3.091 Fall Term 2004

Homework #1

Solutions

1-9. (a) diamond, element, nonmetal
(b) brass, mixture, metals;
(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.

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

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

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

1-49. 1.99268×10^{-23} g; 12.0000 amu

1-50. 1200.0 amu, 1300.3 amu

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

1-62. 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. Element X is a metal whose chemical properties are similar to potassium. There is only one isotope of element X. The mass of X in amu is 22.98976. Use the trends in masses in Table 1.4 to identify element X.

Answer: It is clear from the table that for the light elements the ratio of the atomic number to atomic mass is very close to 1:2. So the integer nearest to ½ of 22.98976 is 11. That makes the element sodium.

2-83.

$$\text{mol C} = (194.2 \times 0.4948)\ \text{g} \times \frac{1\ \text{mol C}}{12.011\ \text{g}} = 8.000\ \text{mol C}$$

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

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

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

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

2-102. (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. $4\ P_4(s) + 5\ S_8(s) \rightarrow 4\ P_4S_{10}(s)$

$0.500\ \text{mol } P_4 \times (4\ \text{mol } P_4S_{10}) / (4\ \text{mol } P_4) = 0.500\ \text{mol } P_4S_{10}$

$0.500\ S_8 \times (4\ \text{mol } P_4S_{10}) / (5\ \text{mol } S_8) = 0.400\ \text{mol } P_4S_{10}$

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. $Fe_2O_3(s) + 2\ Al(s) \rightarrow Al_2O_3(s) + 2\ Fe(l)$

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

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

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

2-173. 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.