Worksheet: Calculating Empirical & Molecular Formulas
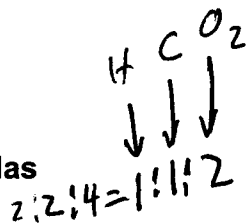
1. The empirical formula for the compound having the formula $H_2C_2O_4$ is

    [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_2 [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?

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

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

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

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

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.

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?

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.

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.

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. 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

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$H \quad C \quad O_2$

$\downarrow \downarrow \downarrow$

$2:2:4 = 1:1:2$

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

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

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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

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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 $(C \times 1) + (H \times 2) + (O \times 1) = 12 + 2 + 16 = 30$

$60/30 = 2$ $C_2H_4O_2$

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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 $85.6 g\ C \times \dfrac{1\ mol}{12\ g} = 7.13\ mol$ /// $14.4 g\ H \times \dfrac{1 mol}{1.01 g} = 14.26\ mol$

$\dfrac{14.26}{7.13} = \dfrac{H}{C} = \dfrac{2}{1} \rightarrow C_1 H_2 \rightarrow CH_2$

③ $12.1 g\ C \times \dfrac{1\ mol}{12.0\ g} = 1.01\ mol$ $16.2 g\ O \times \dfrac{1\ mol\ O}{16.0 g\ O} = 1.01\ mol\ O$

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

$C_1 O_1 Cl_2$ $COCl_2$

④ $40.0 g\ C \times \dfrac{1 mol}{12 g} = 3.33\ mol$ /// $6.7 g\ H \times \dfrac{1 mol}{1.01 g} = 6.63\ mol$

⑤ $3.3 g\ O \times \dfrac{1 mol}{16 g} = 3.33\ mol$ $\dfrac{H}{C} = \dfrac{H}{O} = \dfrac{6.63}{3.33} \approx \dfrac{2}{1}$

$C_1 H_2 O_1$ CH_2O

⑤ $25.94 g \times \dfrac{1 mol}{14 g} = \dfrac{1.85}{N} mol$ /// $74.06 g \times \dfrac{1 mol}{16 g} = \dfrac{4.63}{} mol$

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

⑥ $18.29 g\ H \times \dfrac{1 mol\ H}{1.01 g\ H} = \dfrac{18.1}{} mol\ H$ $81.71 g\ C \times \dfrac{1 mol}{12.0 g} = 6.81\ mol$

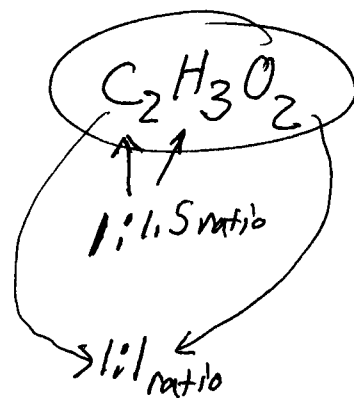$\dfrac{H}{C} = \dfrac{18.1}{6.81} = 2.66 = 2\tfrac{2}{3} = \dfrac{8}{3}$ C_3H_8

⑦ $54.2g\ F \times \dfrac{1\ \text{mol}\ F}{19.0\ g\ F} = \underline{2.85}\ \text{mol}\ F$ ||| $45.8g\ S \times \dfrac{1\ \text{mol}\ S}{32.1\ g\ S} = \underline{1.43}\ \text{mol}\ S$

$$\dfrac{2.85}{1.43} = \dfrac{F}{S} = \dfrac{2}{1} \rightarrow S_1 F_2 \rightarrow \boxed{SF_2}$$

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⑧ $40.68g\ C \times \dfrac{1\ \text{mol}}{12\ g} = \underline{3.39}\ \text{mol}\ C$ ||| $54.20g\ O \times \dfrac{1\ \text{mol}}{16\ g} = \underline{3.39}\ \text{mol}$

$5.12g\ H \times \dfrac{1\ \text{mol}\ H}{1.01\ g\ H} = \underline{5.07}\ \text{mol}\ H$ |||

$\dfrac{C}{O} = \dfrac{3.39}{3.39} = \dfrac{1}{1}$ $\dfrac{5.07}{3.39} = \dfrac{H}{C} = \dfrac{1.5}{1} = \dfrac{3}{2}$ $\boxed{C_2 H_3 O_2}$

$1:1.5\ \text{ratio}$

$\rightarrow 1:1\ \text{ratio}$

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⑨ $50.04g\ C \times \dfrac{1\ \text{mol}}{12\ g} = \underline{4.17}\ \text{mol}$ ||| $5.59g\ H \times \dfrac{1\ \text{mol}\ H}{1.01\ g\ H} = \underline{5.53}\ \text{mol}\ H$

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

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

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

$C_3 H_4 O_2$

$3:4\ \text{ratio}$ $2:1\ \text{ratio}$

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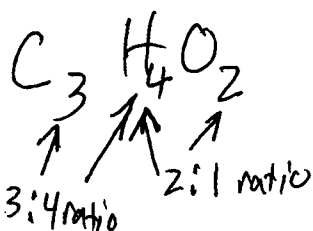
⑩ The compound is lanthanum oxide. "The oxide" refers to lanthanum oxide.

