TOPIC 1: STOICHIOMETRIC RELATIONSHIPS

1) Convert 4,672,000,000 into scientific notation. 4.672×10^9

2) Convert 0.000005210 into scientific notation. 5.210×10^{-6}

3) Convert 50.0 g to milligrams.

$$50.0\,g\left(\frac{1000\,mg}{1\,g}\right) = 50{,}000\,mg$$

4) Convert 150. dm^3 to liters.

$$150.\,dm^3\left(\frac{0.1\,m}{1\,dm}\right)^3\left(\frac{100\,cm}{1\,m}\right)^3\left(\frac{1\,mL}{1\,cm^3}\right)\left(\frac{1\,L}{1000\,mL}\right) = 150.\,L$$

5) How many significant figures are in the number 4.0070 x 1012? 4

6) An object has a mass of 40.1g and occupies a volume of 8.20 cm^3. What is the density of the object?

$$\frac{40.1\,g}{8.20\,cm^3} = 4.89\,g\,cm^{-3}$$

7) Calculate the percent yield if 28.0g of MgCl2 is produced, but 32.0g of MgCl2 should have been produced.

$$\frac{28.0\,g}{32.0\,g}(100) = 87.5\%\ yield$$

8) How many atoms are in 52.4g of nickel?

$$52.4\,g\,Ni\left(\frac{1\,mol\,Ni}{58.69\,g}\right)\left(\frac{6.02\times10^{23}\,Ni\,atoms}{1\,mol\,Ni}\right) = 5.37\times10^{23}\,Ni\ atoms$$

9) 6.00g of water contains how many moles of water?

$$6.00\,g\,H_2O\left(\frac{1\,mol\,H_2O}{18.02\,g}\right) = 0.333\,mol\,H_2O$$

10) What is the molar mass of methane?

CH_4 $\quad 12.01g + 4(1.01g) = 16.05\,g$

11) How many hydrogen atoms are in 3.0 moles of ethanol, C_2H_5OH?

$$3\,mol\,C_2H_5OH\left(\frac{6\,mol\,H}{1\,mol\,C_2H_5OH}\right)\left(\frac{6.02\times10^{23}\,H\,atoms}{1\,mol}\right) = 1.1\times10^{25}\,H\ atoms$$

12) What is the empirical formula of glucose, $C_6H_{12}O_6$?

$C_6H_{12}O_6 \div 6 = CH_2O$

13) A compound with an empirical formula of CH_2 has a molecular mass of 42.09. What is its molecular formula?

$CH_2 = 12.01g + 2(1.01g) = 14.03\,g$ EF mass

$42.09\,g \div 14.03\,g = 3$ $\qquad CH_2 \times 3 =$

C_3H_6

14) A compound of nickel has a mass composition of 37.9% nickel, 20.7% sulfur, and 41.4% oxygen. What is its empirical formula? * Assume a 100g sample.

$37.9\text{g Ni}\left(\frac{1\text{mol Ni}}{58.69\text{g}}\right) = 0.646\text{ mol Ni}$

$20.7\text{g S}\left(\frac{1\text{mol S}}{32.06\text{g}}\right) = 0.646\text{ mol S}$

$41.4\text{g O}\left(\frac{1\text{mol O}}{16.00\text{g}}\right) = 2.57\text{ mol O}$

$\div 0.646$

1 mol Ni

1 mol S

3.98 mol O ⇒ 4

$NiSO_4$

15) Aluminum and iron(III) oxide react to form iron and aluminum oxide. What mass of iron is produced from the reaction of 21.4g of aluminum and 91.3g of iron(III) oxide? What is the limiting reactant? What is the excess reactant?

$2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3$

$21.4\text{g Al}\left(\frac{1\text{mol Al}}{26.98\text{g}}\right)\left(\frac{1\text{mol Fe}}{1\text{mol Al}}\right)\left(\frac{55.85\text{g}}{1\text{mol Fe}}\right) = 44.3\text{g Fe}$

* LR.

$91.3\text{g } Fe_2O_3\left(\frac{1\text{mol } Fe_2O_3}{159.70\text{g}}\right)\left(\frac{2\text{mol Fe}}{1\text{mol } Fe_2O_3}\right)\left(\frac{55.85\text{g}}{1\text{mol Fe}}\right) = 112.\text{g Fe}$

* ER.

Al is LR

Fe_2O_3 is ER.

16) What volume of nitrogen forms when 100. g of ammonia, NH_3, decomposes completely into its elements at STP?

