Chem 127
Prof. Mark Jensen
Exam #1
9/26/08

Name KEY

Pledge:
When you have completed this exam, please consider the following:

I affirm that I have neither committed nor witnessed a violation of academic integrity in the completion of this exam.

Signed _____

Answer the questions on the following pages, paying strict attention to **significant figures** where applicable. Answers given without supporting work WILL NOT be given full credit.

Some potentially useful information: $N = 6.022 \times 10^{23}$

1 in = 2.54 cm 1 mi = 1760 yd 1 yd = 36 in

1 lb = 453.6 g 1 ft = 12 in 1 gallon = 3.785 dm^3

1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 —	9 VIIIB	10 —	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1 **H** 1.008																	2 **He** 4.00
3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.71	29 **Cu** 63.54	30 **Zn** 65.37	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.91	36 **Kr** 83.30
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** 98.91	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.4	47 **Ag** 107.87	48 **Cd** 112.40	49 **In** 114.82	50 **Sn** 118.69	51 **Sb** 121.75	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.30
55 **Cs** 132.91	56 **Ba** 137.34	71 **Lu** 174.97	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.85	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.09	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.37	82 **Pb** 207.19	83 **Bi** 208.98	84 **Po** 210	85 **At** 210	86 **Rn** 222
87 **Fr** 223	88 **Ra** 226.03	103 **Lr** 262.1	104 **Rf**	105 **Db**	106 **Sg**	107 **Bh**	108 **Hs**	109 **Mt**									

57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** 146.92	62 **Sm** 150.35	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.92	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04
89 **Ac** 227.03	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** 237.05	94 **Pu** 239.05	95 **Am** 241.06	96 **Cm** 247.07	97 **Bk** 249.08	98 **Cf** 251.08	99 **Es** 254.09	100 **Fm** 257.10	101 **Md** 258.10	102 **No** 255

1. (12 pts) Zinc metal reacts with aqueous hydrochloric acid (HCl) to produce hydrogen gas (H_2) and aqueous zinc chloride ($ZnCl_2$).

   a) Write the balanced equation for this reaction.

$$Zn_{(s)} + 2\,HCl_{(aq)} \longrightarrow H_{2(g)} + ZnCl_{2(aq)}$$

   b) How many milliliters of 0.120 M HCl would be needed to react completely with 4.7 g of zinc?

$$(4.7\text{ g Zn})\left(\frac{1\text{ mol Zn}}{65.37\text{ g Zn}}\right)\left(\frac{2\text{ mol HCl}}{1\text{ mol Zn}}\right) = 0.14_4\text{ mol HCl}$$

$$\text{mol} = M \cdot V$$

$$V = \frac{\text{mol}}{M} = \frac{0.14_4\text{ mol HCl}}{0.120\text{ mol/L}} = 1.2\text{ L}$$

$$= \boxed{1.2 \times 10^3\text{ mL}}$$

2. (10 pts) Perform the following conversions:

   a) 9.75×10^{-4} cubic micrometers to cubic feet

$$\left(9.75\times10^{-4}\,\mu m^3\right)\left(\frac{10^{-6}\text{ m}}{\mu m}\right)^3\left(\frac{100\text{ cm}}{m}\right)^3\left(\frac{1\text{ in}}{2.54\text{ cm}}\right)^3\left(\frac{ft}{12\text{ in}}\right)^3$$

$$= 3.44\times10^{-20}\,ft^3$$

   b) 32.0 miles per gallon to kilometers per liter

$$\left(\frac{32.0\text{ miles}}{gal}\right)\left(\frac{1760\text{ yd}}{mi}\right)\left(\frac{36\text{ in}}{yd}\right)\left(\frac{2.54\text{ cm}}{in}\right)\left(\frac{m}{100\text{ cm}}\right)\left(\frac{km}{1000\text{ m}}\right)\cdots$$

$$\left(\frac{gal}{3.785\,dm^3}\right)\left(\frac{dm^3}{L}\right) = 13.6\text{ km/L}$$

3. (20 pts) One of the steps in the commercial process for converting ammonia (NH_3) to nitric acid is the conversion of NH_3 to NO: $NH_3(g) + O_2(g) \rightarrow NO(g) + H_2O(g)$ (unbalanced)

a) Write the balanced equation for this reaction. (Hint: the coefficients in front of NH_3 and NO need to be the same.)

$$4\ NH_{3(g)} + 5\ O_{2(g)} \rightarrow 4\ NO_{(g)} + 6\ H_2O_{(g)}$$

b) How many grams of NO could be made if 1.50 g of NH_3 reacts with 2.75 g of O_2?

$$(1.50\ g\ NO)\left(\frac{1\ mole\ NO}{17.034\ g}\right)\left(\frac{4\ mole\ NO}{4\ mole\ NH_3}\right)\left(\frac{30.01\ g\ NO}{mole\ NO}\right) = 2.64_3\ g\ NO$$

$$(2.75\ g\ O_2)\left(\frac{1\ mol\ O_2}{32.00\ g\ O_2}\right)\left(\frac{4\ mole\ NO}{5\ mole\ O_2}\right)\left(\frac{30.01\ g\ NO}{mole\ NO}\right) = \underline{2.06_3\ g\ NO}$$

↑ limiting reactant

theoretical yield

$$\Rightarrow \boxed{2.06\ g\ NO}$$

c) If the percent yield using the starting amounts in part *b* was 67.3%, how much NO was actually formed?

