524 g of $\text{Pb}(\text{NO}_3)_2$
37. 19.726 g of PbCl_2

38. 3.03 g of PbSO_4
39. 4.95 g of CuCl
40. 34.18 g of CuCl_2
41. 1.995 g of CuSO_4
42. 20.73 g of ZnCl_2
43. 17 g of AgNO_3
44. 2.83 g of NH_4Cl
45. 0.5676 g of $(\text{NH}_4)_2\text{SO}_4$
46. 4.212 g of NH_4VO_3
47. 32.585 g of KClO_3
48. 5.136 g of KIO_3
49. 1.8625 g of NaClO
50. 108.786 g of NaNO_2

Exercise 4b: Calculation of the Mass of Material in a Given Number of Moles

Calculate the mass of the following substances given the number of moles.

1. 2 moles of H_2O
2. 3 moles of CO_2
3. 2.8 moles of NH_3
4. 0.5 moles of $\text{C}_2\text{H}_5\text{OH}$
5. 1.2 moles of C_2H_4
6. 0.64 moles of SO_2
7. 3 moles of SO_3
8. 1 mole of HBr
9. 0.016 moles of H_2SO_4
10. 0.15 moles of HNO_3
11. 0.45 moles of NaCl
12. 0.25 moles of NaNO_3
13. 0.14 moles of Na_2CO_3
14. 2 moles of NaOH
15. 0.9 moles of Na_2SO_4
16. 0.05 moles of KMnO_4
17. 0.18 moles of K_2CrO_4

18. 1 mole of KHCO_3

19. 1.5 moles of KI

20. 0.12 moles of CsNO_3

21. 0.1 moles of CaCl_2

22. 0.25 moles of $\text{Ca}(\text{NO}_3)_2$

23. 0.004 moles of $\text{Ca}(\text{OH})_2$

24. 0.1 moles of CaSO_4

25. 0.21 moles of BaCl_2

26. 0.072 moles of AlCl_3

27. 0.357 moles of $\text{Al}(\text{NO}_3)_3$

28. 0.0293 moles of $\text{Al}_2(\text{SO}_4)_3$

29. 0.117 moles of FeSO_4

30. 0.6 moles of FeCl_2

31. 0.018 moles of FeCl_3

32. 0.1 moles of $\text{Fe}_2(\text{SO}_4)_3$

33. 0.09 moles of PbO

34. 3.1 moles of PbO_2

35. 0.00029 moles of Pb_3O_4

36. 0.15 moles of $\text{Pb}(\text{NO}_3)_2$

37. 0.1 moles of PbCl_2

38. 0.0159 moles of PbSO_4

39. 0.04 moles of CuCl

40. 0.9 moles of CuCl_2

41. 3 moles of CuSO_4

42. 0.165 moles of ZnCl_2

43. 0.06 moles of AgNO_3

44. 0.08 moles of NH_4Cl

45. 0.0739 moles of $(\text{NH}_4)_2\text{SO}_4$

46. 0.037 moles of NH_4VO_3

47. 0.078 moles of KClO_3

48. 0.07 moles of KIO_3

49. 1 mole of NaClO

50. 5 moles of NaNO_2

Exercise 4c: Calculation of the Volume of a Given Number of Moles of a Gas

Calculate the volume (in cm^3) of the following gases given the number of moles (assume standard conditions where 1 mole occupies 24,000 cm^3).

1. 1 mole of CH_4

2. 0.1 moles of O_2

3. 0.5 moles of N_2

4. 2 moles of H_2

5. 0.12 moles of CO_2

6. 3.4 moles of SO_2

7. 0.11 moles of SO_3

8. 0.004 moles of HBr

9. 10 moles of NH_3

10. 0.45 moles of NO

11. 0.0056 moles of NO_2

12. 0.009 moles of N_2O

13. 0.04 moles of Cl_2

14. 0.123 moles of HCl

15. 0.0023 moles of H_2S

16. 8 moles of CH_4

17. 0.00001 moles of O_2

18. 6 moles of N_2

19. 0.0076 moles of CO

20. 3 moles of $\text{H}_2\text{O(g)}$

Exercise 4d: Calculation of the Number of Moles of Gas in a Given Volume

Calculate the number of moles of the following gases given their volumes (in cm^3) at standard conditions (1 mole = 24,000 cm^3).

1. 200 cm^3 of CH_4

2. 500 cm^3 of O_2

3. 1,000 cm^3 of N_2

4. 1,280 cm^3 of H_2

5. 235 cm^3 of CO_2

6. 225 cm³ of SO₂
7. 255 cm³ of SO₃
8. 80 cm³ of HBr
9. 2,000 cm³ of NH₃
10. 2,400 cm³ of NO
11. 700 cm³ of NO₂
12. 5,600 cm³ of N₂O
13. 2,200 cm³ of Cl₂
14. 210 cm³ of HCl
15. 800 cm³ of H₂S
16. 80 cm³ of CH₄
17. 1.92 cm³ of O₂
18. 20,000 cm³ of N₂
19. 420 cm³ of CO
20. 900 cm³ of H₂O(g)

Exercise 4e: Calculation of the Mass of a Given Volume of Gas

Calculate the mass of the following gases given their volumes (in cm³) at standard conditions (1 mole = 24,000 cm³).

1. 200 cm³ of CH₄
2. 500 cm³ of O₂
3. 1,000 cm³ of N₂
4. 1,280 cm³ of H₂
5. 235 cm³ of CO₂
6. 225 cm³ of SO₂
7. 255 cm³ of SO₃
8. 80 cm³ of HBr
9. 2,000 cm³ of NH₃
10. 2,400 cm³ of NO
11. 700 cm³ of NO₂
12. 5,600 cm³ of N₂O
13. 2,200 cm³ of Cl₂
14. 210 cm³ of HCl
15. 800 cm³ of H₂S

16. 80 cm³ of CH₄

17. 1.92 cm³ of O₂

18. 20,000 cm³ of N₂

19. 420 cm³ of CO

20. 900 cm³ of H₂O(g)

Exercise 4f: Calculation of the Volume of a Given Mass of Gas

Calculate the volume (in cm³) of the following gases given their masses at standard conditions (1 mole = 24,000 cm³).

1. 5.76 g of CH₄

2. 13.2 g of O₂

3. 10 g of N₂

4. 0.5 g of H₂

5. 0.352 g of CO₂

6. 0.448 g of SO₂

7. 2.25 g of SO₃

8. 16.2 g of HBr

9. 680 g of NH₃

10. 135 g of NO

11. 136 g of NO₂

12. 700 g of N₂O

13. 159.5 g of Cl₂

14. 7.3 g of HCl

15. 5.95 g of H₂S

16. 1.6 g of CH₄

17. 0.5 g of O₂

18. 2 g of N₂

19. 18.55 g of CO

20. 80 g of H₂O(g)

Exercise 4g: Calculation of the Relative Molecular Mass of a Gas from Mass and Volume Data

Calculate the relative molecular mass (M_r) of the following gases given their mass and volume at standard conditions (1 mole = 24,000 cm³).