Total mass = mass of the oxide = 10.29g ||| $7.33g \times \dfrac{1\ \text{mol}}{138.9\ g} = \underline{0.0528}\ \text{mol}\ La$

− mass of lanthanum alone = 7.33g

mass of oxygen alone = 2.96g || $2.96g \times \dfrac{1\ \text{mol}}{16\ g} = \underline{0.185}\ \text{mol}\ O$

$\dfrac{0.186\ \text{mol}\ O}{0.0528\ \text{mol}\ La} = \dfrac{3.5}{1} = \dfrac{7}{2} = La_2 O_7$

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

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

$\frac{C}{H} = \frac{7.69}{7.62} = 1.0 = \frac{1}{1}$ $\boxed{CH}$ $\boxed{C_2H_2}$
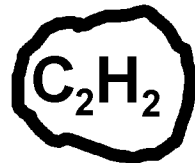
(13) $CH_2 = 12+2 = 14$ $56/14 = 4$ $\boxed{C_4H_8}$

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

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

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

$\boxed{CH_2Br}$ $\frac{H}{0} = \frac{1.07}{1.07} = \frac{1}{1}$
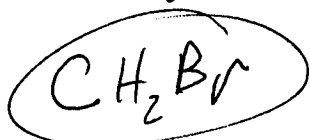
(16) $10.13g\ C \times \frac{1 mol}{12g} = \underline{0.844} mol$ $89.87g\ Cl \times \frac{1 mol}{35.45g} = \underline{2.54}\ mol\ Cl$
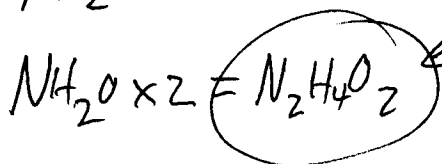
$\frac{Cl}{C} = \frac{2.54}{0.844} = \frac{3}{1}$ $CCl_3 = $ empirical formula
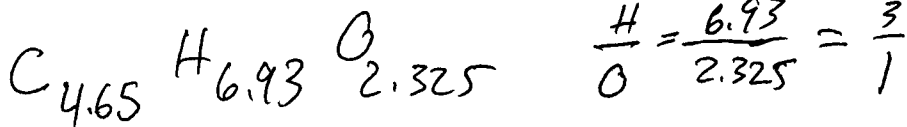mass $= 12+(35.5\times3) = 118.35$

$\frac{237}{118.35} = 2$ $\boxed{C_2Cl_6}$
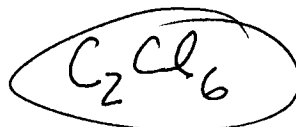
(17) $NH_2O = 14+2+16 = 32$ $32 \times 1 = 32$
$32 \times 2 = 64 \longleftarrow$ this is in between
55 and 65!
$32 \times 3 = 96$

$NH_2O \times 2 = \boxed{N_2H_4O_2}$

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

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

$C_{4.65}H_{6.93}O_{2.325}$ $\qquad$ $\dfrac{H}{O} = \dfrac{6.93}{2.325} = \dfrac{3}{1}$

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

$C_2H_3O_1$ $\qquad$ $\dfrac{C}{O} = \dfrac{4.65}{2.325} = \dfrac{2}{1}$

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

$\boxed{C_2H_3O}$ = e.f. $\qquad$ $\dfrac{H}{C} = \dfrac{6.93}{4.65} = \dfrac{1.5}{1} = \dfrac{3}{2}$

$\boxed{C_4H_6O_2}$ = M.f.
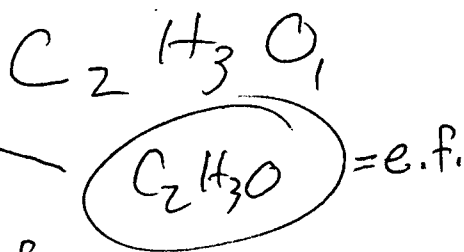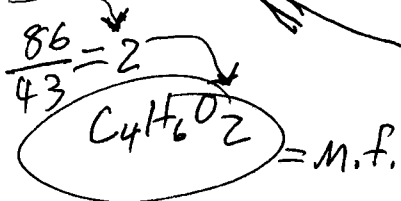
(19)

$65.45g\ C \times \dfrac{1\ mol}{12g} = 5.45\ mol$ $\qquad$ $C_{5.45}H_{5.40}O_{1.82}$

$5.45g\ H \times \dfrac{1\ mol}{1.01g} = \mathbf{5.40}\ mol$ $\qquad$ $\dfrac{C}{H} = \dfrac{5.45}{5.40} = \dfrac{1}{1}$

$29.10g\ O \times \dfrac{1\ mol}{16g} = 1.82\ mol$ $\qquad$ $\dfrac{C}{O} = \dfrac{5.45}{1.82} = \dfrac{3}{1}$

$C_3H_3O_1$ $\boxed{C_3H_3O}$
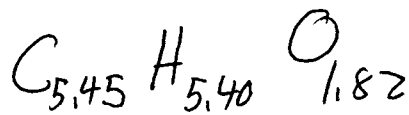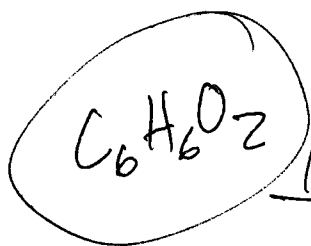
$\boxed{C_6H_6O_2}\ \dfrac{100}{55} = 1.82 = $ maybe $2, I\ guess$ $\qquad$ $C \times 3 = 36$
$\downarrow$ $\qquad\qquad\qquad\qquad\qquad\qquad$ $H \times 3 = 3$
Hmmm.... $\qquad\qquad\qquad\qquad\qquad$ $+\ \ O \times 1 = 16$
I think that $\qquad\qquad\qquad\qquad\qquad$ _____
"100" was supposed $\qquad\qquad\qquad\qquad$ $55 g/mol$
to be "110",
Typo???

(20) See work on top of #20 question