$2NH_3 \rightarrow N_2 + 3H_2$

$100.\text{g } NH_3\left(\frac{1\text{mol } NH_3}{17.04\text{g}}\right)\left(\frac{1\text{mol } N_2}{2\text{mol } NH_3}\right)\left(\frac{22.4\text{dm}^3}{1\text{mol } N_2}\right) = 65.7\text{dm}^3$

17) A helium party balloon has a volume of 12.0L. At room temperature (25°C) the internal pressure is 1.05atm. Calculate the number of moles of helium in the balloon.

$PV = nRT$

$n = \frac{PV}{RT}$

$R = 8.31\text{JK}^{-1}\text{mol}^{-1}$

$n = \frac{(1.06\times10^5\text{Pa})(0.0120\text{m}^3)}{(8.31\text{JK}^{-1}\text{mol}^{-1})(298.15\text{K})} = 0.513\text{mol}$

$V = 12.0\text{L}\left(\frac{1\text{m}^3}{1000\text{L}}\right) = 0.0120\text{m}^3$

$P = 1.05\text{atm}\left(\frac{1.01\times10^5\text{Pa}}{1\text{atm}}\right) = 1.06\times10^5\text{Pa}$

$T = 25 + 273.15 = 298.15\text{K}$

18) The gas left in a used aerosol can is at a pressure of 1.00atm at 27.0°C. If this can is thrown into a fire, what is the pressure of the gas when its temperature reaches 927 °C?

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$P_2 = \frac{P_1T_2}{T_1}$

$P_2 = \frac{(1.01\times10^5\text{Pa})(1200.15\text{K})}{300.15\text{K}} = 1.01\times10^5\text{Pa}$

$P_1 = 1.00\text{atm}\ 1.01\times10^5\text{Pa}$

$T_1 = 27.0 + 273.15 = 300.15\text{K}$

$T_2 = 927 + 273.15 = 1200.15\text{K}$

19) The volume of a gas is 20.0L at 275K and 92.1kPa. Find its volume at STP.

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$V_2 = \frac{P_1V_1T_2}{T_1P_2}$

$V_2 = \frac{(9.21\times10^4\text{Pa})(0.020\text{m}^3)(273\text{K})}{(275\text{K})(10^5\text{Pa})} = 1.8\times10^{-2}\text{m}^3$

$20.\text{L}\left(\frac{1\text{m}^3}{1000\text{L}}\right)\left(\frac{1\text{m}}{100\text{cm}}\right)^3 = 0.02\text{m}^3$

$P_1 = 92.1\text{kPa}\left(\frac{1000\text{Pa}}{1\text{kPa}}\right) = 9.21\times10^4\text{Pa}$

20) What volume of 18.0M sulfuric acid is required to prepare 16.5dm³ of 0.126M sulfuric acid?

$M_1V_1 = M_2V_2$

$V_1 = \frac{M_2V_2}{M_1}$

$\frac{(0.126\text{M})(16.5\text{dm}^3)}{18.0\text{M}} = 0.116\text{dm}^3$ or 116cm^3

Challenge Problems

1) The white limestone cliffs of Dover, England contain a large percentage of calcium carbonate. A sample of limestone with a mass of 84.4g reacts with an excess of hydrochloric acid to form calcium chloride water and carbon dioxide gas. The mass of calcium chloride formed from this reaction is 81.8g, what is the percentage of calcium carbonate in the limestone?

Limestone 84.4g → $CaCO_3$? g

↓ +HCl

$CaCl_2$ 81.8g

$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$

(1) Back Calculate to g $CaCO_3$ in the limestone.

$$81.8\,g\,CaCl_2\left(\frac{1\,mol\,CaCl_2}{110.98\,g}\right)\left(\frac{1\,mol\,CaCO_3}{1\,mol\,CaCl_2}\right)\left(\frac{100.09\,g\,CaCO_3}{1\,mol\,CaCO_3}\right) = 73.77\,g\,CaCO_3$$

(2) Calculate % using ↗

$$\frac{73.77\,g\,CaCO_3}{84.4\,g\,limestone} = 87.4\%\ CaCO_3 \text{ in the limestone}$$