1. 0.8 g occupies 120 cm³

2. 1.6 g occupies 600 cm³

3. 0.5 g occupies 150 cm³

4. 0.71 g occupies 240 cm³

5. 0.02 g occupies 2,400 cm³

6. 0.14 g occupies 120 cm³

7. 0.075 g occupies 60 cm³

8. 0.29 g occupies 120 cm³

9. 0.08 g occupies 60 cm³

10. 0.56 g occupies 480 cm³

11. 0.17 g occupies 120 cm³

12. 0.085 g occupies 120 cm³

13. 0.19 g occupies 120 cm³

14. 0.07 g occupies 60 cm³

15. 0.22 g occupies 120 cm³

16. 0.16 g occupies 120 cm³

17. 0.844 g occupies 96 cm³

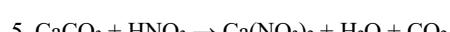
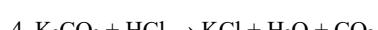
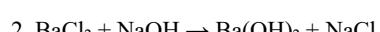
18. 0.365 g occupies 240 cm³

19. 0.405 g occupies 120 cm³

20. 0.32 g occupies 60 cm³

Exercise 6a: Balancing Equations

Balance the following chemical equations.



14. $\text{CH}_4 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$

15. $\text{C}_4\text{H}_{10} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$

16. $\text{PCl}_3 + \text{H}_2\text{O} \rightarrow \text{H}_3\text{PO}_3 + \text{HCl}$

17. $\text{HNO}_3 + \text{Cu} \rightarrow \text{Cu}(\text{NO}_3)_2 + \text{NO} + \text{H}_2\text{O}$

18. $\text{HNO}_3 + \text{Cu} \rightarrow \text{Cu}(\text{NO}_3)_2 + \text{NO}_2 + \text{H}_2\text{O}$

19. $\text{H}_3\text{PO}_4 + \text{NaOH} \rightarrow \text{NaH}_2\text{PO}_4 + \text{H}_2\text{O}$

20. $\text{H}_3\text{PO}_4 + \text{NaOH} \rightarrow \text{Na}_3\text{PO}_4 + \text{H}_2\text{O}$

21. $\text{H}_3\text{PO}_4 + \text{NaOH} \rightarrow \text{Na}_2\text{HPO}_4 + \text{H}_2\text{O}$

22. $\text{NaOH} + \text{Cl}_2 \rightarrow \text{NaClO}_3 + \text{NaCl} + \text{H}_2\text{O}$

23. $\text{N}_2 + \text{H}_2 \rightarrow \text{NH}_3$

24. $\text{NaBr} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + \text{HBr}$

25. $\text{HBr} + \text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{O} + \text{SO}_2 + \text{Br}_2$

26. $\text{C}_2\text{H}_5\text{OH} + \text{PCl}_3 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{H}_3\text{PO}_3$

27. $\text{Fe}_3\text{O}_4 + \text{H}_2 \rightarrow \text{Fe} + \text{H}_2\text{O}$

28. $\text{Fe}_2\text{O}_3 + \text{CO} \rightarrow \text{Fe} + \text{CO}_2$

29. $\text{C}_2\text{H}_5\text{OH} + \text{CH}_3\text{CO}_2\text{H} \rightarrow \text{CH}_3\text{CO}_2\text{C}_2\text{H}_5 + \text{H}_2\text{O}$

30. $\text{KMnO}_4 + \text{HCl} \rightarrow \text{KCl} + \text{MnCl}_2 + \text{H}_2\text{O} + \text{Cl}_2$

Exercise 6b: What's Wrong Here?

Identify and correct the errors in the following equations.

1. $\text{Na}(\text{s}) + \text{H}_2\text{O}(\text{aq}) \rightarrow \text{NaOH}(\text{aq}) + \text{H}(\text{g})$
2. $\text{PbNO}_3(\text{aq}) + \text{NaCl}(\text{aq}) \rightarrow \text{PbCl}(\text{s}) + \text{NaNO}_3(\text{aq})$
3. $\text{CaOH}(\text{aq}) + \text{HCl}(\text{aq}) \rightarrow \text{CaCl}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
4. $\text{C}_2\text{H}_4(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$
5. $\text{MgCO}_3(\text{s}) + \text{HCl}(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$
6. $\text{Cu}(\text{NO}_3)_2(\text{s}) \rightarrow \text{CuO}(\text{s}) + \text{NO}_2(\text{g}) + \text{O}_3(\text{g})$
7. $\text{Pb}(\text{s}) + \text{AgNO}_3(\text{aq}) \rightarrow \text{Pb}(\text{NO}_3)_2(\text{aq}) + \text{AgCl}(\text{s})$
8. $\text{AlCl}_2(\text{s}) + \text{KOH}(\text{aq}) \rightarrow \text{Al}(\text{OH})_2(\text{s}) + \text{KCl}(\text{aq})$
9. $\text{NaCO}_3(\text{s}) + \text{HCl}(\text{aq}) \rightarrow \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$
10. $\text{AgNO}_3(\text{aq}) + \text{NaCl}(\text{aq}) \rightarrow \text{AgCl}(\text{aq}) + \text{NaNO}_3(\text{aq})$

Exercise 6c: Writing Equations in Symbols from Equations in Words

Write balanced symbol equations for the following reactions described in words.

1. Zinc + copper(II) sulphate \rightarrow copper + zinc sulphate
2. Calcium hydroxide + ammonium chloride \rightarrow calcium chloride + water + ammonia
3. Lead(II) nitrate \rightarrow lead(II) oxide + nitrogen dioxide + oxygen
4. Silicon tetrachloride + water \rightarrow silicon dioxide + hydrogen chloride
5. Calcium hydrogen carbonate \rightarrow calcium carbonate + water + carbon dioxide
6. Octane + oxygen \rightarrow carbon dioxide + water
7. Sodium hydroxide + chlorine (or bromine or iodine) \rightarrow sodium chlorate(V) (or bromate or iodate) + sodium chloride (or bromide or iodide) + water
8. Metal (Li, Na, K, Rb, Cs) + water \rightarrow metal hydroxide + hydrogen
9. Tin(II) chloride + mercury(II) chloride \rightarrow mercury(I) chloride + tin(IV) chloride
10. Sulphuric acid + potassium iodide \rightarrow iodine + hydrogen sulphide + potassium hydrogen sulphate + water

