4.2 The Mole Concept

Set 1

1. (a) 55.85 g
   (b) 58.93 g
   (c) $2 \times 35.45 = 70.90$ g
   (d) 35.45 g
   (e) $14.01 + 2 \times 16.00 = 46.01$ g
   (f) $2 \times 30.97 + 5 \times 16 = 141.94$ g
   (g) $24.31 + 12.01 + 48 = 84.32$ g
2. (a) 2.0 mol
   (b) 1.52 mol
   (c) 0.03 mol
   (d) 0.50 mol
   (e) 1.00×10^6 mol
3. (a) 16.03 g
   (b) 96.14 g
   (c) 245.2 g
   (d) 121.6 g
   (e) 370.48 g
4. (a) 1.41×10^{25} atoms
   (b) 2.71×10^{23} ions
   (c) 5.42×10^{25} ions
   (d) 1.31×10^{25} molecules
   (e) 2.63×10^{25} atoms
5. (a) 0.6 mol
   (b) 0.6 mol
   (c) 4.65×10^6 mol
   (d) 1.16×10^{-8} mol
   (e) 9.30×10^{-7} mol

Set 2

6. (a) $4Li_{(s)} + O_{2(g)} \rightarrow 2Li_2O_{(s)}$
   (b) 0.72 mol
   (c) 0.36 mol
   (d) 10.76 g
7. (a) (i) 6.43 g FeO
   $2Fe_{(s)} + O_{2(g)} \rightarrow 2FeO_{(s)}$
   (ii) 9.45 g Al_2O_3
   $4Al_{(s)} + 3O_{2(g)} \rightarrow 2Al_2O_{3(s)}$
   (b) Different metals combine with oxygen in different ratios depending on their valencies, so the same mass of each metal will produce different masses of their oxides.
8. (a) (i) 130.78 mol
   (ii) 130.78 mol
   (iii) 8.31 kg
   (b) 7.90 kg
   (c) 326.94 mol
9. (a) $Zn_{(s)} + H_2SO_{4(aq)} \rightarrow ZnSO_{4(aq)} + H_{2(g)}$
   (b) (i) 0.05 mol
   (ii) 0.05 mol
   (iii) 7.90 g
10. (a) $Mg_{(s)} + H_2SO_{4(aq)} \rightarrow MgSO_{4(aq)} + H_{2(g)}$
    241.17 g
    (b) $2HgO_{(s)} \rightarrow 2Hg + O_{2(g)}$
    7.50 g

Set 3

11. (a) $BaCl_{2(aq)} + Na_2SO_{4(aq)} \rightarrow BaSO_{4(s)} + 2NaCl_{(aq)}$
    (b) (i) 3.97 g
    (ii) 6.52 g
12. (a) 2.5 mol
    (b) 5 mol
    (c) 10.08 g
    (d) 90.08 g
    (e) 30.11×10^{23} molecules
13. (a) A reactant that is completely used up in a chemical reaction.
    (b) $Ca_{(s)} + 2H_2O_{(l)} \rightarrow Ca(OH)_2 + H_{2(g)}$
    (c) (i) water
    (ii) no limiting reagent
    (iii) calcium
    (iv) calcium
14. (a) $4P_{(s)} + 5O_{2(g)} \rightarrow 2P_2O_{5(s)}$
    (b) (i) oxygen
    (ii) phosphorus
    (c) 2.84 g
    (d) Poisonous. Wear gloves, lab coat and goggles when handling phosphorus. Use fume cupboard. Avoid breathing vapour.
15. (a) A mole is the number of atoms present in exactly 12 g of the isotope carbon-12. There are 6.022×10^{23} atoms, and this number is called Avogadro's number.
    (b) (i) 154.04 g
    (ii) 2.11×10^{24} molecules
    (iii) 4.22×10^{25} atoms

4.3 Gases and Moles

Set 1

1. (a) (i) The volume occupied by 1 mole of a gas at a particular temperature and pressure.
   (ii) A pressure of 100 kPa and a temperature of 25°C.
   (b) 24.79 L
   (c) (i) Equal volumes of all gases, measured at the same temperature and pressure, contain equal numbers of particles.
   (ii) The ratio of the volumes of gases involved in a chemical reaction can be expressed as simple whole numbers.
2. (a) 2.02 mol
   (b) 2.2 mol
   (c) 2.02 mol
   (d) 2.2 mol
3. (a) (i) 2271 L (ii) 2479 L
   (b) (i) 2271 L (ii) 2479 L
   (c) (i) 61.32 L (ii) 66.93 L
   (d) (i) 61.32 L (ii) 66.93 L
4. (a) $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$
   (b) (i) 3 L (ii) 2 L
   (c) 0.04 mol
   (d) 1.13 g
5. (a) $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$
   (b) Hydrogen (i) 9 L (ii) 5 L
   Oxygen (i) 3 L (ii) 1 L
   Water (i) 0 L (ii) 4 L

