3.091 Fall Term 2002

Homework #1

Solutions

1-9. (a) diamond, element, nonmetal
(b) brass, mixture, metals;
(1-3.) (c) soil, mixture, contains metal and nonmetals
(g) salt, compound, composed of metal and nonmetal
(h) iron, element, metal
(i) steel, mixture, metal

1-39. (1-22.)

	Z	A	e
^{31}P	15	31	15
^{18}O	8	18	8
$^{39}K^{+}$	19	39	18
$^{58}Ni^{2+}$	28	58	26

1-47. (1-23.) Three: ^{16}O, ^{17}O, ^{18}O.

1-48. (1-24.) All have the same number of protons but different numbers of neutrons.

1-49. (1-25.) 1.99268×10^{-23} g; 12.0000 amu

1-50. (1-26.) 1200.0 amu, 1300.3 amu

1-51. (1-27.) (b) The random selection will include isotopes ^{12}C and ^{13}C.

1-62. (1-28.) Fluorapatite, $Ca_5(PO_4)_3F$ contains 5 Ca^{2+} and 3 PO_4^{3-} ions, therefore, there is a charge of $(5)(+2) + 3(-3) = 10 - 9$ remaining after counting up the contribution of the Ca^{2+} and PO_4^{3-} ions. Since fluorapatite is a neutral molecule, the charge on the fluoride ion must be –1.

1-88. (1-44.) Since the atomic mass of an element is proportional to the relative percentages of its isotopes, this element would have a mass close to 11 amu. Boron with an atomic mass of 10.811 meets this criterion. The heavier isotope of boron would have 6 neutrons, 5 protons, and 5 electrons; the lighter would consist of 5 neutrons, 5 protons, and 5 electrons.

2-83. (2-65.) $$\text{mol C} = (194.2 \times 0.4948)\ \text{g} \times \frac{1\ \text{mol C}}{12.011\text{g}} = 8.000\ \text{mol C}$$

$$\text{mol H} = (194.2 \times 0.0519)\ \text{g} \times \frac{1\ \text{mol H}}{1.0079\,\text{g}} = 10.0\ \text{mol H}$$

$$\text{mol N} = (194.2 \times 0.2885)\ \text{g} \times \frac{1\ \text{mol N}}{14.0067\text{g}} = 4.000\ \text{mol N}$$

$$\text{mol O} = (194.2 \times 0.1648)\text{ g} \times \frac{1 \text{ mol O}}{15.999\text{g}} = 2.000 \text{ mol O}$$

The empirical formula of caffeine is $C_8H_{10}N_4O_2$

2-102. **(2-87.)** (a) $CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O$

(b) $2\ H_2S(g) + 3\ O_2(g) \rightarrow 2\ H_2O(g) + 2\ SO_2(g)$

(c) $2\ B_5H_9(g) + 12\ O_2(g) \rightarrow 5\ B_2O_3 + 9\ H_2O(g)$

2-123. **(2-108.)** $4\ P_4(s) + 5\ S_8(s) \rightarrow 4\ P_4S_{10}(s)$

0.500 mol P_4 × (4 mol P_4S_{10}) / (4 mol P_4) = 0.500 mol P_4S_{10}

0.500 S_8 × (4 mol P_4S_{10}) / (5 mol S_8) = 0.400 mol P_4S_{10}

Since S_8 produces fewer moles of P_4S_{10}, therefore it is the limiting reagent. If P_4 is doubled, S_8 is still the limiting reagent, and the amount of P_4S_{10} produced remains unchanged. If S_8 is doubled, then P_4 becomes the limiting reagent and the yield of P_4S_{10} rises to a value of 0.500 mol.

2-129. **(2-114.)** $Fe_2O_3(s) + 2\ Al(s) \rightarrow Al_2O_3(s) + 2\ Fe(l)$

$$150 \text{ g Al} \times \frac{1 \text{ mol Al}}{26.98\text{g}} \times \frac{2 \text{ mol Fe}}{2 \text{ mol Al}} = 5.56 \text{ mol Fe,}$$

$$250 \text{ g } Fe_2O_3 \times \frac{1 \text{ mol } Fe_2O_3}{159.7\text{g } Fe_2O_3} \times \frac{2 \text{ mol Fe}}{1 \text{ mol } Fe_2O_3} = 3.13 \text{ mol Fe,}$$

Therefore, the limiting reagent is Fe_2O_3. The amount of Fe produced is 175 g Fe.

2-173. **(2-128.)** Cocaine, $C_{17}H_{21}O_4N$, MW = 303.36 g/mol

➩ C = 67.31%; H = 6.98%; N = 4.62%; O = 21.10%

Aspirin, $C_9H_8O_4$, MW = 180.16 g/mol

➩ C = 60.00%; H = 4.48%; O = 35.52%

With a 7.31% difference in the amount of C and a 2.5% difference in the amount of H, it should be possible to distinguish between cocaine and aspirin by elemental analysis of carbon and hydrogen.