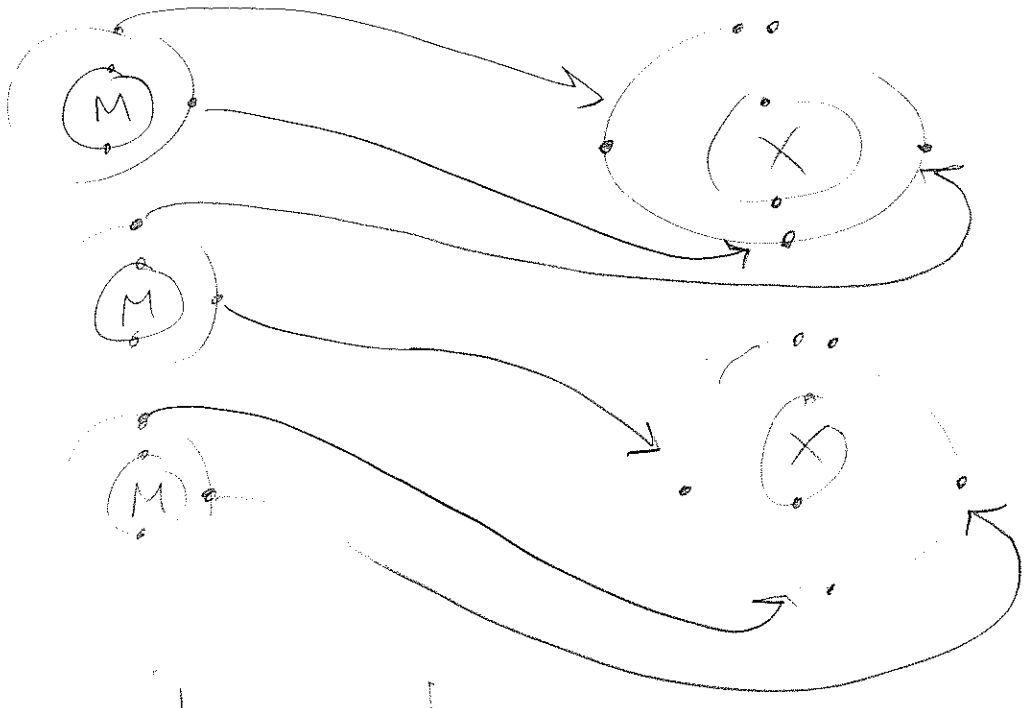
2) Two elements are to be combined to form a balanced compound. The first element, M (fictitious), has two valence electrons. The second (fictitious) element, X, has five valence electrons. Show, using Bohr models and describe using words how many M's and how many X's will come together to form a balanced ionic compound.

* M will loose e⁻ & X will gain e⁻.

M looses 2 & X need's 3 ⇒ need a common denominator

3M + 2X

(3×2=6) (2×3=6)



M_3X_2

3) The following information concerns <u>six consecutive elements in the periodic table</u>. Study the information carefully and then identify each element.

<u>Element A</u> is a diatomic gas at room temperature. It combines with element B to form a compound B_2A.

<u>Element B</u> reacts with water to produce heat and causes rapid movement across the surface of the water. Element B reacts with element F to form the compound BF.

<u>Element C</u> is a diatomic gas at room temperature. 22.4 liters of the gas at 0°C and a pressure of 1.0 atm weighs 28.0g.

<u>Element D</u> is a gas that does not form compounds with anything.

<u>Element E</u> is a non-metal solid that in some forms can conduct electricity moderately. It combines with element A to form common compounds EA and EA_2.

<u>Element F</u> exists as a diatomic gas at room temperature. It is the most reactive nonmetal of all the elements in this question.

A = N, O, F, Cl, Br, I, H → -2 → O

B = reactive metal → +1 ~~or +2~~ → Na

C = N, O, F, Cl, Br, I, H → 1 mol = 28g ⇒ Molar Mass = 14g → N

D = nobel gas Ne .. Ar

E = C or Si → C

F = N, O, F, Cl, Br, I, H → ~~F, O~~, Cl

C, N, O, F, Ne, Na

4) A fundamental feature of stoichiometric calculations and using dimensional analysis is the canceling of units. Using the following equation and constant prove that the units do in fact cancel.

$R = 8.31\ J\ K^{-1}\ mol^{-1}$, pressure in Pa, temperature in K, n in mols, volume in m^3

The ideal gas law states that PV=nRT, solve for R and prove that the units are equal on both sides of the equation. (some research into units may be needed here, the Internet will help)

$PV = nRT$

$R = \frac{PV}{nT}$ $\qquad R = \frac{Pa \cdot m^3}{mol \cdot K}$

$J\ K^{-1}\ mol^{-1} = Pa\ m^3\ mol^{-1}\ K^{-1}$

$Pa = N\ m^{-2}$

$J = Pa\ m^3$

$J = N\ m^{-2}\ m^3$

$J = N\ m$ ✓