Exercise 7: Writing equations from experimental data

1. When a solution containing 2.67 g of aluminium chloride was treated with excess silver nitrate solution, 4.30 g of silver chloride were precipitated. Write an equation for the reaction which has taken place.
2. When a solution containing 1.94 g of potassium chromate(VI) was treated with excess lead(II) nitrate solution, 3.23 g of lead(II) chromate(VI) was precipitated. Write an equation for the reaction which took place.
3. On heating, 3.40 g of silver nitrate decomposed to give 2.16 g of silver. Write an equation for the reaction which took place.
4. Phosphoric(V) acid, H_3PO_4 , reacts with sodium hydroxide solution in three distinct stages depending upon the quantity of sodium hydroxide solution used:
 - When 25 cm^3 of 0.1 mol dm^{-3} phosphoric(V) acid is treated with 25 cm^3 of 0.1 mol dm^{-3} sodium hydroxide solution, the resulting solution has a pH of about 2.
 - When 25 cm^3 of 0.1 mol dm^{-3} phosphoric(V) acid is treated with 50 cm^3 of 0.1 mol dm^{-3} sodium hydroxide solution, the resulting solution has a pH of about 7.
 - When 25 cm^3 of 0.1 mol dm^{-3} phosphoric(V) acid is treated with 75 cm^3 of 0.1 mol dm^{-3} sodium hydroxide solution, the resulting solution has a pH of about 13.
 i) How many moles of phosphoric(V) acid are present in 25 cm^3 of a 0.1 mol dm^{-3} solution?
 ii) How many moles of sodium hydroxide are present in 25 cm^3 of a 0.1 mol dm^{-3} solution?
 iii) Write equations for the three reactions that take place.
 iv) What volume of 0.1 mol dm^{-3} sodium hydroxide solution would be required to completely neutralise 25 cm^3 of 0.1 mol dm^{-3} phosphoric(V) acid?
5. 2.495 g of hydrated copper(II) sulphate, $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$, was heated to drive off the water of crystallisation. The anhydrous copper(II) sulphate remaining had a mass of 1.595 g . Find the value of x and write an equation for the reaction taking place.
6. 2.495 g of hydrated copper(II) sulphate was dissolved in water and the solution treated with excess barium chloride solution. 2.33 g of barium sulphate was precipitated. Confirm that the value of x is the same as that found in question 5 and write an equation for the reaction between copper(II) sulphate solution and barium chloride solution.
7. When 0.085 g of ammonia gas was passed over heated copper(II) oxide, 0.72 g of copper was produced. Write an equation for the reaction which took place.

8. When 0.68 g of an organic compound containing carbon, hydrogen, and oxygen only was burnt in excess oxygen, 0.88 g of carbon dioxide and 0.72 g of water were produced. Find the empirical formula of the compound and write an equation for the reaction which took place.

9. When 0.278 g of hydrated iron(II) sulphate, $\text{FeSO}_4 \cdot x\text{H}_2\text{O}$, was heated gently until no further change occurred, 0.152 g of anhydrous iron(II) sulphate remained. Does this support the idea that $x = 7$?

10. When 0.278 g of hydrated iron(II) sulphate was strongly heated, a mixture of gases was given off and a solid remained. The solid was found to be iron(III) oxide with a mass of 0.080 g. Write an equation for the reaction that took place.

Exercise 8: Calculations of amounts of products/reactants based on equations

1. What mass of iron can be obtained by the reduction of 32 g of iron(III) oxide with carbon monoxide?
2. What mass of barium sulphate can be precipitated when excess barium chloride solution is added to 25 cm³ of a 0.1 mol dm⁻³ solution of sodium sulphate?
3. In the production of ethyl ethanoate, 0.46 g of ethanol is mixed with an excess of ethanoic acid. What mass of each reactant is present in the equilibrium mixture?
4. What mass of iron(II) sulphate can be obtained by the action of 100 tonnes of 1 mol dm⁻³ sulphuric acid on an excess of iron?
5. What mass of sodium chloride can be obtained when hydrogen chloride gas is passed into 100 cm³ of a saturated solution of sodium chloride containing 36 g of sodium chloride?
6. What mass of sodium hydroxide and copper(II) hydroxide can be obtained when 100 cm³ of a 1 mol dm⁻³ solution of sodium hydroxide is added to 100 cm³ of a 0.25 mol dm⁻³ solution of copper(II) sulphate?
7. What volume of hydrogen, measured at RTP, can be obtained when 4.8 g of magnesium reacts with excess 1 mol dm⁻³ sulphuric acid?
8. What mass of calcium nitrate and what volume of carbon dioxide at RTP can be obtained by the action of 100 cm³ of 1 mol dm⁻³ nitric acid on an excess of calcium carbonate?
9. What volume of gas (nitrogen dioxide and oxygen) is obtained when 3.31 g of lead(II) nitrate is heated? (Assume all volumes are measured at RTP.)
10. What mass of hydrated magnesium sulphate, $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$, can be obtained from 1.2 g of magnesium? Write an equation for the reaction that takes place.
11. What mass of lead(II) iodide can be obtained when excess potassium iodide solution is added to 100 cm³ of a 0.1 mol dm⁻³ solution of lead(II) nitrate?
12. What mass of sodium carbonate is needed to produce 100 g of sodium oxide when heated?
13. What mass of ethanol is needed to produce 1 dm³ of carbon dioxide at RTP when the ethanol undergoes fermentation?
14. Calculate the mass of:
 - i) zinc hydroxide
 - ii) aluminium hydroxide
 - iii) magnesium hydroxideprecipitated when 100 cm³ of 0.5 mol dm⁻³ sodium hydroxide solution is added to separate 100 cm³ portions of 0.25 mol dm⁻³ solutions of zinc sulphate, aluminium sulphate, and magnesium sulphate.
15. What volume of carbon dioxide is produced when 1 g of calcium carbonate is treated with excess 1 mol dm⁻³ hydrochloric acid? (All gas volumes measured at RTP.)

16. What mass of magnesium is needed to produce 100 cm^3 of hydrogen at RTP when treated with excess 1 mol dm^{-3} hydrochloric acid?

17. What masses of sodium chloride and sodium chlorate(V) are produced when 10 g of sodium hydroxide reacts with excess chlorine?

18. What volumes of nitrogen and hydrogen, measured at RTP, are required to produce 1 tonne of ammonia?

19. What mass of nitric acid and what volume of oxygen (measured at RTP) can be obtained from 36 tonnes of ammonia?

20. What mass of calcium carbonate and what volume of 10 mol dm^{-3} hydrochloric acid are required to produce 1 dm^3 of carbon dioxide at RTP?

Exercise 9: Calculations based on equations involving only gases

Section (a)

Assuming all volumes are measured under the same conditions of temperature and pressure, calculate the volumes of gaseous reactants and products in the following:

1. The combustion of 10 cm^3 of methane, CH_4 .
2. The combustion of 10 cm^3 of ethane, C_2H_6 .
3. The combustion of 10 cm^3 of propane, C_3H_8 .
4. The combustion of 10 cm^3 of octane vapour, C_8H_{18} .
5. The synthesis of 20 cm^3 of ammonia, NH_3 , from nitrogen and hydrogen.

Section (b)

Assuming all volumes are measured at RTP unless otherwise stated:

1. What volume of oxygen is required to convert 1 dm^3 of nitrogen monoxide, NO , into nitrogen dioxide, NO_2 ?
2. What volume of air (assume 20% oxygen by volume) is required to convert 100 cm^3 of sulphur dioxide into sulphur trioxide?
3. What volume of ammonia reacting with excess air (assume 20% oxygen by volume) will produce 2 dm^3 of nitrogen monoxide?
4. What volume of oxygen is required to burn completely 6.5 mol of methane?
5. What volume of hydrogen, measured at RTP, is required to reduce 8 g of copper(II) oxide to copper?
6. 10 cm^3 of carbon monoxide is mixed with 20 cm^3 of oxygen and ignited. What volume of gas remains?
7. 50 cm^3 of propane is mixed with 200 cm^3 of oxygen and ignited. What is the final volume of the gas mixture?
8. 50 cm^3 of methane is mixed with 50 cm^3 of oxygen and ignited. What is the final volume of the gas mixture?
9. 10 cm^3 of nitrogen is mixed with 50 cm^3 of hydrogen and a spark applied. Assuming all the nitrogen reacts, what volume of gas remains?
10. 10 cm^3 of hydrogen is mixed with 10 cm^3 of oxygen and ignited. What volume of gas remains?

