Name (**in ink**) ANSWER KEY

Student Number (**in ink**) ____________________

Fall 2012 SC/CHEM 1000 A - Quiz #1

October 4, 2012

Calculators are permitted.
Answer all questions on this paper; **additional paper for rough work is not permitted. You may carry out your work in pencil if you wish, but please write your final answer in ink.**

Time Allowed: 50 minutes

Total Marks = 30

1. **(4 pts)** Magnesium metal reacts with dilute sulfuric acid according to the equation

$$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$$

How many grams of magnesium are required to react with excess $H_2SO_4(aq)$ to give 174.1 mL of $H_2(g)$ at 1.00 atm pressure and 28°C.?

$$n = \frac{PV}{RT} = \frac{(1.00\ atm)(0.1741\ L)}{(0.08206\ L\ atm\ K^{-1}\ mol^{-1})(301.15\ K)} = 7.045 \times 10^{-3}\ mol$$

$$n_{H_2} = n_{Mg}$$

$$m = (24.31\ g\ mol^{-1})(7.045 \times 10^{-3}\ mol) = 0.171\ g\ Mg$$

2. **(6 pts)** Solid copper oxide reacts with ammonia gas according to the following equation,

$$3\ CuO(s) + 2\ NH_3(g) \rightarrow 3\ Cu(s) + N_2(g) + 3\ H_2O(g)$$

50.0g of CuO(s) was placed in an 80.0L reaction vessel, and the vessel was evacuated. Ammonia gas was then gradually introduced into the vessel, slow enough for the reaction to proceed, until the total pressure in the vessel (after reaction) was 1.00 atm. What are the partial pressures of all three gases in the vessel?

$M_{CuO} = 79.55\,g\ mol^{-1}$ $\quad T = 180°C = 453.15K$

$50.0g\ CuO = 0.6285\ mol\ CuO$

$P_{NH_3} + P_{N_2} + P_{H_2O} = 1.00\ atm$

$$n_{TOT} = \frac{PV}{RT} = \frac{(1.00\ atm)(80.0L)}{(0.08206\ L\ atm\ K^{-1}mol^{-1})(453.15K)}$$

$n_{TOT} = 2.151\ mol$

n_{N_2} from RXN $= \frac{1}{3} n_{CuO} = 0.2095\ mol$

$n_{H_2O} = n_{CuO} = 0.6285\ mol$

$\}$ $0.8380\ mol < 2.151$

$\therefore\ n_{NH_3}$ must be $2.151 - 0.8380 = 1.313\ mol$

$$P_x = \frac{n_x RT}{V} = \frac{(0.08206\ L\ atm\ K^{-1}mol^{-1})(453.15K)}{80.0L} n_x$$

$P_x = 0.4648\ n_x$

$P_{NH_3} = 0.610\ atm$

$P_{N_2} = 0.0974\ atm$

$P_{H_2O} = 0.2921\ atm$

3. **(6 pts)** 2.41g of a gaseous compound containing only boron and hydrogen was transferred to a previously evacuated 2.22 L flask. After the transfer, the pressure in the flask was measured to be 730 torr at 25°C. What is the molecular formula of the compound?

$$PV = nRT$$

$$n = \frac{m}{M}$$

$$\therefore \quad PV = \frac{mRT}{M}$$

$$M = \frac{mRT}{PV} = \frac{(2.41\,g)(0.08206\,L\,atm\,K^{-1}\,mol^{-1})(298.15\,K)}{(0.9605\,atm)(2.22\,L)}$$

$$M = 27.65\,g\,mol^{-1}$$

$$B_xH_y \approx 27.7\,g\,mol^{-1}$$

$$B_2H_6 \Rightarrow 27.7\,g\,mol^{-1}$$

4. **(8 pts)** A tubular fluorescent lamp in a fully evacuated supply compartment on the international space station was originally filled with a small amount of mercury vapour. When the lamp began to flicker the astronauts concluded there was a tiny hole in the tube. They measured that the pressure inside the tube dropped from 2.31 torr to 2.09 torr after 24 hours. The volume of the tube is 1.39L. The temperature of the compartment was constant at 82K over the 24 hour period. Please calculate the diameter of the hole in millimeters (assuming it is round).

