ch. 3.3 & 3.5 % composition & empirical formula

empirical formula

is the chemical formula using the lowest ratio of integers of subscripts

ex

CF	EF
H_2O_2	HO
$C_6H_{12}O_6$	CH_2O
H_2O	H_2O

note: $CF = (EF)_n$, n integer

ex if $EF = CH_2O$

& molar mass of cpd = 120 g/mol

then CF ?

as $CF = (EF)_n$

molar mass of CF = molar mass of EF * n

$$n = \frac{\text{molar mass of CF}}{\text{molar mass of EF}}$$

$$= \frac{120 \text{ g/mol}}{30 \text{ g/mol}} = 4$$

i.e. $CF = (CH_2O)_4 = C_4H_8O_4$

? Can:

EF ← mole ratio of atoms in the cpd ← # mol of atoms in the cpd ← # g of atoms in the cpd

problems

① cpd has 3 g C, 1 g H, 4 g O; EF?

i) $3\ \text{g C} \times \frac{1\ \text{mol C}}{12\ \text{g C}} = 0.25\ \text{mol C}$

$1\ \text{g H} \times \frac{1\ \text{mol H}}{1\ \text{g H}} = 1\ \text{mol H}$

$4\ \text{g O} \times \frac{1\ \text{mol O}}{16\ \text{g O}} = 0.25\ \text{mol O}$

ii) C : H : O

0.25 : 1 : 0.25

1 : 4 : 1

iii) ∴ EF = CH_4O

② cpd has 9 mg C, 1.5 mg H, & 8 mg O; EF?

i) $9\ \text{mg C} \times \frac{1\ \text{g}}{10^3\ \text{mg}} \times \frac{1\ \text{mol C}}{12\ \text{g C}} \times \frac{10^3\ \text{mmol}}{1\ \text{mol}} = 0.75\ \text{mmol C}$

$1.5\ \text{mg H} \times \frac{1\ \text{g}}{10^3\ \text{mg}} \times \frac{1\ \text{mol H}}{1\ \text{g H}} \times \frac{10^3\ \text{mmol}}{\text{mol}} = 1.5\ \text{mmol H}$

$8\ \text{mg O} \times \frac{1\ \text{g}}{10^3\ \text{mg}} \times \frac{1\ \text{mol O}}{16\ \text{g O}} \times \frac{10^3\ \text{mmol}}{1\ \text{mol}} = 0.5\ \text{mmol O}$

ii) C : H : O

0.75 mmol : 1.5 mmol : 0.5 mmol

1.5 : 3 : 1

3 : 6 : 2

iii) EF = $C_3H_6O_2$

background: % composition by mass

% X in Y = $\frac{\# g \ X \text{ in } Y}{\# g \ Y}$

eg % C in CO_2 = $\frac{\# g \ C \text{ in } CO_2}{\# g \ CO_2}$

assume have a 1 mol sample of CO_2

→ has 1 mol C in 1 mol CO_2

→ = $\frac{12}{44}$ = 27.3%

(3) cpd has 52.8% Cl & 47.2% Cu; EF?

i) assume 100 g sample cpd

52.8 g Cl $\frac{1 \text{ mol Cl}}{35.5 \text{ g Cl}}$ = 1.487 mol Cl

47.2 g Cu $\frac{1 \text{ mol Cu}}{63.5 \text{ g Cu}}$ = 0.7433 mol Cu

ii) Cu : Cl

0.7433 : 1.487

1 : 2

iii) EF = $CuCl_2$

(4) H_xC_y + O_2 → CO_2 + H_2O ; EF of cpd?

1.0 g, excess, 2.75 g, 2.25 g

↑ i.e. consume all of the hydrocarbon

note: # g C in cpd = # g C in CO_2

g H in cpd = # g H in H_2O

i) % C in CO_2 = $\frac{\# g \ C \text{ in } CO_2}{\# g \ CO_2}$ = $\frac{12}{44}$ = $\frac{\# g \ C \text{ in } CO_2}{2.75 \text{ g}}$

g C in CO_2 = 0.75 g C

ii) # g cpd = # g C in cpd + # g H in cpd

1 g = 0.75 g + # g H in cpd

g H in cpd = 0.25 g

iii) $0.25\ g\ H \times \frac{1\ mol\ H}{1\ g\ H} = 0.25\ mol\ H$

$0.75\ g\ C \times \frac{1\ mol\ C}{12\ g\ C} = 0.0625\ mol\ C$

iv) C : H

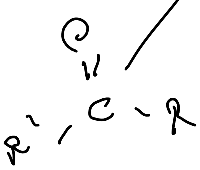
0.0625 : 0.25

1 : 4

v) EF = CH_4

(5) ketone + O_2 → CO_2 + H_2O ; EF of cpd?

1g, excess, 2.276g, 0.931g



.... EF = C_3H_6O