Exercise 10: Ionic Equations

Write the balanced ionic equations for the following reactions.

1. $\text{Pb}^{2+}(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{Pb}(\text{OH})_2(\text{s})$
2. $\text{Al}^{3+}(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{Al}(\text{OH})_3(\text{s})$

3. $\text{Al(OH)}_3(\text{s}) + \text{OH}^-(\text{aq}) \rightarrow \text{AlO}_2^-(\text{aq}) + \text{H}_2\text{O}(\text{l})$
4. $\text{Cl}_2(\text{g}) + \text{OH}^-(\text{aq}) \rightarrow \text{ClO}_3^-(\text{aq}) + \text{Cl}^-(\text{aq}) + \text{H}_2\text{O}(\text{l})$
5. $\text{S}_2\text{O}_3^{2-}(\text{aq}) + \text{I}(\text{s}) \rightarrow \text{S}_4\text{O}_6^{2-}(\text{aq}) + \text{I}^-(\text{aq})$
6. $\text{Cu}^{2+}(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{Cu}(\text{OH})_2(\text{s})$
7. $\text{CO}_3^{2-}(\text{s}) + \text{H}^+(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$
8. $\text{Zn}(\text{s}) + \text{H}^+(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{H}_2(\text{g})$
9. $\text{Zn}(\text{s}) + \text{Pb}^{2+}(\text{aq}) \rightarrow \text{Pb}(\text{s}) + \text{Zn}^{2+}(\text{aq})$
10. $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$
11. $\text{Mg}(\text{s}) + \text{H}^+(\text{aq}) \rightarrow \text{Mg}^{2+}(\text{aq}) + \text{H}_2(\text{g})$
12. $\text{CO}_3^{2-}(\text{s}) + \text{H}^+(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$
13. $\text{CuO}(\text{s}) + \text{H}^+(\text{aq}) \rightarrow \text{Cu}^{2+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
14. $\text{Ba}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$
15. $\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{AgCl}(\text{s})$
16. $\text{Zn}(\text{s}) + \text{Ag}^+(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{Ag}(\text{s})$
17. $\text{NaOH}(\text{aq}) + \text{HCl}(\text{aq}) \rightarrow \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
18. $\text{KOH}(\text{aq}) + \text{HNO}_3(\text{aq}) \rightarrow \text{KNO}_3(\text{aq}) + \text{H}_2\text{O}(\text{l})$
19. $\text{NaOH}(\text{aq}) + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + \text{H}_2\text{O}(\text{l})$
20. $\text{KOH}(\text{aq}) + \text{CH}_3\text{CO}_2\text{H}(\text{aq}) \rightarrow \text{CH}_3\text{CO}_2\text{K}(\text{aq}) + \text{H}_2\text{O}(\text{l})$

Exercise 11a: Calculations Based on Concentrations in Solution

Calculate the number of moles or mass based on the given concentrations and volumes.

1. Number of moles in 25 cm³ of 1.0 mol dm⁻³ NaOH
2. Number of moles in 50 cm³ of 0.5 mol dm⁻³ HCl
3. Number of moles in 25 cm³ of 2.5 mol dm⁻³ H₂SO₄
4. Number of moles in 10 cm³ of 0.5 mol dm⁻³ NaCl
5. Number of moles in 100 cm³ of 0.25 mol dm⁻³ KOH
6. Number of moles in 250 cm³ of 0.1 mol dm⁻³ NH₃
7. Number of moles in 50 cm³ of 0.25 mol dm⁻³ CaCl₂
8. Number of moles in 20 cm³ of 0.5 mol dm⁻³ AgNO₃
9. Number of moles in 25 cm³ of 0.05 mol dm⁻³ KMnO₄
10. Number of moles in 50 cm³ of 0.1 mol dm⁻³ CuSO₄
11. Mass of solute in 25 cm³ of 0.5 mol dm⁻³ NaCl
12. Mass of solute in 25 cm³ of 0.25 mol dm⁻³ NaNO₃

13. Mass of solute in 50 cm^3 of 1.0 mol dm^{-3} NaOH
14. Mass of solute in 10 cm^3 of 1.0 mol dm^{-3} AgNO_3
15. Mass of solute in 100 cm^3 of 0.5 mol dm^{-3} Na_2SO_4
16. Mass of solute in 25 cm^3 of 0.4 mol dm^{-3} H_2SO_4
17. Mass of solute in 20 cm^3 of 0.1 mol dm^{-3} KMnO_4
18. Mass of solute in 50 cm^3 of 0.25 mol dm^{-3} CuSO_4
19. Mass of solute in 10 cm^3 of 0.5 mol dm^{-3} NH_4Cl
20. Mass of solute in 25 cm^3 of 0.2 mol dm^{-3} FeSO_4
21. Concentration of a solution containing 2.0 g of NaOH in 100 cm^3
22. Concentration of a solution containing 9.8 g of H_2SO_4 in 100 cm^3
23. Concentration of a solution containing 1.59 g of CuSO_4 in 100 cm^3
24. Concentration of a solution containing 8.5 g of NaNO_3 in 100 cm^3
25. Concentration of a solution containing 4.14 g of $\text{Pb}(\text{NO}_3)_2$ in 100 cm^3
26. Concentration of a solution containing 5.28 g of $(\text{NH}_4)_2\text{SO}_4$ in 100 cm^3
27. Concentration of a solution containing 16 g of NaOH in 100 cm^3
28. Concentration of a solution containing 39.2 g of H_2SO_4 in 100 cm^3
29. Concentration of a solution containing 25 g of FeSO_4 in 100 cm^3
30. Concentration of a solution containing 0.331 g of $\text{Pb}(\text{NO}_3)_2$ in 100 cm^3
31. Concentration of a solution containing 0.535 g of NH_4Cl in 100 cm^3
32. Concentration of a solution containing 10 g of H_2SO_4 in 50 cm^3
33. Concentration of a solution containing 2.12 g of Na_2CO_3 in 100 cm^3
34. Concentration of a solution containing 0.395 g of KMnO_4 in 50 cm^3
35. Concentration of a solution containing 25 g of NaCl in 60 cm^3

Exercise 11b: Simple Volumetric Calculations

Perform the following volumetric calculations based on the given data.