$$PV = nRT = \frac{N}{N_A}RT$$

$$P = \frac{NRT}{VN_A}$$

$$\frac{N}{V} = \frac{PN_A}{RT}$$

$$z_w = \frac{N}{4V}\left(\frac{8RT}{\pi M}\right)^{1/2}$$

$$z_w = \frac{PN_A}{4RT}\left(\frac{8RT}{\pi M}\right)^{1/2}$$

For P we can take initial P of 2.31 torr or avg P of 2.20 torr. We'll do the latter.

$$z_w = \frac{(2.895\times10^{-3}\text{ atm})(6.022\times10^{23}\text{ mol}^{-1})}{4(0.08206\text{ L atm K}^{-1}\text{mol}^{-1})(82K)}\left[\frac{8(8.3155\text{ J K}^{-1}\text{mol}^{-1})(82K)}{\pi(0.20059\text{ Kg mol}^{-1})}\right]^{1/2}$$

$$= 6.477\times10^{19}\text{ L}^{-1}\left(8.657\times10^{3}\text{ J Kg}^{-1}\right)^{1/2}$$

$$= 6.026\times10^{21}\text{ J}^{1/2}\text{Kg}^{-1/2}\text{L}^{-1} = 6.026\times10^{21}\frac{(\text{Kg m}^2\text{s}^{-2})^{1/2}}{\text{Kg}^{1/2}\text{L}}$$

$$= 6.026\times10^{21}\frac{\text{Kg}^{1/2}\text{m s}^{-1}}{\text{Kg}^{1/2}\text{L}} = 6.026\times10^{21}\frac{\text{m}}{\text{L S}}\left(\frac{1000\text{ L}}{\text{m}^3}\right)$$

$$= 6.026\times10^{24}\text{ m}^{-2}\text{s}^{-1}$$

(OVER)

$$Z_W = 6.026 \times 10^{24}\ m^{-2} s^{-1}$$

$$PV = nRT$$

$$n = \frac{V}{RT} P$$

$$\Delta n = \frac{V}{RT} \Delta P = \frac{1.39\,L}{(0.08206\ L\,atm\,K^{-1}\,mol^{-1})(82K)} (2.895 \times 10^{-4}\ atm)$$

$$= 5.980 \times 10^{-5}\ mol \Rightarrow 3.601 \times 10^{19}\ atoms$$

$$N_{LEAK} = Z_W A t$$

$$A = \frac{N_{LEAK}}{Z_W\, t} = \frac{3.601 \times 10^{19}}{(6.026 \times 10^{24}\ m^{-2} s^{-1})(8.64 \times 10^{4} s)} = 6.916 \times 10^{-11}\ m^2$$

$$\pi r^2 = 6.916 \times 10^{-11}\ m^2$$

$$r = 4.693 \times 10^{-6}\ m$$

$$d = 9.4 \times 10^{-6}\ m = 9.4\ \mu m$$

5. The van der Waals constants for tetrachloromethane (CCl_4) are a = 20.4 L^2atm mol^{-2} and b = 0.1383 L mol^{-1}.

(a) **(4 pts)** What pressure will 0.120 mol of $CCl_4(g)$ occupy at 65 °C in a 6.0L vessel?

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

$$\left[P + \frac{(20.4\,L^2\,atm\,mol^{-2})(0.120\,mol)^2}{(6.0L)^2}\right]\left[6.0L - (0.120\,mol)(0.1383\,L\,mol^{-1})\right]$$

$$= 0.120\,mol\,(0.08206\,L\,atm\,K^{-1}\,mol^{-1})(338.15\,K)$$

$$(P + 8.160\times10^{-3}\,atm)(5.983\,L) = 3.33\,L\,atm$$

$$P + 8.160\times10^{-3} = 0.5565$$

$$P = 0.548\,atm = 0.55\,atm$$

To 2 sig figs

(b) **(2 pts)** How many torr difference is the real pressure from the ideal pressure under the same volume and temperature conditions?

$$P_{IDEAL} = \frac{nRT}{V} = \frac{(0.120\,mol)(0.08206\,L\,atm\,K^{-1}\,mol^{-1})(338.15\,K)}{6.0\,L}$$

$$P_{IDEAL} = 0.555\,atm$$

$$\Delta P = 0.555 - 0.548 = 7.000\times10^{-3}\,atm = 5.3\,torr$$