$$\%\ yield = \frac{actual}{theoretical} \times 100$$

$$67.3 = \frac{actual}{2.06_3} \times 100$$

$$\boxed{actual = 1.39\ g\ NO}$$

4. (14 pts) Glycerol, $C_3H_8O_3$, is a substance used extensively in the manufacture of cosmetics, foodstuffs, antifreeze, and plastics. Pure glycerol is a water soluble liquid with a density of 1.2656 ~~g/L~~ g/mL at 15°C.

   a) Calculate the molarity of a solution of glycerol made by dissolving 40.000 mL of pure glycerol at 15°C in enough water to make 350.00 mL of solution.

$$(40.000\ \text{mL gly})\left(\frac{1.2656\ \text{g gly}}{1\ \text{mL gly}}\right)\left(\frac{1\ \text{mol gly}}{92.094\ \text{g gly}}\right) = 0.54970\ \text{mol}$$

$$\frac{.54970\ \text{mol}}{.35000\ \text{L}} = 1.5706\ \text{M}$$

   b) What would be the concentration of glycerol in a solution made by taking 20.00 mL of the solution in part *a* and diluting with water to a final volume of 400.0 mL?

$$M_1V_1 = M_2V_2$$

$$(1.5706\ \text{M})(20.00\ \text{mL}) = M_2(400.0\ \text{mL})$$

$$M_2 = 0.07853\ \text{M}$$

5. (26 pts) Compound X is known to contain only carbon, hydrogen, and oxygen. Combustion analysis of a 2.93-g sample of compound X yields 5.05 g of carbon dioxide and 1.55 g of water.

a) What is the empirical formula of compound X?

$$(5.05\text{ g } CO_2)\left(\frac{1\text{ mol } CO_2}{44.00\text{ g } CO_2}\right)\left(\frac{1\text{ mol C}}{1\text{ mol } CO_2}\right)\left(\frac{12.011\text{ g C}}{\text{mol C}}\right) = 1.3785\text{ g C}$$

$$= .1148\text{ mol C}$$

$$(1.55\text{ g } H_2O)\left(\frac{1\text{ mol } H_2O}{18.01\text{ g } H_2O}\right)\left(\frac{2\text{ mol H}}{1\text{ mol } H_2O}\right)\left(\frac{1.0079\text{ g H}}{\text{mol H}}\right) = 0.173\text{ g H}$$

$$= .1721\text{ mol H}$$

$$2.93\text{ g C+H+O} - 1.3785\text{ g C} - 0.173\text{ g H} = 1.38\text{ g O}\left(\frac{1\text{ mol O}}{16.00}\right) = .0862\text{ mol O}$$

$$C_{\frac{.1148}{.0862}}H_{\frac{.1721}{.0862}}O_{\frac{.0862}{.0862}}$$

$$C_{1.33}H_{2.00}O_1 \times 3$$

$$\boxed{C_4H_6O_3}$$

b) If the molecular weight of X is in the range of 400-425 amu, what is its molecular formula?

$C_4H_6O_3$: $4(12.01) + 6(1.008) + 3(16.00) = 102.09$

$\times 4$

$\times 4$

$$\boxed{C_{16}H_{24}O_{12}}$$

408.36 g/mol

c) What would be the mass in kilograms of 3.15×10^{27} molecules of compound X?

$$(3.15\times10^{27}\text{ molecules})\left(\frac{1\text{ mol X}}{6.022\times10^{23}\text{ molecules X}}\right)\left(\frac{408.36\text{ g X}}{\text{mol X}}\right)\left(\frac{\text{kg}}{1000\text{ g}}\right)$$

$$= 2.14\times10^{3}\text{ kg}$$

d) How many hydrogen atoms are there in 3.70 ng of compound X?

$$(3.70\times10^{-9}\text{ g X})\left(\frac{1\text{ mol X}}{408.36\text{ g X}}\right)\left(\frac{6.022\times10^{23}\text{ molecules}}{1\text{ mol X}}\right)\left(\frac{24\text{ H atoms}}{\text{molecule}}\right)$$

$$= 1.31\times10^{14}\text{ H atoms}$$

6. (18 pts) Multiple choice / Fill in the blank

A. Graphite and diamond are two _____ of carbon.

a) elements
b) isotopes
c) formulas
d) ions
e) allotropes

B. The mass of 6.022×10^{23} molecules of oxygen gas (O_2) is 32.00 g, and the average mass of one molecule of oxygen gas is 32.00 amu.

C. Which of the following statements ~~are~~ is NOT consistent with Dalton's atomic theory?

a) Atoms can change partners in a chemical reaction.
b) Two elements can combine together to form more than one compound.
c) One element can be converted into another in a nuclear reaction.
d) One gram of water has the same mass percentages of hydrogen and oxygen as one kilogram of water.
e) The properties of nitrogen are different from the properties of oxygen.

D. Which of the following is NOT considered to be one of the five traditional branches of chemistry?

a) molecular
b) analytical
c) physical
d) inorganic
e) biochemistry

E. The symbols of the four most abundant elements in the earth's crust, oceans, and atmosphere are (in order, highest to lowest):

1: O 2: Si 3: Al 4: Fe

F. An instrument that allows scientists to "see" atoms is the:

a) gas chromatograph – mass spectrometer microscope
b) atomic imaging microscope
c) scanning tunneling microscope
d) electron diffraction microscope
e) ion beam reflecting microscope

G. Which of the following is not an SI base unit?

a) meter
b) liter
c) kilogram
d) mole
e) Kelvin

Remember to consider the pledge!!