1. Concentration of a solution when 4.2 g of NaOH is dissolved in 100 cm^3
2. Concentration of a solution when 6.8 g of Na_2CO_3 is dissolved in 100 cm^3
3. Concentration of a solution when 5.88 g of NaCl is dissolved in 100 cm^3
4. Concentration of a solution when 9.8 g of H_2SO_4 is dissolved in 25 cm^3
5. Concentration of a solution when 6.0 g of NaOH is dissolved in 100 cm^3
6. Concentration of a solution when 4.0 g of NaOH is dissolved in 100 cm^3
7. Concentration of a solution when 0.4 g of NaOH is dissolved in 100 cm^3

8. Concentration of a solution when 0.535 g of NH_4Cl is dissolved in 100 cm^3

9. Concentration of a solution when 13.25 g of $(\text{NH}_4)_2\text{SO}_4$ is dissolved in 100 cm^3

10. Concentration of a solution when 39.2 g of H_2SO_4 is dissolved in 100 cm^3

11. Concentration of a solution when 8.5 g of NaNO_3 is dissolved in 100 cm^3

12. Concentration of a solution when 25 g of NaCl is dissolved in 100 cm^3

13. Concentration of a solution when 5.65 g of Na_2CO_3 is dissolved in 100 cm^3

14. Concentration of a solution when 4.95 g of CuSO_4 is dissolved in 100 cm^3

15. Concentration of a solution when 8.775 g of Na_2SO_4 is dissolved in 100 cm^3

16. pH of a solution with a hydrogen ion concentration of 0.001 mol dm^{-3}

17. Concentration of a solution when 25 cm^3 of 0.1 mol dm^{-3} NaOH reacts with 25 cm^3 of HCl

18. Volume of 0.1 mol dm^{-3} HCl required to neutralize 25 cm^3 of 0.2 mol dm^{-3} NaOH

19. Volume of 0.5 mol dm^{-3} H_2SO_4 required to neutralize 100 cm^3 of 0.25 mol dm^{-3} NaOH

20. Volume of 0.2 mol dm^{-3} NaOH required to neutralize 25 cm^3 of 0.2 mol dm^{-3} HCl

21. Mass of NaCl produced when 25 cm^3 of 0.1 mol dm^{-3} NaOH reacts with excess HCl

22. Mass of CaCO_3 required to produce 100 cm^3 of CO_2 at STP when reacted with excess HCl

23. Volume of CO_2 produced at STP when 1.0 g of CaCO_3 reacts with excess HCl

24. Mass of Mg and volume of H_2 produced at STP when 25 cm^3 of 0.2 mol dm^{-3} HCl reacts with excess Mg

25. Volume of H_2 produced at STP when 0.48 g of Mg reacts with excess HCl

PART 02- Answers from the Original Document

Exercise 1

1*	18	**21***	111	**41***	159.5
2*	44	**22***	164	**42***	161.4
3*	17	**23***	74	**43***	170
4*	46	**24***	136	**44***	53.5
5*	28	**25***	208	**45***	132
6*	64	**26***	1335	**46***	117.0
7*	80	**27***	213	**47***	122.5
8*	81	**28***	342	**48***	166.0
9*	98	**29***	152	**49***	74.5
10*	63	**30***	127	**50***	69.0

11	58.5	**31**	162.5	**51**	249.5
12	85	**32**	400	**52**	278
13	106	**33**	223	**53**	964
14	40	**34**	239	**54**	248
15	142	**35**	685	**55**	126
16	158	**36**	331	**56**	246
17	194	**37**	278	**57**	2635
18	100	**38**	303	**58**	60
19	166	**39**	99.0	**59**	58
20	195	**40**	134.5	**60**	122

Exercise 2

1	NaCl	21	BaSO₄	41	PbCO₃	61	PCl₃
2	NaOH	22	AlCl₃	42	PbO	62	PCl₅
3	Na₂CO₃	23	Al₂O₃	43	PbO₂	63	P₂O₃
4	Na₂SO₄	24	Al(OH)₃	44	PbCl₂	64	P₂O₅
5	Na₃PO₄	25	Al₂(SO₄)₃	45	PbCl₄	65	H₃PO₄
6	KCl	26	CuSO₄	46	PbS	66	H₂SO₄
7	KBr	27	CuO	47	SnCl₂	67	HNO₃
8	KI	28	CuCl₂	48	SnCl₄	68	HCl
9	KHCO₃	29	Cu(NO₃)₂	49	FeSO₄	69	CCl₄
10	KNO₂	30	Cu₂O	50	FeCl₂	70	SiCl₄
11	MgCl₂	31	CuCl	51	Fe₂(SO₄)₃	71	SiO₂
12	Mg(NO₃)₂	32	Zn(NO₃)₂	52	FeCl₃	72	SO₂
13	Mg(OH)₂	33	ZnCO₃	53	Fe(OH)₃	73	SO₃
14	MgO	34	ZnO	54	Fe(OH)₂	74	H₂S
15	MgCO₃	35	AgCl	55	NH₄Cl	75	Cl₂O
16	CaO	36	AgBr	56	(NH₄)₂CO₃	76	NO₂
17	CaCl₂	37	AgI	57	NH₄OH	77	NO
18	CaSO₄	38	AgNO₃	58	NH₄NO₃	78	CO₂
19	CaCO₃	39	Ag₂O	59	(NH₄)₂SO₄	79	CO
20	BaCl₂	40	Pb(NO₃)₂	60	(NH₄)₃PO₄	80	HOH / H₂O

Exercise 3

1. Water
2. Carbon dioxide
3. Ammonia
4. Oxygen
5. Hydrogen
6. Sulphur dioxide (or sulphur(IV) oxide)
7. Sulphur trioxide (or sul[phur(VI) oxide])
8. Hydrogen chloride
9. Hydrogen iodide
10. Hydrogen fluoride
11. Methane
12. Hydrogen sulphide
13. Hydrogen bromide
14. Sulphuric acid
15. Nitric acid
16. Sodium chloride
17. Sodium nitrate
18. Sodium carbonate
19. Sodium hydroxide
20. Sodium sulphate
21. Calcium chloride
22. Calcium nitrate
23. Calcium hydroxide
24. Calcium sulphate
25. Barium chloride
26. Aluminium chloride
27. Aluminium nitrate
28. Aluminium sulphate
29. Iron(II) sulphate
30. Iron(II) chloride

31. Iron(III) chloride
32. Iron(III) sulphate
33. Lead(II) oxide
34. Lead(IV) oxide
35. Lead(II) nitrate
36. Lead(II) chloride
37. Lead(II) sulphate
38. Copper(II) nitrate
39. Copper(I) chloride
40. Copper(II) chloride
41. Copper(II) sulphate
42. Zinc chloride
43. Silver nitrate
44. Ammonium chloride
45. Ammonium sulphate
46. Ammonium vanadate(V)
47. Potassium chlorate(V)
48. Potassium iodate
49. Sodium chlorate(I)
50. Sodium nitrite
51. Ethane
52. Butane
53. Octane
54. Ammonium carbonate
55. Potassium manganate(VII)
56. Potassium chromate(VI)
57. Potassium hydrogencarbonate
58. Potassium iodide
59. Cobalt(II) nitrate
60. Potassium astatide

