CHEM 103
R&R 3
3 June 2024
Adapted from a 7 June 2021 document

1. When the following elements or compounds are present in ionic compounds, what will their charge be? Write the symbol and charge, e.g. Chlorine: Cl⁻

    a. Nitrogen: N^{3-}

    b. Oxygen: O^{2-}

    c. Bromine: Br^{-}

    d. Magnesium: Mg^{2+}

    e. Rubidium: Rb^{+}

    f. Silver: Ag^{+}

    g. Nitrite: NO_2^{-}

    h. Phosphate: PO_4^{3-}

    i. Ammonium: NH_4^{+}

2. Balance the following ionic compounds:

    Na $\underline{1}$ NO₂   Be(ClO) $\underline{2}$

    Mg₃(PO₄) $\underline{2}$ Li(OH) $\underline{1}$ Na $\underline{2}$ (HPO₄)

3. Mercury forms a compound with chlorine that is 73.9% mercury and 26.1% chlorine by mass. What is the empirical formula?

For simplicity, consider 100. g compound. ⟹ 73.9g Hg, 26.1g Cl present.

$$73.9 \text{ g Hg} \cdot \frac{\text{mol Hg}}{200.59 \text{ g Hg}} = 0.368 \text{ mol Hg}$$

$$26.1 \text{ g Cl} \cdot \frac{\text{mol Cl}}{35.453 \text{ g Cl}} = 0.736 \text{ mol Cl}$$

1:2 ratio

emp. form. is $HgCl_2$

4. Complete combustion of a 20.10 g sample of naphthalene in oxygen yields 69.00 g CO_2 and 11.30 g H_2O. Determine the empirical formula of naphthalene.

$C: 12.01 \frac{g}{mol}$ $H: 1.008 \frac{g}{mol}$ $O: 16.00 \frac{g}{mol}$

$CO_2: 44.01 \ g/mol$ $H_2O: 18.02 \ g/mol$

$69.00 \ g \ CO_2 \cdot \frac{mol \ CO_2}{44.01 \ g \ CO_2} \cdot \frac{mol \ C}{mol \ CO_2} = 1.568 \ mol \ C \iff 18.83g$

$11.30 \ g \ H_2O \cdot \frac{mol \ H_2O}{18.02 \ g \ H_2O} \cdot \frac{2 \ mol \ H}{mol \ H_2O} = 1.254 \ mol \ H \iff 1.264g$

the full 20.10g! naphthalene contains no O.

$\boxed{emp. \ form. \quad is \quad C_5H_4}$

5. Isoprene is a compound that can be polymerized to form synthetic rubber. It is composed (by mass) of 88.17% carbon and 11.83% hydrogen. Its molar mass is 136.10 g mol⁻¹. What are the empirical and molecular formulae for isoprene?

Consider 100.0 g isoprene.

$88.17 \ g \ C \cdot \frac{mol \ C}{12.01 \ g \ C} = 7.341 \ mol \ C$

$11.83 \ g \ H \cdot \frac{mol \ H}{1.008 \ g \ H} = 11.74 \ mol \ H$

$\Big] \ 1:1.6 \ ratio$

$\boxed{\begin{array}{l} emp. \ form. \quad is \quad C_5H_8 \\ molecular \ formula \ is \ C_{10}H_{16} \end{array}}$

$\leftarrow 68.11 \frac{g}{mol} = \frac{1}{2} \ molar \ mass$

6. A large family of boron-hydrogen compounds has the general formula B_xH_y. One member of this family contains 88.5% boron by mass; the remainder is hydrogen. What is its empirical formula?

Consider 100. g compound.

$88.5 \text{ g } B \cdot \dfrac{\text{mol } B}{10.811 \text{ g } B} = 8.19 \text{ mol } B$ ⎤
                                                                    ⎥ 1 : 1.4 ratio
$11.5 \text{ g } H \cdot \dfrac{\text{mol } H}{1.008 \text{ g } H} = 11.4 \text{ mol } H$ ⎦

emp. form. is B_5H_7

7. Valproic acid, which is used to treat seizures and bipolar disorder, is composed only of C, H, and O. A 0.165 g sample is combusted, yielding 0.166 g H_2O and 0.403 g CO_2. The molar mass of valproic acid is 144 g/mol. What are the empirical and molecular formulae?

General combustion reaction: $C_xH_yO_z + O_2 \rightarrow CO_2 + H_2O$

We know all the C in the CO_2 comes from valproic acid. Same logic for H in H_2O.

$0.403 \text{ g } CO_2 \cdot \dfrac{\text{mol } CO_2}{44.01 \text{ g } CO_2} \cdot \dfrac{\text{mol } C}{\text{mol } CO_2} = 0.009157 \text{ mol } C$ ⎤
                                                                                        ⎥ 4 : 8 : 1 ratio
$0.166 \text{ g } H_2O \cdot \dfrac{\text{mol } H_2O}{18.02 \text{ g } H_2O} \cdot \dfrac{2 \text{ mol } H}{\text{mol } H_2O} = 0.0184 \text{ mol } H$ ⎦

The C and H make up:

$(0.009157 \text{ mol})(12.01 \tfrac{g}{mol}) + (0.0184 \text{ mol})(1.008 \tfrac{g}{mol})$

$= 0.1265 \text{ g} \Rightarrow O$ comprises the remaining 0.0365 g.

$0.0365 \text{ g } O \cdot \dfrac{\text{mol } O}{16.00 \text{ g } O} = 0.00228 \text{ mol } O$

emp. form. is C_4H_8O ← $72.10 \frac{g}{mol} = \frac{1}{2}$ molar mass

molecular formula is $C_8H_{16}O_2$

CONFIRMATION:

Valproic acid structure: