Worksheet: Calculating Empirical & Molecular Formulas

1. The empirical formula for the compound having the formula $H_2C_2O_4$ is

   [A] C_2H_2 [B] CO_2H [C] COH [D] $C_2O_4H_2$ [E] COH_2

2. Calculate the empirical formula of a compound that is 85.6% C and 14.4% H (by mass).

   [A] CH [B] CH [C] C_3H_5 [D] C_2H_4 [E] C_2H

3. A compound is analyzed and found to contain 12.1% carbon, 16.2% oxygen, and 71.7% chlorine (by mass). Calculate the empirical formula of this compound.

   [A] $COCl_2$ [B] CO_2Cl_2 [C] CO_2Cl [D] $COCl_4$ [E] COCl

4. A compound contains 40.0% carbon, 6.7% hydrogen, and 53.3% oxygen (by mass). Calculate the empirical formula.

   [A] C_2H_2O [B] CH_2O [C] CH_4O [D] C_2HO_2 [E] $C_3H_6O_3$

5. A compound contains 25.94% N and 74.06% O (by mass). What is the empirical formula?

   N_2O_5

6. Calculate the empirical formula of a compound containing 18.29% H and 81.71% C (by mass).

   C_3H_8

7. Determine the empirical formula of a compound containing 54.2% F and 45.8% S (by mass).

   SF_2

8. A compound has 40.68% carbon, 5.12% hydrogen, and 54.20% oxygen (by mass). Calculate its empirical formula.

   $C_2H_3O_2$

9. Calculate the empirical formula of a compound that is 50.04% C, 5.59% H, and 44.37% O (by mass).

   $C_3H_4O_2$

10. A 7.33-g sample of lanthanum, La, combines with oxygen to give 10.29 g of the oxide. Calculate the empirical formula of this oxide.

    La_2O_7

11. Calculate the molecular formula of a compound with the empirical formula CH_2O and a molar mass of 150 g/mol.

    [A] $C_3H_6O_3$ [B] $C_5H_{10}O_5$ [C] $C_2H_4O_2$ [D] $C_4H_8O_4$ [E] $C_6H_{12}O_6$

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12. Acetylene gas is 92.3% carbon and 7.7% hydrogen (by mass), and its molar mass is 26 g/mol. What is its molecular formula?

[A] C_2H_2 [B] CH_4 [C] CH [D] C_4H_4 [E] none of these

13. The empirical formula of a compound is known to be CH_2, and its molar mass is 56 g/mol. What is the molecular formula?

C_4H_8

14. The empirical formula of a compound is CH_2O, and its mass is 120 amu/molecule. Calculate its molecular formula.

[A] $C_3H_6O_3$ [B] $C_2H_4O_2$ [C] $C_4H_8O_4$ [D] CH_2O [E] none of these

15. A compound contains 12.8% C, 2.1% H, and 85.1% Br (by mass). Calculate the empirical formula and the molecular formula of this compound given that the molar mass is 188 g/mol.

CH_2Br

16. A compound contains 10.13% C and 89.87% Cl (by mass). Determine both the empirical formula and the molecular formula of the compound given that the molar mass is 237 g/mol.

17. A certain compound has an empirical formula of NH_2O. Its molar mass is between 55 and 65 g/mol. Its molecular formula is

[A] $N_2H_4O_2$ [B] $N_2H_2O_2$ [C] not calculable [D] NH_2O

18. A compound has a molar mass of 86 g/mol and has the percent composition (by mass) of 55.8% C, 37.2% O, and 7.0% H. Determine the empirical formula and the molecular formula.

C_2H_3O

19. A compound has a molar mass of 100 g/mol and the percent composition (by mass) of 65.45% C, 5.45% H, and 29.09% O. Determine the empirical formula and the molecular formula.

[A] CHO and $C_6H_6O_6$ [B] CH_4O and $C_3H_{12}O_3$ [C] C_3HO and $C_6H_2O_2$

[D] CH_2O and $C_4H_8O_4$ [E] C_3H_3O and $C_6H_6O_2$

#20 $(C\times1)+(H\times2)+(O\times1)=12+2+16=30$

$60/30=2$ → $C_2H_4O_2$

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20. The empirical formula for acetic acid is CH_2O. Its molar mass is 60 g/mol. The molecular formula is

[A] C_2H_6O [B] CH_2O [C] $C_2H_4O_2$ [D] C_2HO_2 [E] none of these

(2) $85.6\,g\,C\times\frac{1\,mol}{12\,g}=7.13\,mol$ /// $14.4\,g\,H\times\frac{1\,mol}{1.01\,g}=14.26\,mol$

$\frac{14.26}{7.13}=\frac{H}{C}=\frac{2}{1}\rightarrow C_1H_2\rightarrow CH_2$

(3) $12.1\,g\,C\times\frac{1\,mol}{12.0\,g}=1.01\,mol$ $16.2\,g\,O\times\frac{1\,mol\,O}{16.0\,g\,O}=1.01\,mol\,O$

$71.7\,g\,Cl\times\frac{1\,mol}{35.45\,g}=2.02\,mol$ $C_{1.01}O_{1.01}Cl_{2.02}$

$C_1O_1Cl_2$ $COCl_2$

(4) $40.0\,g\,C\times\frac{1\,mol}{12\,g}=3.33\,mol$ /// $6.7\,g\,H\times\frac{1\,mol}{1.01\,g}=6.63\,mol$

$53.3\,g\,O\times\frac{1\,mol}{16\,g}=3.33\,mol$ $\frac{H}{C}=\frac{H}{O}=\frac{6.63}{3.33}\approx\frac{2}{1}$

$C_1H_2O_1$ CH_2O

(5) $25.9\,g\times\frac{1\,mol}{14\,g}=1.85\,mol\,N$ /// $74.06\,g\times\frac{1\,mol}{16\,g}=4.63\,mol\,O$

$\frac{O}{N}=\frac{4.63}{1.85}=\frac{2.5}{1}=\frac{5}{2}$ N_2O_5

(6) $18.29\,g\,H\times\frac{1\,mol\,H}{1.01\,g\,H}=18.1\,mol\,H$ $81.71\,g\,C\times\frac{1\,mol}{12.0\,g}=6.81\,mol$

$\frac{H}{C}=\frac{18.1}{6.81}=2.66=2\frac{2}{3}=\frac{8}{3}$ C_3H_8

(7) $54.2\text{g F} \times \frac{1\text{ mol F}}{19.0\text{ g F}} = 2.85\text{ mol F}$ /// $45.8\text{g S} \times \frac{1\text{ mol S}}{32.1\text{g S}} = 1.43\text{ mols}$

$\frac{2.85}{1.43} = \frac{F}{S} = \frac{2}{1} \rightarrow S_1F_2 \rightarrow SF_2$

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(8) $40.68\text{g C} \times \frac{1\text{ mol}}{12\text{ g}} = 3.39\text{ mol C}$ /// $54.20\text{g O} \times \frac{1\text{ mol}}{16\text{g}} = 3.39\text{ mol}$

$5.12\text{g H} \times \frac{1\text{ mol H}}{1.01\text{ g H}} = 5.07\text{ mol H}$ ///

$\frac{C}{O} = \frac{3.39}{3.39} = \frac{1}{1}$ $\frac{5.07}{3.39} = \frac{H}{C} = \frac{1.5}{1} = \frac{3}{2}$

$C_2H_3O_2$

1 : 1.5 ratio

1 : 1 ratio

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(9) $50.04\text{g C} \times \frac{1\text{ mol}}{12\text{g}} = 4.17\text{ mol}$ /// $5.59\text{g H} \times \frac{1\text{ mol H}}{1.01\text{g H}} = 5.53\text{ mol H}$

$44.37\text{g O} \times \frac{1\text{ mol O}}{16\text{ g O}} = 2.77\text{ mol O}$

$\frac{5.53}{2.77} = \frac{H}{O} = \frac{2}{1}$ /// $\frac{5.53}{4.17} = 1.33 = \frac{4}{3} = \frac{H}{C}$

$\frac{4.17}{2.77} = \frac{1.5}{1} = \frac{3}{2} = \frac{C}{O}$

$C_3H_4O_2$

3 : 4 ratio

2 : 1 ratio

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(10) The compound is lanthanum oxide. "The oxide" refers to lanthanum oxide.