Exercise 4a

1	0.50	26	0.10
2	2.0	27	0.10
3	0.10	28	0.0085
4	5.0	29	0.26
5	20	30	0.104
6	0.010	31	0.20
7	1.0	32	0.082
8	0.22	33	0.050
9	0.0010	34	1.34
10	0.050	35	0.025
11	0.33	36	0.204
12	0.25	37	0.071
13	0.021	38	0.010
14	0.020	39	0.050
15	0.125	40	0.254
16	0.020	41	0.0125
17	0.167	42	0.152
18	1.0	43	0.10
19	0.046	44	0.053
20	0.020	45	0.0043
21	0.0010	46	0.036
22	0.25	47	0.266
23	0.02	48	0.024
24	0.0025	49	0.025
25	0.20	50	1.574

Exercise 4b

1	36 g	26	14.95 g
2	132 g	27	76.2 g
3	47.6 g	28	10.03 g
4	23 g	29	17.82 g
5	33.6 g	30	145.2 g
6	40.96 g	31	2.925 g

| 7 | 240 g | 32 | 12.25 g |

| 8 | 81 g | 33 | 21.4 g |

| 9 | 1.152 g | 34 | 745 g |

| 10 | 9.45 g | 35 | 0.069 g |

| 11 | 26.3 g | 36 | 49.9 g |

| 12 | 59.5 g | 37 | 27.8 g |

| 13 | 11.66 g | 38 | 4.82 g |

| 14 | 80.0 g | 39 | 9.92 g |

| 15 | 127.8 g | 40 | 302.4 g |

| 16 | 7.9 g | 41 | 756.5 g |

| 17 | 34.92 g | 42 | 39.53 g |

| 18 | 90 g | 43 | 10.2 g |

| 19 | 249 g | 44 | 11.6 g |

| 20 | 23.4 g | 45 | 9.76 g |

| 21 | 12.2 g | 46 | 4.34 g |

| 22 | 672.4 g | 47 | 9.59 g |

| 23 | 0.296 g | 48 | 41.0 g |

| 24 | 13.6 g | 49 | 304 g |

| 25 | 43.68 g | 50 | 1397 g |

Exercise 4c

| 1 | 24000 cm³ | 11 | 134.4 cm³ |

| 2 | 2400 cm³ | 12 | 216 cm³ |

| 3 | 12000 cm³ | 13 | 960 cm³ |

| 4 | 48000 cm³ | 14 | 2952 cm³ |

| 5 | 2880 cm³ | 15 | 55.2 cm³ |

| 6 | 81600 cm³ | 16 | 192000 cm³ |

| 7 | 2640 cm³ | 17 | 0.24 cm³ |

| 8 | 96 cm³ | 18 | 144000 cm³ |

| 9 | 240000 cm³ | 19 | 182.4 cm³ |

| 10 | 10800 cm³ | 20 | 72000 cm³ |

Exercise 4d

| 1 | 0.0083 mol | 11 | 0.0292 mol |

2	0.0208 mol	12	0.2333 mol
3	0.0416 mol	13	0.0917 mol
4	0.0533 mol	14	0.0088 mol
5	0.0098 mol	15	0.0333 mol
6	0.0094 mol	16	0.0033 mol
7	0.0106 mol	17	0.000080 mol
8	0.0033 mol	18	0.8333 mol
9	0.0833 mol	19	0.0175 mol
10	0.10 mol	20	0.0375 mol

Exercise 4e

1	0.367 g	11	0.875 g
2	0.354 g	12	10.27 g
3	1.166 g	13	2.38 g
4	5.333 g	14	0.263 g
5	0.78 g	15	1.217 g
6	0.763 g	16	0.270 g
7	0.757 g	17	0.011 g
8	0.233 g	18	38.33 g
9	0.167 g	19	0.683 g
10	3.20 g	20	1.05 g

Exercise 4f

1	1091 cm³	11	56000 cm³
2	7059 cm³	12	30545 cm³
3	8571 cm³	13	20308 cm³
4	7500 cm³	14	16000 cm³
5	702 cm³	15	5260 cm³
6	670 cm³	16	2370 cm³
7	3380 cm³	17	375 cm³
8	30000 cm³	18	12000 cm³
9	2400000 cm³	19	26526 cm³
10	180000 cm³	20	77143 cm³

Exercise 4g

| 1 | 160 | 11 | 34 |

| 2 | 64 | 12 | 17 |

| 3 | 80 | 13 | 38 |

| 4 | 71 | 14 | 28 |

| 5 | 2.0 | 15 | 44 |

| 6 | 28 | 16 | 32 |

| 7 | 30 | 17 | 211 |

| 8 | 58 | 18 | 36.5 |

| 9 | 32 | 19 | 81 |

| 10 | 28 | 20 | 128 |

Exercise 5**Section (a)**

1. CaCO3
2. Na2SO4
3. Na2S2O3
4. PbO
5. Pb3O4
6. H3PO3
7. H2SO3
8. CH4
9. C3H8
10. HO (giving H2O2)
11. H4N2O3 (NH4NO3)
12. FeSO4·7H2O (FeSO4H14)

Section (b)

1. C2H4
2. C3H6
3. P2I4
4. N2H4S2O8
5. P4O10
6. C2H4O2 (CH3COOH)

7. C_4H_{10}

8. Fe_2O_3

9. $\text{H}_2\text{S}_2\text{O}_8$

10. C_6H_6

Section (c)

1. PbO

2. KO_2

3. C_2H_2

4. AlCl_3

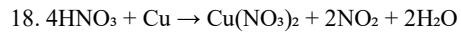
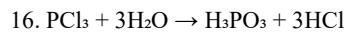
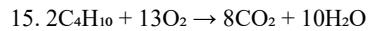
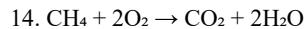
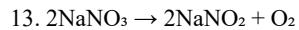
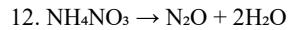
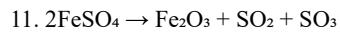
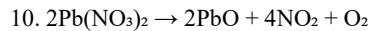
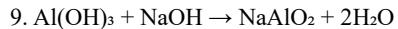
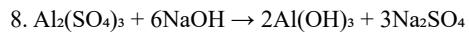
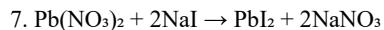
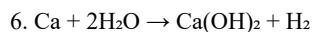
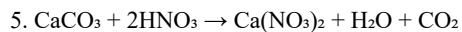
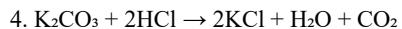
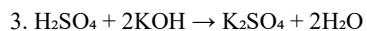
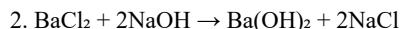
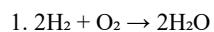
5. CH_4

6. Yes

7. $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$

8. $\text{PCl}_5, \text{PCl}_3, \text{Cl}_2$

Exercise 6a



19. $\text{H}_3\text{PO}_4 + \text{NaOH} \rightarrow \text{NaH}_2\text{PO}_4 + \text{H}_2\text{O}$

20. $\text{H}_3\text{PO}_4 + 3\text{NaOH} \rightarrow \text{Na}_3\text{PO}_4 + 3\text{H}_2\text{O}$