Set 2

6. (a) $C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)}$
   (b) 10 mL of propane reacted with 50 mL of oxygen to produce 30 mL of carbon dioxide and 40 mL of water vapour. This shows a ratio of reactants and products as 1:5:3:4, which is the same numbers as used to balance the equation.
7. (a) $C_xH_y + 2O_{2(g)} \rightarrow xCO_{2(g)} + y/2H_2O_{(l)}$
   (b) CH_4
8. (a) 0.04 mol
   (b) 0.04 mol — both gases occupy the same volume at the same temperature and pressure so contain the same number of moles.
   (c) (i) 72.5 g
   (ii) chlorine (exists as diatomic molecules)
9. (a) 52.92%
   (b) 81.71%
   (c) 40.10%
10. (a) 88.82%
    (b) 34.63%
    (c) 57.48%

Set 3

11. (a) H — 2.76% Cl — 97.24%
    (b) Ca — 71.47% O — 28.53%
12. (a) (i) 3 mol (ii) 73.37 L (iii) 96 g
    (b) This statement would only be correct if both substances were gases; $KClO_3$ is a solid.
13.

Table A16

Compound	Empirical	Molecular
2-pentene	CH_2	C_5H_{10}
Hexane	C_3H_7	C_6H_{14}
Glucose	CH_2O	$C_6H_{12}O_6$

14. (a) SiH_4
    (b) Cu_2S
    (c) $CaCO_3$
    (d) Mn_2O_7
15. (a) NH_2 (b) N_2H_4

Exam-style Questions

Part A Multiple-choice questions

1. B; 2. C; 3. D; 4. D; 5. D

Part B Short-answer and longer-response questions

6. (a) Electrical conductivity is high for metals, as they have mobile delocalised electrons. These are found on the left side of the periodic table. It is low for non-metals which are found on the right side of the table.
   (b) If we ignore Group VIII, electronegativity is highest at the top right corner of the periodic table, where atoms have high electron attracting power. Electronegativity decreases as you go down the table and across from right to left. It is lowest at the bottom left corner of the table. Atoms of electrons found here have difficulty attracting electrons.
7. (a) Electronegativity is the ability of atoms of an element to attract 1 or more electrons.
   (b) (i) Li; (ii) Cl; (iii) Fr
   (c) K and Br. These are further apart in the periodic table, so will have a greater difference in electronegativity and thus the compound they form will be more ionic.
   (d) Electronegativity decreases.
   (e) The outer shell is further from the positive nucleus, so electrons will be less strongly attracted.
8. (a) First ionisation energy is the energy needed to pull the first electron from the outermost orbit of a gaseous atom.
   (b) $Na_{(g)} \rightarrow Na^+ + e$
   (c) Group VIII
   (d) (i) Na to Ar
   (ii) increases
   (iii) As you go across the periodic table the number of protons increases. These are positively charged so the positive charge on the nucleus increases. This higher positive charge attracts electrons more strongly, so they are harder to remove.
9. (a) Number of atoms present in 12 g of the isotope carbon-12.
   (b) (i) 8.87×10^{-4} mol
   (ii) 6.09×10^{-12} mol
10. (a) $2Al_2O_{3(s)} \rightarrow 4Al_{(s)} + 3O_{2(g)}$
    (b) 53% aluminium 47% oxygen
11. (a) 46.66%
    (b) Ammonium sulfate is best as it contains the lowest nitrogen content.
12. (a) Gay Lussac developed the law of combining gas volumes which states that the ratio of the volumes of gases involved in a chemical reaction can be expressed as simple whole numbers.
    (b) The whole number ratios of gas volumes are the same as the mole ratios in a reaction.
    (c) 0.75 mol
13. (a) Equal volumes of all gases, measured under the same conditions of temperature and pressure, contain equal numbers of particles.
    (b) He showed that volumes of gases vary in the same proportion as the number of moles.