Total mass = mass of the oxide = 10.29g

− mass of lanthanum alone = 7.33g

mass of oxygen alone = 2.96g

$7.33\text{g} \times \frac{1\text{ mol}}{138.9\text{ g}} = 0.0528\text{ mol La}$

$2.96\text{g} \times \frac{1\text{ mol}}{16\text{ g}} = 0.185\text{ mol O}$

$\frac{0.185\text{ mol O}}{0.0528\text{ mol La}} = \frac{3.5}{1} = \frac{7}{2} = La_2O_7$

(11) $CH_2O = 12+2+16 = 30$ $\frac{150}{30} = 5$ $CH_2O \times 5 = C_5H_{10}O_5$

(12) $92.3g \times \frac{1mol}{12g} = 7.69 mol$ $7.7g\,H \times \frac{1mol}{1.01g} = 7.62 mol$

$\frac{C}{H} = \frac{7.69}{7.62} = 1.0 = \frac{1}{1}$ **CH**

(13) $CH_2 = 12+2 = 14$ $56/14 = 4$ **C_4H_8**

(14) $CH_2O = 12+2+16 = 30$ $\frac{120}{30} = 4$ **$C_4H_8O_4$**

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(15) $12.8g\,C \times \frac{1mol}{12g} = 1.07 mol$ $2.1g\,H \times \frac{1mol}{1.01g} = 2.08 mol\,H$

$85.1g\,Br \times \frac{1\ mol}{79.9\ g} = 1.07\ mol$ $\frac{H}{Br} = \frac{2.08}{1.07} = 1.95 = \frac{2}{1}$

$\frac{H}{O} = \frac{1.07}{1.07} = \frac{1}{1}$

CH_2Br

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(16) $10.13g\,C \times \frac{1\ mol}{12g} = 0.844\ mol$ $89.87g\,Cl \times \frac{1mol}{35.45g} = 2.54\ mol\,Cl$

$\frac{Cl}{C} = \frac{2.54}{0.844} = \frac{3}{1}$ CCl_3 = empirical formula

mass = $12+(35.5\times3) = 118.35$

$\frac{237}{118.35} = 2$ **C_2Cl_6**

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(17) $NH_2O = 14+2+16 = 32$

~~$32\times1=32$~~

$32\times2=64$ ← this is in between 55 and 65!

~~$32\times3=96$~~

$NH_2O \times 2 = N_2H_4O_2$

(18) $55.8\,g\,C \times \frac{1\,mol}{12\,g} = 4.65\,mol$ $\quad 7.0\,g\,H \times \frac{1\,mol}{1.01\,g} = 6.93\,mol$

$37.2\,g\,O \times \frac{1\,mol}{16\,g} = 2.325\,mol$

$C_{4.65}H_{6.93}O_{2.325}$ $\quad \frac{H}{O} = \frac{6.93}{2.325} = \frac{3}{1}$

$\frac{C}{O} = \frac{4.65}{2.325} = \frac{2}{1}$

$C_2H_3O_1$

$\frac{H}{C} = \frac{6.93}{4.65} = \frac{1.5}{1} = \frac{3}{2}$

C_2H_3O = e.f.

$C \times 2 = 24$
$H \times 3 = 3$
$+ O \times 1 = 16$
43

$\frac{86}{43} = 2$

$C_4H_6O_2$ = m.f.

(19) $65.45\,g\,C \times \frac{1\,mol}{12\,g} = 5.45\,mol$

$5.45\,g\,H \times \frac{1\,mol}{1.01\,g} = 5.40\,mol$

$29.10\,g\,O \times \frac{1\,mol}{16\,g} = 1.82\,mol$

$C_{5.45}H_{5.40}O_{1.82}$

$\frac{C}{H} = \frac{5.45}{5.40} = \frac{1}{1}$

$\frac{C}{O} = \frac{5.45}{1.82} = \frac{3}{1}$

$C_3H_3O_1$ $\quad C_3H_3O$

$C_6H_6O_2$ $\quad \frac{100}{55} = 1.82 =$ maybe 2, I guess

Hmmm....
I think that "100" was supposed to be "110"
Typo???

$C \times 3 = 36$
$H \times 3 = 3$
$+ O \times 1 = 16$
$55\,g/mol$

(20) See work on top of #20 question