21. $\text{H}_3\text{PO}_4 + 2\text{NaOH} \rightarrow \text{Na}_2\text{HPO}_4 + 2\text{H}_2\text{O}$

22. $6\text{NaOH} + 3\text{Cl}_2 \rightarrow \text{NaClO}_3 + 5\text{NaCl} + 3\text{H}_2\text{O}$

23. $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$

24. $2\text{NaBr} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{HBr}$

25. $2\text{HBr} + \text{H}_2\text{SO}_4 \rightarrow 2\text{H}_2\text{O} + \text{SO}_2 + \text{Br}_2$

26. $3\text{C}_2\text{H}_5\text{OH} + \text{PCl}_3 \rightarrow 3\text{C}_2\text{H}_5\text{Cl} + \text{H}_3\text{PO}_3$

27. $\text{Fe}_3\text{O}_4 + 4\text{H}_2 \rightarrow 3\text{Fe} + 4\text{H}_2\text{O}$

28. $\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$

29. $\text{C}_2\text{H}_5\text{OH} + \text{CH}_3\text{CO}_2\text{H} \rightarrow \text{CH}_3\text{CO}_2\text{C}_2\text{H}_5 + \text{H}_2\text{O}$

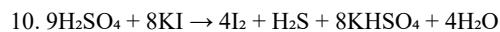
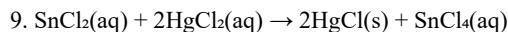
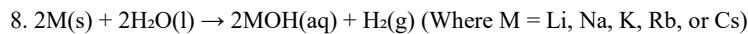
30. $2\text{KMnO}_4 + 16\text{HCl} \rightarrow 2\text{KCl} + 2\text{MnCl}_2 + 8\text{H}_2\text{O} + 5\text{Cl}_2$

Exercise 6b

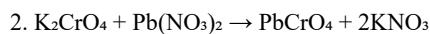
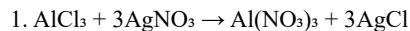
- Hydrogen is not H but H_2 , which gives: $2\text{Na(s)} + 2\text{H}_2\text{O(aq)} \rightarrow 2\text{NaOH(aq)} + \text{H}_2\text{g}$
- Since the valency of lead is 2 not 1, lead nitrate is not PbNO_3 but $\text{Pb}(\text{NO}_3)_2$ and also lead chloride is PbCl_2 : $\text{Pb}(\text{NO}_3)_2\text{aq} + 2\text{NaCl(aq)} \rightarrow \text{PbCl}_2\text{s} + 2\text{NaNO}_3\text{aq}$
- Calcium hydroxide is Ca(OH)_2 : $\text{Ca(OH)}_2\text{aq} + 2\text{HCl(aq)} \rightarrow \text{CaCl}_2\text{aq} + 2\text{H}_2\text{O(l)}$
- This does not balance: $\text{C}_2\text{H}_4\text{g} + 3\text{O}_2\text{g} \rightarrow 2\text{CO}_2\text{g} + 2\text{H}_2\text{O(l)}$
- A magnesium compound cannot give a calcium compound!
- Ozone O_3 is not produced by heating a nitrate, O_2 is: $2\text{Cu}(\text{NO}_3)_2\text{s} \rightarrow 2\text{CuO(s)} + 4\text{NO}_2\text{g} + \text{O}_2\text{g}$
- This reaction does not take place and so no equation can be written.
- Aluminium has a valency of 3 not 2 as in this equation: $\text{AlCl}_3\text{s} + 3\text{KOH(aq)} \rightarrow \text{Al(OH)}_3\text{s} + 3\text{KCl(aq)}$
- Sodium has a valency of 1 not 2 as in this equation: $\text{Na}_2\text{CO}_3\text{s} + 2\text{HCl(aq)} \rightarrow 2\text{NaCl(aq)} + \text{H}_2\text{O(l)} + \text{CO}_2\text{g}$
- Silver chloride is not soluble in water. Thus the AgCl needs a (s) symbol: $\text{AgNO}_3\text{aq} + \text{NaCl(aq)} \rightarrow \text{AgCl(s)} + \text{NaNO}_3\text{aq}$

Exercise 6c

- $\text{Zn(s)} + \text{CuSO}_4\text{aq} \rightarrow \text{Cu(s)} + \text{ZnSO}_4\text{aq}$
- $\text{Ca(OH)}_2\text{s} + 2\text{NH}_4\text{Cl(s)} \rightarrow \text{CaCl}_2\text{s} + 2\text{H}_2\text{O(g)} + 2\text{NH}_3\text{g}$
- $2\text{Pb}(\text{NO}_3)_2\text{s} \rightarrow 2\text{PbO(s)} + 4\text{NO}_2\text{g} + \text{O}_2\text{g}$
- $\text{SiCl}_4\text{l} + 2\text{H}_2\text{O(l)} \rightarrow \text{SiO}_2\text{s} + 4\text{HCl(g)}$
- $\text{Ca}(\text{HCO}_3)_2\text{aq} \rightarrow \text{CaCO}_3\text{s} + \text{H}_2\text{O(l)} + \text{CO}_2\text{g}$
- $2\text{C}_8\text{H}_{18}\text{g} + 25\text{O}_2\text{g} \rightarrow 16\text{CO}_2\text{g} + 18\text{H}_2\text{O(l)}$
- $6\text{NaOH(aq)} + 3\text{Cl}_2\text{g} \rightarrow \text{NaClO}_3\text{aq} + 5\text{NaCl(aq)} + 3\text{H}_2\text{O(l)}$
- $6\text{NaOH(aq)} + 3\text{Br}_2\text{g} \rightarrow \text{NaBrO}_3\text{aq} + 5\text{NaBr(aq)} + 3\text{H}_2\text{O(l)}$

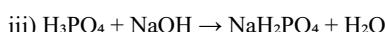


Exercise 7



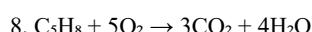
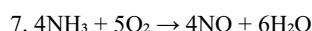
4. i) 1 mole

ii) 2 moles



iv) 75 cm³

5. x = 3



9. It is



Exercise 8

1. 11.2 g

2. 21.6 g

3. 0.682 g of ethanoic acid and 0.523 g of ethanol

4. 143 tonnes

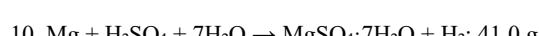
5. 14.5 g

6. 8.0 g of sodium hydroxide, 9.75 g of copper hydroxide

7. 12000 cm³

8. 54.7 g of calcium nitrate, 8.0 dm³ of carbon dioxide

9. 6 dm³ total (4.8 dm³ of nitrogen dioxide and 1.2 dm³ of oxygen)



11. 31.9 g

12. 324.3 g

13. 5.11 g of ethanol, 2.67 dm³ of carbon dioxide

14. (i) 12.30 g of zinc hydroxide

(ii) 9.12 g of aluminium hydroxide

(iii) 9.67 g of magnesium hydroxide

15. 0.600 dm³

16. 0.100 g

17. 2.94 g of sodium chloride, 1.065 g of sodium chlorate(V)

