Chem 105 Exam 3 Name Key

This exam is schedule for 75 minutes and I anticipate it to take the full time allotted. You are free to leave if you finish. In multiple part problems, points awarded will not be penalized for incorrect answer on previous parts, so simply **move on if you get stuck on one part**. If you need to, make up an answer for the previous part. Always neatly show work for partial credit.

Equations and constants:

$E = h\nu$ $\quad c = 2.998\ x\ 10^{8}\ {}^{m}/_{s}$ $\quad c = \lambda\nu$ $\quad h = 6.626\ x\ 10^{-34} J$

$E_n = \frac{-2.18x10^{-18} J}{n^2}$ $\quad KE = \frac{1}{2}mv^2$ $\quad E_{coulomb} = 231pm \cdot aJ \frac{q_1 q_2}{r}$

$m_{electron} = 9.109x10^{31} kg$ $\quad \lambda = \frac{h}{mv}$ $\quad V_{cylinder} = \pi r^2 h$

$PV = nRT$ $\quad R = 0.08206\ \frac{L \cdot atm}{mol \cdot K}$

$P = \frac{F}{area}$ $\quad F = ma$

$1atm = 760\ mmHg = 760\ torr$ $\quad 1atm = 1.01325\ bar$ $\quad 1atm = 101325\ Pa$

1. How many oxygen atoms are found in 14.25 grams of sodium carbonate?

$14.25\ g\ Na_2CO_3 \left| \frac{mol}{105.99\ g} \right| \frac{3\ mol\ O}{1\ mol\ Na_2CO_3} \left| \frac{6.022 \times 10^{23}\ atoms}{1\ mol} \right.$

Na_2CO_3

$105.99\ g$

2.429×10^{23} atoms

2. Determine $[NO_3^-]$ when 36.224 g of magnesium nitrate is dissolved in 1.86 L of water.

$Mg(NO_3)_2 = 148.33\ g/mol$

$36.244\ g\ Mg(NO_3)_2 \left| \frac{mol}{148.33\ g} \right| \frac{2\ mol}{1\ mol\ Mg(NO_3)_2} = \frac{0.489\ mol\ NO_3^-}{1.86\ L} = 0.262\ M$

3. What is the mass of oxygen found in 244.5 mL of dinitrogen oxide gas at 3.64 atm and 145 °C

$n = \frac{PV}{RT} = \frac{(3.64\ atm)(0.2445\ L)}{\left(0.08206\ \frac{L \cdot atm}{mol\ K}\right)(145 + 273.15)} = 0.0259\ mol\ N_2O \left| \frac{1\ mol\ O}{1\ mol\ N_2O} \right. = 0.0259\ mol$

$0.0259\ mol\ O \left| \frac{16\ g}{mol} \right. = 0.4144\ g$

4. Determine the empirical formula of a compound that is 3.26% hydrogen, 19.36% carbon, and 77.38% oxygen.

$3.26\ g\ H \left| \frac{mol}{1.01\ g} \right. = 3.23 \div 1.62 = 2$

$19.36\ g\ C \left| \frac{mol}{12.01\ g} \right. = 1.62 \div 1.62 = 1$

$77.38\ g\ O \left| \frac{mol}{16\ g} \right. = 4.84 \div 1.62 = 3$

H_2CO_3

5. Barium sulfate can be made when aluminum sulfate is mixed together with barium nitrate.
   a. Write a balanced reaction.

$Al_2(SO_4)_3(aq) + 3Ba(NO_3)_2(aq) \rightarrow 2Al(NO_3)_3(aq) + 3BaSO_4(s)$

   b. What type of reaction is described here? double displacement

   c. Write a net ionic equation for this reaction.

$Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4(s)$

   d. If 5.000 grams of each reactant are combined, determine the mass of barium sulfate that will be made if the reaction proceeds with a 90% yield.

$Al_2(SO_4)_3 \rightarrow 342.17\ g/mol$ $\quad Ba(NO_3)_2 \rightarrow 261.35\ g/mol$ $\quad BaSO_4 \rightarrow 233.4\ g/mol$

$$5\ g\ Al_2(SO_4)_3 \left| \frac{mol}{342.17\ g} \right| \frac{3\ mol\ BaSO_4}{1\ mol} \left| \frac{233.4\ g}{mol} \right| = 10.23\ g$$

$$5\ g\ Ba(NO_3)_2 \left| \frac{mol}{261.35\ g} \right| \frac{3\ mol}{3\ mol} \left| \frac{233.4\ g}{mol} \right| = 4.465\ g\ BaSO_4 \quad \times 0.9 = \boxed{4.019\ g}$$

