Worksheet #8

Empirical Formulas

1. State the empirical formula for each of the following compounds: a) C_4H_8; b) $C_2H_6O_2$; c) N_2O_5; d) $Ba_3(PO_4)_2$; e) Te_4I_{16}

2. What is the empirical formula for a compound that contains 0.063 mol chlorine and 0.22 mol oxygen?

3. What is the empirical formula for a compound that contains 26.1% carbon, 4.3% hydrogen and 69.6 % oxygen?

4. An oxide of nitrogen contains 30.45% N and 69.55% O. What is its empirical formula?

Molecular Formulas

5. The molar mass of the oxide of nitrogen in question #9 is 92 g/mol. What is its molecular formula?

6. A chloride of silicon contains 79.1% chlorine. If its molar mass is 269 g/mol, what is its molecular formula?

7. Cortisol is a steroid hormone that is used to reduce inflammation. It has a molar mass of 362.47 g/mol, and is comprised of 69.6% C, 8.34% H, and 22.1% O. What is its molecular formula?

8. Menthol is a substance commonly used in cough drops. It has a molar mass of 156.3 g/mol and is comprised of 77.4% C, 12.9% H, and 10.2% O. What is its molecular formula?

Formulas from Mass Data

9. A new compound containing xenon and fluorine was isolated. If 0.526 g of xenon reacted, and 0.678 g of the new compound was isolated, what is its empirical formula?

10. A sample of 1.256 g of elemental sulfur (S) is combined with fluorine to give a compound with the formula SF_x, a stable, colorless gas. If you have isolated 5.722 g of SF_x, what is the value of x?

11. A sample of 1.25 g of germanium is combined with excess chlorine to form 3.69 g of a product with the formula Ge_xCl_y. What is the empirical formula of the product?

Chapter 7 – The Simplest, or Empirical, Formula
Section A

Determine the empirical formula for each compound whose percentage composition is shown below.

1. 43% C and 57% O

2. 40.3% K, 26.7% Cr, and 33.0% O

3. 32.0% C, 42.6% O, 18.7% N, and the remainder H

4. 31.9% K, 28.9% Cl, and the remainder O

5. 52.8% Sn, 12.4% Fe, 16.0% C, and 18.8% N

Determine the molecular formula for each compound whose percentage composition is shown below.

6. 84.9% Hg and the remainder Cl, with a molecular weight of 472.2 g/mol.

7. 12.26% N, 3.54% H, 28.1% S, and 56.1% O. The molecular weight is 228.2 g/mol. The formula is known to contain the NH_4^+ grouping. Write your formula accordingly.

8. 71.5% Hg, 5.0% N, 17.1% O, and 6.4% H_2O, with molecular weight of 561.2 g/mol

Answers to Worksheet #8

Empirical Formulas

To calculate empirical formulas, follow the steps outlined below: (assume percentages given in
the problems are grams)
Step 1: convert to moles
Step 2: divide each by the lowest number of moles
Step 3: (only if necessary) multiply all by the same factor in order to obtain whole numbers. .
X.1 and X.9 are considered whole numbers
Step 4: The numbers obtained in Step 2 (or Step 3 if it were necessary) are the subscripts in the
formula
.

1. a) CH_2; b) CH_3O; c) N_2O_5; d) $Ba_3(PO_4)_2$; e) TeI_4.

2. Step 1 is already done, so we will start with step 2:

$$Cl = \frac{0.063mol}{0.063mol} = 1 \qquad O = \frac{0.22mol}{0.063mol} = 3.5$$

Step 3 is necessary:
Cl = 1•2 = 2 O = 3.5•2 = 7
Step 4: Cl_2O_7 – dichlorine heptaoxide

3. Step 1:

$$C = 26.1\left|\frac{1mol}{12.01g}\right| = 2.17mol \qquad H = 4.3g\left|\frac{1mol}{1.008g}\right| = 4.27mol$$

$$O = 69.6g\left|\frac{1mol}{16.00g}\right| = 4.35mol$$

Step 2:

$$C = \frac{2.17mol}{2.17mol} = 1 \qquad H = \frac{4.27mol}{2.17mol} = 1.9 \qquad O = \frac{4.35mol}{2.17mol} = 2.0$$

Step 3 isn't necessary. Step 4: CH_2O_2

4. Step 1: $N = 30.45g\left|\frac{1mol}{14.01g}\right| = 2.17mol$ $O = 69.55g\left|\frac{1mol}{16.00g}\right| = 4.35mol$

Step 2: $N = \frac{2.17mol}{2.17mol} = 1$ $O = \frac{4.35mol}{2.17mol} = 2.0$

Step 3: isn't necessary. Step 4: NO_2

Molecular Formulas

To calculate molecular formulas, follow the steps outlined below:
Step 1: calculate empirical formula (see above)
Step 2: divide the molecular formula mass given to you in the problem by the empirical formula mass
Step 3: multiply the subscripts in the empirical formula by the number obtained in Step 2.

