Chem 115
Test 1 Review Problems
Answers

1. Fill in either the name or formula, as required.

Cu_2S	**copper(I) sulfide**
$\mathbf{Ba_3N_2}$	barium nitride
$Al(ClO_3)_3$	**aluminum chlorate**
$\mathbf{N_2O_6}$	dinitrogen hexoxide

2. Boron forms a large number of compounds with hydrogen, called boranes, which are named by their own nomenclature system. Consider a 25.00-g sample of pentaborane-9, B_5H_9.
[m.w. B_5H_9 = 63.12 u; at. wt. B = 10.81 u; at. wt. H = 1.008 u]
a. How many moles of B_5H_9 are in the sample?

$$\mathrm{mol\,B_5H_9} = (25.00\,\mathrm{g\,B_5H_9})\left(\frac{\mathrm{mol\,B_5H_9}}{63.12\,\mathrm{g\,B_5H_9}}\right) = 0.3961\,\mathrm{mol\,B_5H_9}$$

b. How many moles of hydrogen are in the sample?

$$\mathrm{mol\,H} = (0.3961\,\mathrm{mol\,B_5H_9})\left(\frac{9\,\mathrm{mol\,H}}{\mathrm{mol\,B_5H_9}}\right) = 3.565\,\mathrm{mol\,H}$$

c. How many boron atoms are in the sample?

$$\mathrm{B\,atoms} = (0.3961\,\mathrm{mol\,B_5H_9})\left(\frac{5\,\mathrm{mol\,B}}{\mathrm{mol\,B_5H_9}}\right)\left(\frac{6.022\times10^{23}\,\mathrm{B\,atoms}}{\mathrm{mol\,B}}\right) = 1.193\times10^{24}\,\mathrm{B\,atoms}$$

d. What is the weight percentage of boron in the sample?

$$\%\mathrm{B} = \frac{(5)(10.81)}{63.12}\times100\% = 85.63\%$$

3. Complete and balance the following reactions:

a. $C_3H_7OH + O_2 \rightarrow$ (combustion) $\quad$ $\mathbf{2\ C_3H_7OH + 9\ O_2 \rightarrow 6\ CO_2 + 8\ H_2O}$

b. $NH_3 + O_2 \rightarrow N_2 + H_2O$ $\quad$ $\mathbf{4\ NH_3 + 3\ O_2 \rightarrow 2\ N_2 + 6\ H_2O}$

c. $B_2O_3 + C + Cl_2 \rightarrow BCl_3 + CO_2$ $\quad$ $\mathbf{2\ B_2O_3 + 3\ C + 6\ Cl_2 \rightarrow 4\ BCl_3 + 3\ CO_2}$

4. A compound is analyzed and found to consist of 43.58% phosphorus and 56.42% sulfur. What is its empirical formula? Assuming that the empirical and molecular formulas are the same, what is the name of the compound? [at. wt. P = 30.97 u; at. wt. S = 32.07 u]

Assume 100 g compound:

$$\mathrm{mol\,P} = (43.58\,\mathrm{g\,P})\left(\frac{\mathrm{mol\,P}}{30.99\,\mathrm{g\,P}}\right) = 1.407\,\mathrm{mol\,P}$$

$$\mathrm{mol\,S} = (56.42\,\mathrm{g\,S})\left(\frac{\mathrm{mol\,S}}{32.07\,\mathrm{g\,S}}\right) = 1.759\,\mathrm{mol\,S}$$

mol P : mol S = 1.00 : 1.25 = 4 : 5

empirical formula = P_4S_5 name = tetraphosphorus pentasulfide

5. A 0.7323-g sample of a certain hydrocarbon (compound of carbon and hydrogen only) is analyzed by combustion, yielding 2.218 g CO_2(*g*) and 1.135 g H_2O(*l*). If the molecular weight is found to be 58.12 u, what is the molecular formula? [m.w. CO_2 = 44.01 u; m.w. H_2O = 18.02 u; at. wt. C = 12.01 u; at. wt. H = 1.008 u].

$$\mathrm{mol\,C} = (2.218\,\mathrm{g\,CO_2})\left(\frac{\mathrm{mol\,CO_2}}{44.01\,\mathrm{g\,CO_2}}\right)\left(\frac{\mathrm{mol\,C}}{\mathrm{mol\,CO_2}}\right) = 0.05040\,\mathrm{mol\,C}$$

$$\mathrm{mol\,H} = (1.135\,\mathrm{g\,H_2O})\left(\frac{\mathrm{mol\,H_2O}}{18.02\,\mathrm{g\,H_2O}}\right)\left(\frac{2\,\mathrm{mol\,H}}{\mathrm{mol\,H_2O}}\right) = 0.1260\,\mathrm{mol\,H}$$

mol C : mol H = 1.0 : 2.5 = 2 : 5

empirical formula = C_2H_5 f.w. = 29.06 u m.w./f.w. = 58.12/29.06 = 2

molecular formula = C_4H_{10}

6. Diborane, B_2H_6 (m.w. = 27.67 u), is a useful reagent in organic syntheses. It can be prepared by the reaction

$$4\ BF_3 + 3\ NaBH_4 \rightarrow 2\ B_2H_6 + 3\ NaBF_4$$

How many grams of diborane should be produced in the reaction of 6.00 g of BF_3 (m.w. = 67.80 u) and 2.75 g of $NaBH_4$ (f.w. = 37.83 u)?

$$\mathrm{mol\,BF_3} = (6.00\,\mathrm{g\,BF_3})\left(\frac{\mathrm{mol\,BF_3}}{67.80\,\mathrm{g\,BF_3}}\right) = 0.0884_{96}\,\mathrm{mol\,BF_3}$$

$$\mathrm{mol\,NaBH_4} = (2.75\,\mathrm{g\,NaBH_4})\left(\frac{\mathrm{mol\,NaBH_4}}{37.83\,\mathrm{g\,NaBH_4}}\right) = 0.0726_{94}\,\mathrm{mol\,NaBH_4}$$

Using the “set” method to identify the limiting reagent, divide each number of moles by its stoichiometric coefficient. The smaller number identifies the limiting reagent.

BF_3 “sets” = $0.0884_{95}/4 = 0.0221$ ☜ Limiting Reagent

$NaBH_4$ “sets” = $0.0726_{94}/3 = 0.0242$

Now, base the calculation on the number of moles of BF_3, the limiting reagent:

$$\mathrm{g\,B_2H_6} = (0.0884_{96}\,\mathrm{mol\,BF_3})\left(\frac{2\,\mathrm{mol\,B_2H_6}}{4\,\mathrm{mol\,BF_3}}\right)\left(\frac{27.67\,\mathrm{g\,B_2H_6}}{\mathrm{mol\,B_2H_6}}\right) = 1.22\,\mathrm{g\,B_2H_6}$$