Activity 3E: Percentage composition, empirical and molecular formulae Ans p. 11

1. What is the percentage composition of each element in potassium nitrate, KNO_3?

2. **a.** Find the percentage of carbon in acetylene, C_2H_2.

b. Calculate the percentage, by weight, of magnesium in magnesium chloride.

3. Find the empirical formulae of the substances with the following percentage compositions:

a. 80% copper, 20% oxygen

b. 53% aluminium, 47% oxygen

c. 1.6% hydrogen, 22.2% nitrogen, 76.2% oxygen

4. **a.** Calculate the empirical formula of the oxide of sulfur which is 40% sulfur by weight.

b. A hydrocarbon contains 90% carbon. Calculate the empirical formula of the hydrocarbon.

5. **a.** An oxide of silicon was produced from 0.28 g of silicon. The mass of the oxide was 0.60 g.

Calculate the empirical formula of the oxide.

b. 10.2 g of vanadium is combined with 21.3 g of chlorine to make vanadium chloride.

Calculate the empirical formula of the vanadium chloride.

6. **a.** The empirical formula of a substance is CH_2. Its molar mass is 84 g mol^{-1}. Find the molecular formula of the substance.

b. A hydrocarbon contains 82.7% carbon and 17.3% hydrogen by weight.

i. Work out the empirical formula.

ii. The molar mass of the compound is 58 g mol^{-1}. What is its molecular formula?

c. A gaseous hydrocarbon was found to contain 80% carbon and 20% hydrogen by mass.

The hydrocarbon was found to have a molar mass of 30 g mol^{-1}. Use this value to work out the molecular formula of the hydrocarbon.

ESA PUBLICATIONS ISBN 978-0-947504-92-2

Activity 3E: Percentage composition, empirical and molecular formulae (page 10)

1. $M(KNO_3) = 101.1 \text{ g mol}^{-1}$

$$\% \text{ K} = \frac{39.1}{101.1} \times 100 = 38.7\%$$

$$\% \text{ N} = \frac{14.0}{101.1} \times 100 = 13.9\%$$

$$\% \text{ O} = \frac{3 \times 16.0}{101.1} \times 100 = 47.5\%$$

2. a. $M(C_2H_2) = 26 \text{ g mol}^{-1}$

$$\% \text{ C} = \frac{2 \times 12}{26} \times 100 = 92.3\%$$

b. $M(MgCl_2) = 95.3 \text{ g mol}^{-1}$

$$\% \text{ Mg} = \frac{24.3}{95.3} \times 100 = 25.5\%$$

3. a. $n(\text{Cu}) = \frac{80}{63.6} = 1.26$

$n(\text{O}) = \frac{20}{16.0} = 1.25$

Ratio Cu : O = $1.26 : 1.25 = \frac{1.26}{1.25} : \frac{1.25}{1.25} = 1 : 1$, i.e. CuO

b. $n(\text{Al}) = \frac{53}{27.0} = 1.96$

$n(\text{O}) = \frac{47}{16.0} = 2.94$

Al : O = $1.96 : 2.94 = \frac{1.96}{1.96} : \frac{2.94}{1.96} = 1 : 1.5 = 2 : 3$, i.e. Al_2O_3

c. $n(\text{H}) = \frac{1.6}{1.0} = 1.6$

$n(\text{N}) = \frac{22.2}{14.0} = 1.59$

$n(\text{O}) = \frac{76.2}{16.0} = 4.76$

H : N : O = $1.6 : 1.59 : 4.76 = \frac{1.6}{1.59} : \frac{1.59}{1.59} : \frac{4.76}{1.59} = 1 : 1 : 3$, i.e. HNO_3

4. a. $n(\text{S}) = \frac{40}{32.1} = 1.25 \text{ mol}$

$n(\text{O}) = \frac{60}{16.0} = 3.75 \text{ mol}$

$n(\text{S}) : n(\text{O}) = 1 : 3$, i.e. SO_3

b. $n(\text{C}) = \frac{90}{12.0} = 7.5$

$n(\text{H}) = \frac{10}{1} = 10.0$

$n(\text{C}) : n(\text{H}) = 7.5 : 10 = \frac{7.5}{7.5} : \frac{10.00}{7.5} = 1 : 1.33 = 1 : \frac{4}{3} = 3 : 4$, i.e. C_3H_4

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5. a. $(\text{Si}) = \dfrac{0.28\text{ g}}{28.1\text{ g mol}^{-1}} = 0.00996\text{ mol}$

$m(\text{O}) = 0.60\text{ g} - 0.28\text{ g} = 0.32\text{ g}$

$n(\text{O}) = \dfrac{0.32\text{ g}}{16.0\text{ g mol}^{-1}} = 0.02\text{ mol}$

$n(\text{Si}) : n(\text{O}) = 1 : 2$, i.e. SiO_2

b. $n(\text{V}) = \dfrac{10.2\text{ g}}{50.9\text{ g mol}^{-1}} = 0.200\text{ mol}$

$n(\text{Cl}) = \dfrac{21.3\text{ g}}{35.5\text{ g mol}^{-1}} = 0.600\text{ mol}$

$n(\text{V}) : n(\text{Cl}) = 1 : 3$, i.e. VCl_3

6. a. $M(CH_2) = 14\text{ g mol}^{-1}$ $M(\text{compound}) = 84\text{ g mol}^{-1}$

$\dfrac{M(\text{compound})}{M(CH_2)} = \dfrac{84}{14} = 6$

Molecular formula $= 6(CH_2) = C_6H_{12}$

b. i. $n(\text{C}) = \dfrac{82.7}{12.0} = 6.89$ $n(\text{H}) = \dfrac{17.3}{1.0} = 17.3$

$n(\text{C}) : n(\text{H}) = 1 : 2.5 = 2 : 5$

EF $= C_2H_5$ $M(C_2H_5) = 29\text{ g mol}^{-1}$

ii. $M(\text{compound}) = 58\text{ g mol}^{-1}$

molecular formula $= 2(C_2H_5) = C_4H_{10}$

c. $n(\text{C}) = \dfrac{80}{12.0} = 6.67$ $n(\text{H}) = \dfrac{20}{1.0} = 20$

$n(\text{C}) : n(\text{H}) = 1 : 3$ EF $= CH_3$

RESOURCES

ESA PUBLICATIONS *ISBN 978-0-947504-92-2*