

# Answer Key

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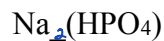
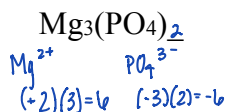
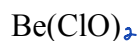
PLI Sheet #3

Monday, 7 June 2021

- When the following elements or compounds are present in ionic compounds, what will their charge be? Write the symbol and charge, e.g. Chlorine:  $\text{Cl}^-$

- Nitrogen:  $\text{N}^{3-}$
- Oxygen:  $\text{O}^{2-}$
- Bromine:  $\text{Br}^-$
- Magnesium:  $\text{Mg}^{2+}$
- Rubidium:  $\text{Rb}^+$
- Silver:  $\text{Ag}^+$
- Nitrite:  $\text{NO}_2^-$
- Phosphate:  $\text{PO}_4^{3-}$
- Ammonium:  $\text{NH}_4^+$

- Balance the following ionic compounds:



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

\* assume 100g of sample \*  $\text{Hg}_x\text{Cl}_y$

$$73.9 \text{ g Hg} \times \frac{1 \text{ mol Hg}}{200.59 \text{ g Hg}} = 0.368 \text{ mol Hg}$$

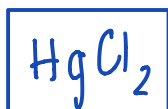
$$26.1 \text{ g Cl} \times \frac{1 \text{ mol Cl}}{35.45 \text{ g Cl}} = 0.736 \text{ mol Cl}$$

Now, divide by smallest mol value:

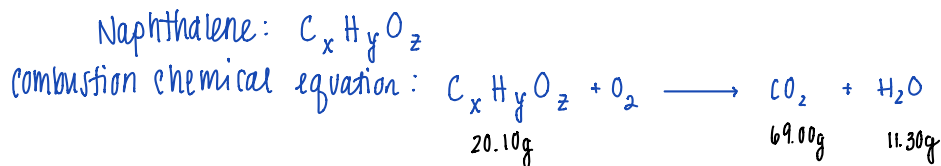
$$\text{Hg: } \frac{0.368 \text{ mol}}{0.368 \text{ mol}} = 1$$

$$\text{Cl: } \frac{0.736 \text{ mol}}{0.368 \text{ mol}} = 2.0006 = 2$$

∴



4. Complete combustion of a 20.10g sample of naphthalene in oxygen yields 69.00g of  $\text{CO}_2$  and 11.30g of  $\text{H}_2\text{O}$ . Determine the empirical formula of naphthalene. ✖ 3F



Because we are told this is a complete combustion, all of the carbon and hydrogen must come from naphthalene!

$$69.00\text{g CO}_2 \times \frac{1\text{ mol CO}_2}{44.01\text{g CO}_2} \times \frac{1\text{ mol C}}{1\text{ mol CO}_2} = 1.5678\text{ mol C}$$

$$11.30\text{g H}_2\text{O} \times \frac{1\text{ mol H}_2\text{O}}{18.02\text{g H}_2\text{O}} \times \frac{2\text{ mol H}}{1\text{ mol H}_2\text{O}} = 1.2541\text{ mol H}$$

Now let's determine the C:H ratio.

$$\text{H: } \frac{1.2541\text{ mol}}{1.2541\text{ mol}} = 1\text{ mol H} \quad \text{C: } \frac{1.5678\text{ mol}}{1.2541\text{ mol}} = 1.25 = \frac{5}{4} \rightarrow \text{roughly a } 1.25\text{C:1H ratio } (\times 4) \rightarrow 5\text{C:4H}$$

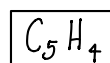
What about oxygen?

$$1.5678\text{ mol C} \times \frac{12.01\text{g C}}{1\text{ mol C}} = 18.83\text{g C}$$

$$1.2541\text{ mol H} \times \frac{1.01\text{g H}}{1\text{ mol H}} = 1.263\text{g H}$$

$$\Rightarrow 18.83\text{g} + 1.263\text{g} = 20.093\text{g} \rightarrow 20.10\text{g} \checkmark$$

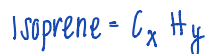
Since we started with a 20.10g sample of naphthalene, we can determine that there is no oxygen in naphthalene!



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 136.10g/mol. What are the empirical and molecular formulae for isoprene?

trick: determine what the number greater than 1 is equal to in fraction form. Multiple by denominator to get whole numbers for ratio!