18. 4.15×10^6 dm³ of nitrogen, 12.5×10^6 dm³ of hydrogen

19. 63 tonnes of nitric acid, 4.8×10^7 dm³ of oxygen

20. 2198 g of calcium carbonate, 4.395 dm³ of 10 M HCl

Exercise 9

Section (a)

1. 20 cm³ O₂, 10 cm³ CO₂, 20 cm³ H₂O(g)

2. 30 cm³ O₂, 20 cm³ CO₂, 20 cm³ H₂O(g)

3. 25 cm³ O₂, 20 cm³ CO₂, 10 cm³ H₂O(g)

4. 125 cm³ O₂, 80 cm³ CO₂, 90 cm³ H₂O(g)

5. 30 cm³ H₂, 20 cm³ NH₃

Section (b)

1. 500 cm³ O₂ ($2\text{NO} + \text{O}_2 \rightarrow 2\text{NO}_2$)

2. 375 cm³ air ($2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3$)

3. 2500 cm³ NH₃ needed, $5/4 \times 2500 = 3125$ cm³ O₂ $\rightarrow 15625$ cm³ air

4. 6.5×24000 cm³ = 156 m³

5. 24000 cm³

6. Final volume = 20 cm³ (10 cm³ CO₂ + 10 cm³ unused O₂)

7. Final volume = 77.5 cm³ (40 cm³ CO₂ + 37.5 cm³ unused O₂)

8. This time the CH₄ is in excess. We must assume that CO₂ is produced (not CO or C)! Final volume = 60 cm³ (30 cm³ CO₂ + 30 cm³ CH₄)

9. N₂ + 3H₂ \rightarrow 2NH₃; 10 cm³, 30 cm³, 20 cm³ + 30 cm³ excess; 20 cm³ NH₃ produced + 30 cm³ excess H₂

10. 2H₂ + O₂ \rightarrow 2H₂O; 10 cm³, 5 cm³ + 5 cm³ excess; Final volume = 5 cm³ (all excess O₂)

Exercise 10

1. Pb²⁺(aq) + 2OH⁻(aq) \rightarrow Pb(OH)₂(s)

2. Al³⁺(aq) + 3OH⁻(aq) \rightarrow Al(OH)₃(s)

3. $\text{Al(OH)}_3(\text{s}) + \text{OH}^-(\text{aq}) \rightarrow \text{AlO}_2^-(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$

4. $\text{Cl}_2(\text{g}) + 6\text{OH}^-(\text{aq}) \rightarrow \text{ClO}_3^-(\text{aq}) + 5\text{Cl}^-(\text{aq}) + 3\text{H}_2\text{O}(\text{l})$

5. $2\text{S}_2\text{O}_3^{2-}(\text{aq}) + \text{I}_2(\text{s}) \rightarrow \text{S}_4\text{O}_6^{2-}(\text{aq}) + 2\text{I}^-(\text{aq})$

6. $\text{Cu}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq}) \rightarrow \text{Cu}(\text{OH})_2(\text{s})$

7. $\text{CO}_3^{2-}(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$

8. $\text{Zn}(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{H}_2(\text{g})$

9. $\text{Zn}(\text{s}) + \text{Pb}^{2+}(\text{aq}) \rightarrow \text{Pb}(\text{s}) + \text{Zn}^{2+}(\text{aq})$

10. $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$

11. $\text{Mg}(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{Mg}^{2+}(\text{aq}) + \text{H}_2(\text{g})$

12. $\text{CO}_3^{2-}(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$

13. $\text{CuO}(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{Cu}^{2+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$

14. $\text{Ba}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$

15. $\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{AgCl}(\text{s})$

16. $\text{Zn}(\text{s}) + 2\text{Ag}^+(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{Ag}(\text{s})$

17–20. $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$ (In every case the reaction is the same)

Exercise 11a

| 1 | 0.025 moles | 19 | 0.079 g |

| 2 | 0.025 moles | 20 | 0.828 g |

| 3 | 0.0625 moles | 21 | 0.1 mol dm⁻³ |

| 4 | 0.005 moles | 22 | 1.0 mol dm⁻³ |

| 5 | 0.025 moles | 23 | 0.03 mol dm⁻³ |

| 6 | 0.025 moles | 24 | 0.1 mol dm⁻³ |

| 7 | 0.0125 moles | 25 | 0.03 mol dm⁻³ |

| 8 | 0.01 moles | 26 | 0.04 mol dm⁻³ |

| 9 | 0.00125 moles | 27 | 0.40 mol dm⁻³ |

| 10 | 0.005 moles | 28 | 0.40 mol dm⁻³ |

| 11 | 0.9125 g | 29 | 0.152 mol dm⁻³ |

| 12 | 1.463 g | 30 | 0.0102 mol dm⁻³ |

| 13 | 2 g | 31 | 0.01 mol dm⁻³ |

| 14 | 1.70 g | 32 | 0.2 mol dm⁻³ |

| 15 | 5.2 g | 33 | 0.02 mol dm⁻³ |

| 16 | 0.98 g | 34 | 0.005 mol dm⁻³ |

| 17 | 0.08 g | 35 | 0.417 mol dm⁻³ |

| 18 | 0.97 g | | |

Exercise 11b

| 1 | 0.168 mol dm⁻³ | 16 | 3.0 |

| 2 | 0.136 mol dm⁻³ | 17 | 0.02 mol dm⁻³ |

| 3 | 0.118 mol dm⁻³ | 18 | 50 cm³ |

| 4 | 1.0 mol dm⁻³ | 19 | 50 cm³ |

| 5 | 0.12 mol dm⁻³ | 20 | 25 cm³ |

| 6 | 0.040 mol dm⁻³ | 21 | 0.359 g |

| 7 | 0.0080 mol dm⁻³ | 22 | 1.0 g |

| 8 | 0.010 mol dm⁻³ | 23 | 240 cm³ |

| 9 | 0.10 mol dm⁻³ | 24 | 0.12 g Mg, 120 cm³ H₂ |

| 10 | 0.40 mol dm⁻³ | 25 | 480 cm³ |

| 11 | 0.050 mol dm⁻³ | |

| 12 | 0.167 mol dm⁻³ | |

| 13 | 2.26 g dm⁻³ | |

| 14 | 0.099 mol dm⁻³ | |

| 15 | 1.755 g dm⁻³ | |

Table of Relative Atomic Masses Extracted from the Document

Element	Symbol	Ar	Element	Symbol	Ar	Element	Symbol	Ar
Hydrogen	H	1	Sodium	Na	23	Iron	Fe	55.8*
Carbon	C	12	Magnesium	Mg	24	Copper	Cu	63.5
Nitrogen	N	14	Aluminium	Al	27	Zinc	Zn	65.4*
Oxygen	O	16	Silicon	Si	28	Silver	Ag	108*
Fluorine	F	19*	Phosphorus	P	31	Iodine	I	127*
Chlorine	Cl	35.5	Sulphur	S	32	Cesium	Cs	133*
Potassium	K	39	Calcium	Ca	40	Barium	Ba	137*
Cobalt	Co	59*	Manganese	Mn	55*	Lead	Pb	207

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