

SCH 3UI: Chapter 4 Test-The Mole, Percent Composition, Empirical  
Formula and Molecular Formula

/48 marks

Part A: Each answer is worth 1 mark. Express all answers to 3 significant  
digits, except where molar mass is calculated.

(Assign each member of the group a number from 1-4; 1-G, 2-R, 3-A, 4-S, all  
final S)

/8 marks

1. Calculate the molar mass of calcium phosphate?  $\text{Ca}_3(\text{PO}_4)_2$   
 $= 310.18 \text{ g/mol}$
2. Calculate the number of atoms in 4.03 moles of  $\text{NH}_3$   
 $N = n \times N_A$   
 $= 2.43 \times 10^{24} \times 4 = 9.704 \times 10^{24} \text{ atoms}$
3. Calculate the number of moles in  $2.03 \times 10^{22}$  molecules of water.  
 $n = N \div N_A$   
 $= 3.37 \times 10^{-2} \text{ mol}$
4. Calculate the mass of 2.05 moles of sodium hydroxide.  $M_{\text{NaOH}} = 40.00 \text{ g/mol}$   
 $m = n \times M$   
 $= 82.00 \text{ g}$
5. Calculate the number of moles in 6.73g of  $\text{Ca}(\text{NO}_3)_2$ .  $M_{\text{Ca}(\text{NO}_3)_2} = 164.1 \text{ g/mol}$   
 $n = m \div M$   
 $= 4.10 \text{ mol} \times 10^{-2}$
6. Calculate the number of atoms in 2.65g of  $\text{AlPO}_4$ .  $M_{\text{AlPO}_4} = 121.95 \text{ g/mol}$   
 $N = (m \div M) \times N_A$   
 $= 1.31 \times 10^{22} \times 6 = 7.85 \times 10^{22} \text{ atoms}$
7. Calculate the number of moles in a 1kg box of NaCl.  $M_{\text{NaCl}} = 58.44 \text{ g/mol}$   
 $n = m \div M$   
 $= 17.1 \text{ mol} \text{ (20 mol)}$
8. Calculate the percentage composition by mass of carbon dioxide.  
 $M_{\text{CO}_2} = 44.01 \text{ g/mol}$

$$\% \text{C} = \frac{12.01}{44.01} = 27.3$$

$$\% \text{O} = \frac{32.00}{44.01} = 72.7$$

Part B: Longer Answer. Continue with assigned numbers and the GRASS method. In this section, each portion is worth 3 marks.

/9 marks

1. Vanillin is the compound responsible for the vanilla flavour. Analysis shows the compound consists of 63.2% C, 5.26% H and 31.6% O by mass. Determine the empirical formula of vanillin.

$$\begin{array}{lll} m_C = 63.2g & n_C = 5.26 & n_C : n_H : n_O \\ m_H = 5.26g & n_H = 5.21 & 2.66 : 2.66 : 1 \\ m_O = 31.6g & n_O = 1.975 & \boxed{C_8H_8O_3} \end{array}$$

2. The artificial sweetener saccharin has the formula  $C_7H_5NO_3S$ . Determine the percentage composition by mass of saccharin.

$$M_{C_7H_5NO_3S} = 183.19 \text{ g/mol}$$

$$\%C = 45.9$$

$$\%O = 26.2$$

$$\%H = 2.8$$

$$\%S = 17.5$$

$$\%N = 7.6$$

3. A 3.0g sample of a compound with a molar mass of 180 g/mol consists of 1.2g C, 0.2g H and 1.6g O. Determine the molecular formula of the compound.

$$n = m \div M$$

$$M = 180 \text{ g/mol}$$

$$m_{\text{in comp}}$$

$$n = m \div M$$

$$\%C = \frac{1.2g}{3.0g} \times 100 = 40 \quad m_C = \frac{40}{100} \times 180 = 72.0g \quad \div 12.01 = 6$$

$$\%H = \frac{0.2g}{3.0g} \times 100 = 6.7 \quad m_H = \frac{6.7}{100} \times 180 = 12.06g \quad \div 1.01 = 12$$

$$\%O = \frac{1.6g}{3.0g} \times 100 = 53.3 \quad m_O = \frac{53.3}{100} \times 180 = 95.94 \quad \div 16 = 6$$

