Empirical & Molecular Formulas

Name__________________________Per___

Please do your work on another piece of paper and show your work so that you can refer to it later to check for mistakes and use for review.

1. Hydrazine is used as a rocket fuel. Its molecular mass is 92.0 g/mole. Analysis of this compound shows that for every 1.0 g of nitrogen there will be 2.28 g of oxygen. Determine the empirical and molecular formulas.

2. Acetylene is a gas used in welding torches. As a fossil fuel it contains carbon and hydrogen. It contains 92.3 % carbon, and 7.7 % hydrogen. The molecular mass is 26 g/mole. Determine the empirical and molecular formula.

3. The hydrocarbon butane - the fuel in bic lighters - has the following composition: 82.7 % carbon and 17.3% hydrogen. The molecular mass of butane is 58.2 g/mole. Determine the empirical and molecular formulas.

4. Chlorofluorocarbons (CFCs), the propellant that was widely used in aerosol cans until it was found to have a detrimental effect on the upper atmosphere ozone layer. One particular CFC is made of 37.3 % carbon, 6.2 % hydrogen, 19.7 % fluorine, and 36.8 % chlorine. The molecular mass of this compound is 96.5 g/mole. Determine the molecular and empirical formulas.

5. Tobacco leaves contain between 2 to 8 % nicotine. Nicotine is made of 74.0 % carbon, 8.7 % hydrogen, and 17.3 % nitrogen. The molecular mass is 162 g/mole. Determine the empirical and molecular formulas.

6. All simple saccharides contain 40.0 % carbon, 6.7 % hydrogen, and 53.3 % oxygen. The molecular mass of these saccharides (also known as carbohydrates) is 180 g/mole. Determine the empirical and molecular formula.

7. A compound has an empirical formula of C_2H_3O and a molar mass of 172 g/mol. Determine the molecular formula.

8. Some molecular compound made of phosphorus and oxygen with a molar mass of 284 g/mole is made of 43.7% phosphorus. Determine the empirical and molecular formulas of this compound.

9. Epinephrine (adrenaline) is a hormone secreted into the bloodstream in times of danger and stress. It is 59.1% carbon, 13% hydrogen, 7.7% nitrogen, and 26.2% oxygen mass. Its molar mass is approximately 183 g/mol.

10. Can the molecular formula of a compound ever be the same as the empirical formula? Justify and provide an example.

Empirical & Molecular Formulas *ANSWERS*

1. **NO_2** **N_2O_4**

$$1g \times \frac{1mol}{14.01g} = 0.0714mol \quad \frac{0.0714}{0.0714} = 1$$

$$2.28g \times \frac{1mol}{16g} = 0.1425mol \quad \frac{0.1425}{0.0714} = 2 \qquad \text{thus } NO_2 \quad 14 + 2(16) = 46g/mol \qquad \frac{92}{46} = 2 \qquad therefore \;\; N_2O_4$$

2. **CH** **C_2H_2**

$$92.3g \times \frac{1mol}{12.01g} = 7.69mol$$

$$7.7g \times \frac{1mol}{1.01g} = 7.7mol \qquad \text{thus } CH \quad 12 + 1 = 13g/mol \qquad \frac{26}{13} = 2 \qquad therefore C_2H_2$$

3. **C_2H_5** **C_4H_{10}**

$$82.7g \times \frac{1mol}{12.01g} = 6.89mol / 6.89 = 1 \times 2$$

$$17.3g \times \frac{1mol}{1.01g} = 17.3mol / 6.89 = 2.5 \times 2 \qquad \text{thus } C_2H_5 \quad 2(12) + 5(1) = 29g/mol \qquad \frac{58.2}{29} = 2 \qquad therefore C_4H_{10}$$

4. **C_3H_6FCl** **same**

$$37.3g \times \frac{1mol}{12.01g} = 3.11mol \quad \frac{3.11}{1.04} = 3$$

$$6.2g \times \frac{1mol}{1.01g} = 6.14mol \quad \frac{6.14}{1.04} = 5.9$$

$$19.7g \times \frac{1mol}{19g} = 1.04mol \quad \frac{1.04}{1.04} = 1$$

$$36.8g \times \frac{1mol}{35.45g} = 1.04mol \quad \frac{1.04}{1.04} = 1$$

$$\text{thus } C_3H_6FCl \quad 3(12) + 6(1) + 19 + 35.45 = 96.45g/mol \qquad \frac{96.5}{96.45} = 1 \qquad therefore\ same:\ C_3H_6FCl$$

5. **C_5H_7N** **$C_{10}H_{14}N_2$**

$$74g \times \frac{1mol}{12.01g} = 6.66mol \quad \frac{6.16}{1.23} = 5$$

$$8.7g \times \frac{1mol}{1.01g} = 8.61mol \quad \frac{8.61}{1.23} = 7$$

$$17.3g \times \frac{1mol}{14.01g} = 1.23mol \quad \frac{1.23}{1.23} = 1$$

$$\text{thus } C_5H_7N \quad 5(12) + 7(1) + 14 = 81g/mol \qquad \frac{162}{81} = 2 \qquad therefore\ C_{10}H_{14}N_2$$

6. **CH_2O** **$C_6H_{12}O$**

$$40g\times\frac{1mol}{12.01g}=3.33mol \quad \frac{3.33}{3.33}=1$$

$$6.7g\times\frac{1mol}{1.01g}=6.63mol \quad \frac{6.63}{3.33}=2$$

$$53.3g\times\frac{1mol}{16g}=3.33mol \quad \frac{3.33}{3.33}=1 \quad \text{thus } CH_2O \quad 12+2(1)+16=30g/mol \quad \frac{180}{30}=6 \quad therefore\ C_6H_{12}O_6$$

7. **C_2H_3O** **$C_8H_{12}O_4$** $2(12)+3(1)+16=81g/mol$ $\frac{172}{43}=4$ *therefore* $C_8H_{12}O_4$

8. **P_2O_5** **P_4O_{10}**

$$43.7g\times\frac{1mol}{30.97g}=1.41mol \quad \frac{1.41}{1.41}=1\times2$$

$$56.3g\times\frac{1mol}{16g}=3.5mol \quad \frac{3.5}{1.41}=2.48\times2 \quad \text{thus } P_2O_5 \quad 2(31)+5(16)=142g/mol \quad \frac{284}{142}=2 \quad therefore\ P_4O_{10}$$

9. **$C_9H_{13}N_2O_3$**

$$54.8g(\%)\times\frac{1mol}{12.01g}=4.56mol \quad \frac{4.56}{1.01}=4.5\times2=9$$

$$6.66g(\%)\times\frac{1mol}{1.01g}=6.59mol \quad \frac{6.59}{1.01}=6.5\times2=13$$

$$14.21g(\%)\times\frac{1mol}{14.01g}=1.01mol \quad \frac{1.01}{1.01}=1\times2=2$$

$$24.34g(\%)\times\frac{1mol}{16g}=1.52mol \quad \frac{1.52}{1.01}=1.5\times2=3$$

thus the molecular formula is the same

thus $C_9H_{13}N_2O_3$ $9(12.01)+13(1.01)+2(14.01)+3(16)=197.24g/mol$

10. **Yes**, water is a good example: H_2O is both an empirical and molecular formula