CHEM131 HOMEWORK #3 KEY

3-38. Caffeine, (Check various graphics in your Lab Manual!) $C_8H_{10}N_4O_2$: Molar Mass = 8*12.01 + 10*1.008 + 4*14.01 + 2*16.00 = 194.2 g/mole. Mass % C = 8*12.01*100/194.2 = 49.47 % C

Sucrose, $C_{12}H_{22}O_{11}$: Molar Mass = 12*12.01 + 22*1.008 + 11*16.00 = 342.3 g/mole. Mass % C = 12*12.01*100/342.3 = 42.10 % C

Ethanol, C_2H_6O: Molar Mass = 2*12.01 + 6*1.008 + 16.00 = 46.07 g/mole. Mass % C = 24.02/46.07 = 52.14 % C *(Note that in each case, the units of g/mole in the numerator and the denominator cancel.)*

3-40. If you begin with 100 g of cyanocobalimin (abbreviated B12 here) your sample contains 4.34 g Co.
4.34 g Co/58.93 g/mole Co = 0.07365 mole Co = 0.07365 mole B12 (from assumption of 1 Co/B12 molecule). 100 g B12/0.07365 mole B12 = 1360 g/mole B12.

3-46. Beginning with 100.0 g adrenalin, you have 56.79 g C, 6.56 g H, 28.37 g O, and 8.28 g N. Finding the # of moles of each, we have 56.79/12.01 = 4.728 mol C, 6.56/1.008 = 6.51 mol H, 28.37/16.00 = 1.773 mol O, 8.28/14.01 = 0.591 mol N. Divide the # of moles of each atom by the smallest, 0.591, gives 4.728/0.591 = 8.00 C:N, 6.51/0.591 = 11.0 H:N, 1.773/0.591 = 3.00 O:N and the empirical formula is $C_8H_{11}O_3N$. The next step would be to find the complete formula, which I did by looking up adrenalin in a text, only to find that the formula for adrenalin is $C_9H_{13}O_3N$. Here is a case of Zumdahl cooking the books. In a real determination of an empirical formula you would expect measuring uncertainties to give you ratios that were close to integers, but not exactly integer values. And he started with the wrong formula to boot!

3-47. This is an involved problem that is best solved by planning your strategy first. From earlier examples, such as problem 3-40, we know how to get the empirical formula if we know the percentages of C, H, O, and N. From the combustion experiment we can find out how much C and how much H was contained in 0.157 g of X. From the ammonia experiment we can find out how much N was contained in 0.103 g of X. (It would have been convenient if both experiments had started with the same mass, but we can adjust for that.)

(213 mg CO_2)(12.01 g C/44.01 g CO_2) = 58.1 mg C; (58.1 mg/157 mg)100 = 37.0 % C

(31.0 mg H_2O)(2x1.008 g H/18.02 g H_2O) = 3.47 mg H;(3.47 mg/157 mg)100 = 2.21% H

(23.0 mg NH_3)(14.01 g N/17.03 g NH_3) = 18.9 mg N; (18.9 mg/103 mg)100 = 18.3% N

100% = 37.0% + 2.2% + 18.3% + % oxygen; % O = 42.5%

Now consider the canonical 100 g sample (enough of these meager milligrams) and find the number of moles of each atom in 100 g. Units will be the same as in problem 3-40. 37.0/12.01 = 3.08 mol C; 2.21/1.008 = 2.19 mol H; 18.3/14.01 = 1.31 mol N; 42.5/16.00 = 2.66 mol O. Dividing each by the smallest gives C:H:N:O, but not in integer ratios yet.

3.08/1.31 = 2.35, 2.19/1.31 = 1.67, 1.31/1.31 = 1.00, 2.66/1.31 = 2.03. Multiplying 2.35:1.67:1.00:2.03 by 3 gives 7.05:5.01:3:6.09 and the empirical formula is $C_7H_5N_3O_6$.

3-56. $C_{12}H_{22}O_{11}$ (*aq*) + H_2O (*l*) → 4 C_2H_5OH (*aq*) + 4CO_2 (*g*)

3-57. 1000 g Al/26.98 g Al/mol = 37.06 mol Al. Since 3 mol of ammonium perchlorate react with 3 mol aluminum, we need 37.06 mol NH_4ClO_4, which ahs a molecular mass of 117.49 g/mol. 37.06*117.49 = 4355 g NH_4ClO_4 = 4.355 kg.

3-64. Starting with a balanced equation is ALWAYS a good idea: 2Al + 3Br_2 ↦ 2$AlBr_3$. 6.0 g Al is 0.222 mol Al and for 100% yield you would get 0.222 mole $AlBr_3$, weighing 0.222*266.68 = 59 g $AlBr_3$. 50.3*100/59 = 85% actual yield.

3-89. X_2Z: 40% X and 60% Z by mass; and from the chemical formula we know molX/molZ = 2 = $(40.0/A_x)/(60.0\ A_z)$ where A is the molar mass of X or Z, respectively. Solving 2 = $(40.0\ A_z)/(60.0\ A_x)$ we get $A_z = 3\ A_x$.

For XZ_2, its molar mass is $A_x + 2\ A_z = A_x + 2\ (3\ A_x) = 7\ A_x$. Thus, %X = $A_x/7A_x$ x 100 = 1/7 x 100 = 14.3 %. %Z = 100.0 % - 14.3 % = 85.7 % Z.

3-99. Always start with the balanced chemical equation….in this case the bets we can do is to balance element "M"

M_2S_3 ↦ 2 MO_2 We also know that 4.000 g M_2S_3 ends up forming 3.723 g MO_2.
So – from the chemical equation we know that 2 mol MO_2 = 1 mol M_2S_3.
Let A = molar mass of M –
this means 2(4.000 g M_2S_3)/(2A+3(32.07 g/mol S)) = 1(3.723 g MO_2)/(A+2 (16.00 g/mol O))
or 8.000 A + 256.0 = 7.446 A + 358.2, 0.554 A = 102.2, or A = 184 g/mol, atomic mass = 184 amu.

H.W.4 Ch.4: 13, 16, 19, 25, 29, 30, 35, 86*