6. Write a balanced reaction for the combustion of solid $C_{15}H_{33}$.

$4C_{15}H_{33}(s) + 93O_2(g) \rightarrow 60CO_2(g) + 66H_2O(g)$

7. 172 mL of water is added to a flask containing 300 mL of 655 mM NaCl. What is the new concentration of the solute?

$$\frac{300\ mL \mid 10^{-3}\ L \mid 655\ mmol}{1\ mL \mid\ L} = \frac{196.5\ mmol}{0.3 + 0.172\ L} = 416.3\ mM$$

8. A flask contains 3.2 moles of an ideal gas at 120 °C. If another 4.4 moles of the gas is added to the flask without changing the volume of pressure, determine the new temperature.

variables n & T $\qquad PV = nRT \qquad \frac{PV}{R} = nT$

$$n_1T_1 = n_2T_2$$

$$3.2\,(120 + 273.15) = (3.2 + 4.4)\,T_2 \qquad T_2 = 165.54\ K$$

$$T_2 = -107.6\ °C$$

9. For each pair, identify which compound will be more soluble in C_8H_{18}. **Clearly justify your answer.**
   a. H_2O or H_2S — non-polar
   b. NCl_3 or PCl_3 — non-polar
   c. $NaCO_3$ or SO_3 — ionic; polar ← more likely to dissolve in non-polar solvent

10. Consider the following reaction:

$$4\ HNO_3\ (aq) + Cu\ (s) \rightarrow Cu(NO_3)_2\ (aq) + 2\ NO_2\ (g) + 2\ H_2O\ (l)$$

58.6 mL of 4.12 M HNO_3 is added to a flask containing 3604 mg of solid copper. If the reaction occurs in a 4.00 L flask held at 100 °C, determine each of the following:

a. The total pressure in the after the reaction completes. 0.868 atm

b. The concentration of $Cu(NO_3)_2$ that is produced. 968 mM.

c. The mass of Cu (s) remaining. ∅ mg

d. The concentration of HNO_3 remaining. 249 mM

$0.0586\ L \mid \frac{4.12\ mol\ HNO_3}{L} \mid \frac{2\ NO_2}{4\ HNO_3} = 0.1207\ mol\ NO_2$

$3.604\ g\ Cu \mid \frac{mol}{63.55\ g} \mid \frac{2\ HNO_3}{1\ Cu} = 0.1134\ mol\ NO_2$

$P = \frac{nRT}{V} = \frac{0.1134\ (0.0826)(373.15)}{4}$

$0.1134\ mol\ NO_2 \mid \frac{1\ Cu(NO_3)_2}{2\ NO_2} = \frac{0.0567\ mol\ Cu(NO_3)_2}{0.0586\ L} = 0.968\ M$

$0.1134\ mol\ NO_2 \mid \frac{4\ HNO_3}{2\ NO_2} = 0.2268\ mol\ used$

$0.0586\ L \mid \frac{4.12\ mol}{L} = 0.2414\ mol\ @\ start$

$0.2414 - 0.2268 = \frac{0.0146\ mol}{0.0586\ L}$

$[HNO_3] = 0.249\ M$

11. Consider the combustion of an unknown compound ($C_xH_yN_z$). Exactly 30 grams of this compound is combusted in a 1.5 L flask at a constant temperature of 300 K. After the combustion reaction completes, 8.327 atm of CO_2, 12.490 atm of H_2O, and 2.776 atm of NO_2 is produced.

    a. What is the empirical formula of this compound?

CO_2 $n = \frac{(8.327)(1.5)}{(0.08206)(300)} = 0.507 \text{ mol } CO_2 \left| \frac{1 \text{ mol C}}{1 \text{ mol } CO_2} \right. = 0.507 \text{ mol C} \div 0.169 = 3$

H_2O $n = \frac{(12.490)(1.5)}{(0.08206)(300)} = 0.761 \text{ mol } H_2O \left| \frac{2 \text{ H}}{1 H_2O} \right. = 1.522 \text{ mol H} \div 0.169 = 9$