\*assume 100g of sample\*



$$88.17\text{g C} \times \frac{1\text{ mol C}}{12.01\text{g C}} = 7.341\text{ mol C}$$

$$11.83\text{g H} \times \frac{1\text{ mol H}}{1.01\text{g H}} = 11.71\text{ mol H}$$

Establish ratio!

$$\text{C: } \frac{7.341\text{ mol}}{7.341\text{ mol}} = 1$$

$$\text{H: } \frac{11.71\text{ mol}}{7.341\text{ mol}} = 1.59 \approx 1.6 = \frac{8}{5}$$

$$1.6\text{ H:1 C} \xrightarrow{(\times 5)} 8\text{ H:5 C} \quad \therefore \text{empirical formula } \text{C}_5\text{H}_8 \Rightarrow 1\text{ mol C}_5\text{H}_8 = 68.13\text{g}$$

$$\frac{136.10\text{g}}{68.13\text{g}} \approx 2$$

$$\therefore \text{molecular formula } \boxed{\text{C}_{10}\text{H}_{16}}$$

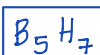
6. A large family of boron-hydrogen compounds has the general formula  $B_xH_y$ . One member of this family contains 88.5% boron (by mass); the remainder is hydrogen. What is its empirical formula?

\* assume 100g sample

$$\begin{array}{r} 100\text{g } B_xH_y \\ - 88.5\text{g B} \\ \hline 11.5\text{g H} \end{array}$$

$$\begin{aligned} 88.5\text{g B} \times \frac{1\text{ mol B}}{10.81\text{g B}} &= 0.187\text{ mol B} \\ 11.5\text{g H} \times \frac{1\text{ mol H}}{1.01\text{g H}} &= 11.39\text{ mol H} \end{aligned} \quad \left. \begin{array}{l} \text{Establish ratio!} \\ B: \frac{0.187\text{ mol}}{0.187\text{ mol}} = 1 \\ H: \frac{11.39\text{ mol}}{0.187\text{ mol}} \approx 1.4 = \frac{7}{5} \end{array} \right\}$$

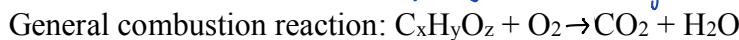
$$1B: 1.4H \xrightarrow{\times 5} 5B: 7H \therefore \text{empirical formula}$$



### CHALLENGE

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

$$0.165\text{g} \quad 0.403\text{g} \quad 0.166\text{g}$$



\* Very similar setup to #4, but now we know there is oxygen in valproic acid...

The carbon and hydrogen in the  $CO_2$  and  $H_2O$  must be derived from valproic acid.

The oxygen in the  $CO_2$  and  $H_2O$  (products) is derived from BOTH  $O_2$  and valproic acid

$$0.166\text{g } H_2O \times \frac{1\text{ mol } H_2O}{18.02\text{g } H_2O} \times \frac{2\text{ mol H}}{1\text{ mol } H_2O} = 0.0184\text{ mol H}$$

$$0.403\text{g } CO_2 \times \frac{1\text{ mol } CO_2}{44.01\text{g } CO_2} \times \frac{1\text{ mol C}}{1\text{ mol } CO_2} = 0.00916\text{ mol C}$$

0.165g of valproic acid is combusted

$$0.00916\text{ mol C} \times \frac{12.01\text{g C}}{1\text{ mol C}} = 0.11\text{g C}$$

$$0.0184\text{ mol H} \times \frac{1.01\text{g H}}{1\text{ mol H}} = 0.0186\text{g H}$$

Now, to determine The amount (in grams) of oxygen that came from valproic acid we subtract the masses of C and H from the sample mass!

$$0.165\text{g } C_xH_yO_z - (0.11\text{g C} + 0.0186\text{g H}) = 0.0364\text{g O}$$

now we can  
calculate  
moles O in  
valproic acid  
value

$$0.0364\text{g O} \times \frac{1\text{ mol O}}{16.00\text{g O}} = 0.00228\text{ mol O}$$

Establish integer ratio by dividing mol amounts by smallest mol

$$C: \frac{0.00916\text{ mol}}{0.00228\text{ mol}} \approx 4$$

$$H: \frac{0.0184\text{ mol}}{0.00228\text{ mol}} \approx 8$$

$$O: \frac{0.00228\text{ mol}}{0.00228\text{ mol}} = 1 \Rightarrow 4C: 8H: 1O \therefore \text{Empirical formula} = \boxed{C_4H_8O}$$

to determine molecular formula, divide given molar mass by molar mass of empirical formula:  $\frac{144\text{g/mol}}{72\text{g/mol}} = 2$

