Quiz 3.4 – Empirical Analysis

Name: Key

Question 1 (2 point)

Give the percent composition for all elements in the following compounds:

- NO_2 $M = 46.01\ g/mol$

$\%N = \frac{1 \cdot 14.01\ g/mol}{46.01\ g/mol} \cdot 100\% = 30.45\%$ $\%O = \frac{2 \cdot 16.00\ g/mol}{46.01\ g/mol} \cdot 100\% = 69.55\%$

- C_2H_5Cl

$M = 64.51\ g/mol$

$\%C = \frac{2 \cdot 12.01\ g/mol}{64.51\ g/mol} \cdot 100\% = 37.23\%$ $\%H = \frac{5 \cdot 1.01\ g/mol}{64.51\ g/mol} \cdot 100\% = 7.83\%$

$\%Cl = \frac{1 \cdot 35.45\ g/mol}{64.51\ g/mol} \cdot 100\% = 54.95\%$

Question 2 (2 points)

Give the empirical formula for compounds with the following compositions:

- 82.66% C and 17.34% H

$\frac{82.66\ g\ C}{12.01\ g\ C} \left| \frac{1\ mol\ C}{} \right. = \frac{6.883\ mol\ C}{6.883} \rightarrow 1C$ $\cdot 2$

$\frac{17.34\ g\ H}{1.01\ g\ H} \left| \frac{1\ mol\ H}{} \right. = \frac{17.17\ mol\ H}{6.883} \rightarrow 2.495H$ $\cdot 2$

C_2H_5

- 62.04% C, 10.41% H, and 27.55% O

$\frac{62.04\ g\ C}{12.01\ g\ C} \left| \frac{1\ mol\ C}{} \right. = \frac{5.166\ mol\ C}{1.722} \rightarrow 3C$

$\frac{10.41\ g\ H}{1.01\ g\ H} \left| \frac{1\ mol\ H}{} \right. = \frac{10.3\ mol\ H}{1.722} \rightarrow 6H$

$\frac{27.55\ g\ O}{16.00\ g\ O} \left| \frac{1\ mol\ O}{} \right. = \frac{1.722\ mol\ O}{1.722} \rightarrow 1O$

C_3H_6O

Question 3 (1 point)

What are the molecular formulas for the compounds in Question 2 if their molecular weights are:

- 58.12 g/mol $M_{EF} = 29.06\ g/mol$, so $58.12\ g/mol \rightarrow C_2H_{10}$

- 116.16 g/mol $M_{EF} = 58.08\ g/mol$ $\frac{116.16}{58.08} = 2$, so $C_6H_{12}O_2$

Question 5 (2 points)

1.25 *g* of an unknown are combusted in excess O_2 to produce 4.28 *g* of CO_2 and 0.730 *g* of H_2O. A separate analysis gave the compound's molar mass as 154.211 *g/mol*

Give the empirical and molecular formulas for the unknown substance

$4.28\,g\ CO_2 \left|\frac{1\ mol\ CO_2}{44.01\,g\ CO_2}\right|\frac{1\ mol\ C}{1\ mol\ CO_2} = \frac{0.09725\ mol\ C}{0.08102} \cdot 12.011\ g/mol = 1.168\,g\ C$

$\rightarrow 1.200 = \frac{6}{5} \cdot 5 = 6$

$1.25\,g - 1.168\,g - 0.08167\,g = \emptyset$ (within error)

$0.730\,g\ H_2O \left|\frac{1\ mol\ H_2O}{18.02\,g\ H_2O}\right|\frac{2\ mol\ H}{1\ mol\ H_2O} = \frac{0.08102\ mol\ H}{0.08102} \cdot 1.008\ g/mol = 0.08167\,g\ H$

$\rightarrow 1 = \frac{5}{5} \cdot 5 = 5$

Empirical: C_6H_5 ← $M = 77\ g/mol$ $\quad \frac{154\ g/mol}{77\ g/mol} = 2$ $\quad$ Molecular: $C_{12}H_{10}$

Question 6 (3 points)

2.75 *g* of an unknown are combusted in excess O_2 to produce 3.94 *g* of CO_2 and 2.15 *g* of H_2O. A separate analysis gave the compound's molar mass as 92.095 *g/mol*

Give the empirical and molecular formulas for the unknown substance

$3.97\,g\ CO_2 \left|\frac{1\ mol\ CO_2}{44.01\,g\ CO_2}\right|\frac{1\ mol\ C}{1\ mol\ CO_2} = \frac{0.08953\ mol\ C}{0.08953} \cdot 12.011\ g/mol = 1.075\,g\ C$

$\rightarrow 1 \approx \frac{3}{3} \cdot 3 = 3$

$2.75\,g - 1.075\,g - 0.2405\,g = 1.434\,g\ O$

$2.15\,g\ H_2O \left|\frac{1\ mol\ H_2O}{18.02\,g\ H_2O}\right|\frac{2\ mol\ H}{1\ mol\ H_2O} = \frac{0.2386\ mol\ H}{0.08953} \cdot 1.008\ g/mol = 0.2405\,g\ H$

$\rightarrow 2.665 \approx \frac{8}{3} \cdot 3 = 8$

$1.434\,g\ O \left|\frac{1\ mol\ O}{16.00\,g\ O}\right. = \frac{0.08964\ mol\ O}{0.08953}$

$\rightarrow 1.001 \approx \frac{3}{3} \cdot 3 = 3$

Empirical = $C_3H_8O_3$ ← $92\ g/mol$ $\quad$ Molecular = $C_3H_8O_3$