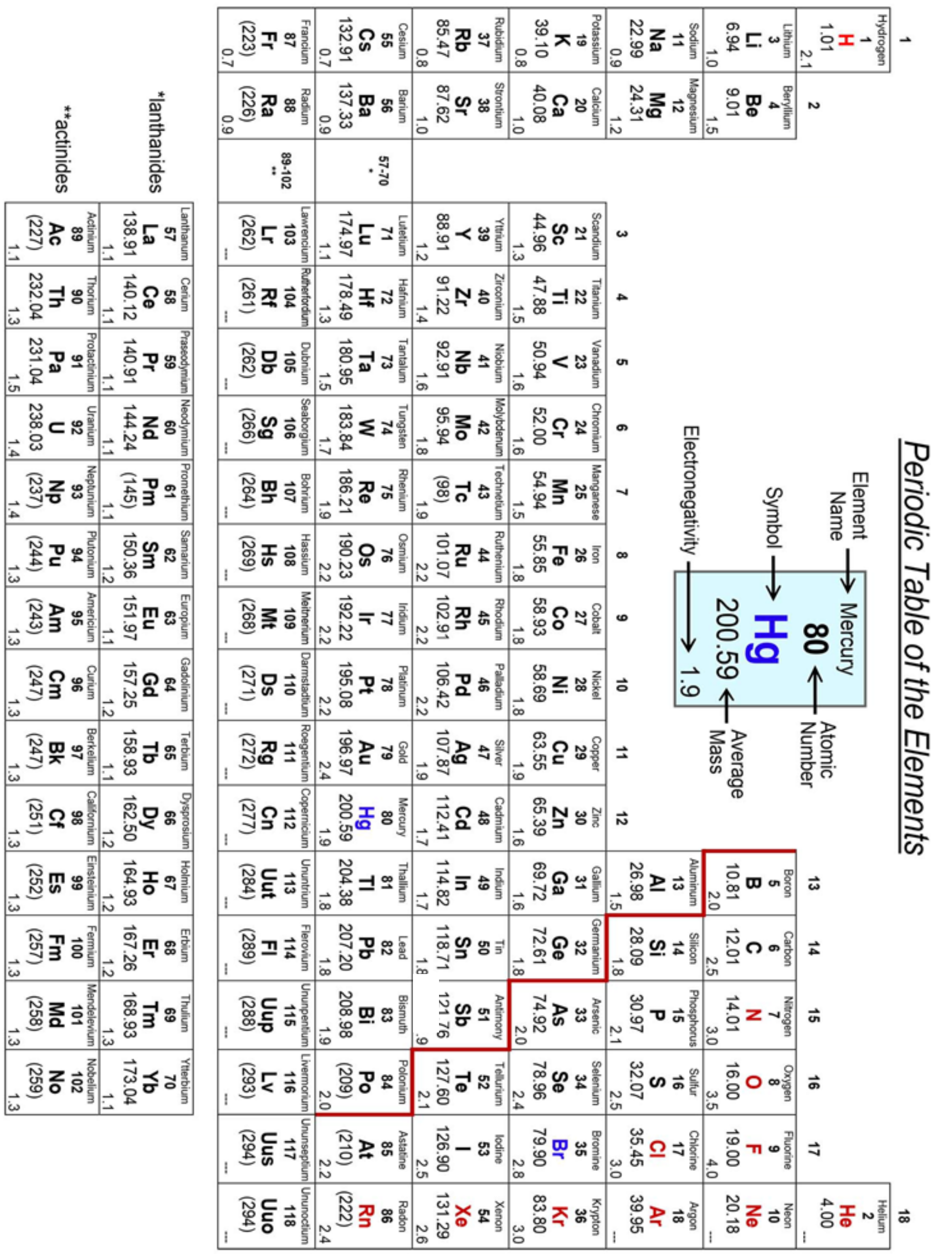
NO_2 $n = \frac{(2.776)(1.5)}{(0.08206)(300)} = 0.169 \text{ mol } NO_2 \left| \frac{1 \text{ N}}{1 NO_2} \right. = 0.169 \text{ mol N} \div .169 = 1$

C_3H_9N

    b. Analysis shows that the molecular weight of this compound is 532.5 g mol^{-1}. What is the molecular formula?

$C_3H_9N = 59.13 \text{ g/mol}$ $\frac{532.5}{59.13} = 9$

$C_{27}H_{81}N_9$



Soluble Compounds	
Compounds	Notable Exceptions:
Group 1A ions	None
Ammonium	None
Acetate	None
Nitrate	None
Halides	Ag^{+}, Pb^{2+}, $Hg_2{}^{2+}$
Sulfate	Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}

Insoluble Compounds	
Compounds Containing	Notable Exceptions
Carbonate	Group IA and NH_4^{+}
Phosphate	Group IA and NH_4^{+}
Sulfide	Group IA, IIA, and NH_4^{+}
Hydroxide	Group IA, NH_4^{+}, Ca^{2+}, Sr^{2+}, Ba^{2+}