5. Step 1 was done in question #9, so we will start with Step 2:

$$\frac{92\frac{g}{mol}}{46.01\frac{g}{mol}} = 2$$

Step3: N = 1•2 = 2

O = 2•2 = 4

N_2O_4

– dinitrogen tetraoxide

6. Step 1: % Si = 100% - 79.1% = 20.9%

$$Cl = 79.1g\left|\frac{1mol}{35.45g}\right| = 2.23mol \qquad Si = 20.9g\left|\frac{1mol}{28.09g}\right| = 0.744mol$$

$$Cl = \frac{2.23mol}{0.744mol} = 2.99 \qquad Si = \frac{0.744mol}{0.744mol} = 1$$

Empirical: $SiCl_3$

Step 2: $\frac{269\frac{g}{mol}}{134.44\frac{g}{mol}} = 2$ Step 3: Si = 1•2 = 2

Cl = 3•2 = 6

Si_2Cl_6 – disilicon hexachloride

7. Step 1:

$$C = 69.6g\left|\frac{1mol}{12.01g}\right| = 5.80mol \qquad H = 8.34g\left|\frac{1mol}{1.008g}\right| = 8.27mol$$

$$O = 22.1g\left|\frac{1mol}{16.00g}\right| = 1.38mol$$

$$C = \frac{5.80mol}{1.38mol} = 4.20 \qquad H = \frac{8.27mol}{1.38mol} = 5.99 \qquad O = \frac{1.38mol}{1.38mol} = 1$$

C = 4.2•5 = 21 H = 6•5 = 30 O = 1•5 = 5 Empirical: $C_{21}H_{30}O_5$

Step 2: $\frac{362.47\frac{g}{mol}}{362.45\frac{g}{mol}} = 1$ Step 3: all subscripts will be the same

$C_{21}H_{30}O_5$ – Cortisol

8. Step 1:

$$C = 77.4g\left|\frac{1mol}{12.01g}\right| = 6.44mol \qquad H = 12.9g\left|\frac{8.27mol}{1.008mol}\right| = 12.8mol$$

$$O = 10.2g\left|\frac{1mol}{16.00g}\right| = 0.638mol$$

$$C = \frac{6.44mol}{0.638mol} = 10.1 \qquad H = \frac{12.8mol}{0.638mol} = 20.0 \qquad O = \frac{0.638mol}{0.638mol} = 1$$

Empirical: $C_{10}H_{20}O$

Step 2: $\dfrac{156.3\frac{g}{mol}}{156.26\frac{g}{mol}}$ Step 3: all subscripts will be the same

$C_{10}H_{20}O$ – Menthol

Answers to Worksheet #8

Formulas from Mass Data

To find formulas from mass data, make sure that you have the mass of all substances that reacted. Remember that the mass of the reactants = mass of products. Next, convert the grams of reactants to moles, and find the ratio of the reactants. Multiply if necessary to make the ratio into whole numbers.

9. Mass of F that reacted = 0.678 g – 0.526 g = 0.152 g

$$MolXe = 0.526gXe\left|\frac{1molXe}{131.3g}\right| = 0.00401molXe \qquad MolF = 0.152gF\,\frac{1molF}{19.00g} = 0.00800molF$$

$$\frac{F}{Xe} = \frac{0.00800mol}{0.00401mol} = 2$$ So, there are 2 F's to every 1 Xe. The compound is XeF_2.

10. Mass of F that reacted = 5.722 g – 1.256 g = 4.466 g

$$MolF = 4.466gF\left|\frac{1molF}{19.00g}\right| = 0.2351molF \qquad MolS = 1.256gS\left|\frac{1molS}{32.07g}\right| = 0.03916molS$$

$$\frac{F}{S} = \frac{0.2351mol}{0.03916mol} = 6$$ So, there are 6 F's to every 1 S. The compound is SF_6.

11. Mass of Cl that reacted = 3.69 g – 1.25 g = 2.44 g

$$MolCl = 2.44gCl\left|\frac{1molCl}{35.45g}\right| = 0.0688molCl \qquad MolGe = 1.25gGe\left|\frac{1molGe}{72.59g}\right| = 0.0172molGe$$

$$\frac{Cl}{Ge} = \frac{0.0688mol}{0.0172mol} = 4$$ *So, there are 4 Cl's to every 1 Ge. The compound is* $GeCl_4$.

Answers to Chapter 7 – The Simplest, or Empirical, Formula

1. CO ($C_{3.6}O_{3.6}$)
2. K_2CrO_4 ($K_{1.03}Cr_{0.514}O_{2.06}$)
3. $C_2O_2NH_5$ ($C_{2.67}O_{2.67}N_{1.34}H_{6.70}$)
4. $KClO_3$ ($K_{0.816}Cl_{0.814}O_{2.45}$)
5. $Sn_2FeC_6N_6$ ($Sn_{0.444}Fe_{0.222}C_{1.33}N_{1.34}$)
6. Hg_2Cl_2 $\left[Hg_{0.423}Cl_{0.423} = HgCl\ (MW = 236.1)\ \frac{472.2}{236.1} = 2 \right]$
7. $(NH_4)_2S_2O_8$ $\left[N_{0.876}H_{3.50}H_{0.875}S_{0.875}O_{3.51} = NH_4SO_4 \quad (MW = 114.1)\frac{228.2}{114.1} = 2 \right]$
8. $Hg_2N_2O_6 \cdot 2H_2O$

$\left[Hg_{0.356}N_{0.375}O_{1.07}(H_2O)_{0.356} = HgNO_3 \cdot H_2O\ (MW = 280.6)\frac{561.2}{280.6} = 2 \right]$