Exam3key

Thursday, March 23, 2017 10:11 AM

Chem 105 Exam 3 Name________________________

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. You are welcome to "buy" hints to any question – it will cost you points, but this is often a better alternative than having the wrong problem solving strategy.

1. How many oxygen atoms are found in 27.3 grams of sodium phosphate?

$$\frac{27.3g\ Na_3PO_4}{}\left|\frac{mol}{163.94\ g}\right|\frac{4\ O}{1Na_3PO_4}\left|\frac{6.022\times10^{23}}{mol}\right. = 4.01\times10^{23}\text{ atoms}$$

2. Determine [NO_3^-] when 46.8 g of iron (II) nitrate is dissolved in 2.95 L of water.

$$\frac{46.8\ g\ Fe(NO_3)_2}{}\left|\frac{mol}{179.87\ g}\right|\frac{2\ mol\ NO_3^-}{1\ Fe(NO_3)_2} = \frac{0.52\ mol}{2.95L} = 0.176\ M$$

3. What is the mass of nitrogen found in 244.5 mL of NO_2 gas at 3.64 atm and 145 °C

0.2445L

418.5 K

$$n = \frac{PV}{RT} = \frac{(3.64)(0.2445)}{(0.08206)(418.5)} = 0.045\ mol$$

$$\frac{0.025 mol\ NO_2}{}\left|\frac{1\ N}{1\ NO_2}\right|\frac{14g}{mol} = \boxed{0.35g}$$

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

$$\frac{3.26\ H}{}\left|\frac{mol}{1.01g}\right. = 3.23/1.61 = 2$$

$$\frac{77.38\ O}{}\left|\frac{mol}{16\ g}\right. = 4.84/1.61 = 3$$

$$\frac{19.36}{}\left|\frac{m}{12.01\ g}\right. = 1.61/1.61 = 1$$

$$\boxed{CH_2O_3}$$

5. What does **reaction order** mean and why is it important in the study of reaction rates?

It is the exponent associated with a reactant in a rate law. It is important because it dictates how sensitive a rate is to changing concentration

6. What are three ways that the rate of a chemical reaction can be changed? Clearly explain the reason that each can influence the rate. You are welcome to use equations and concepts in your answer.

① ΔT → this changes k

② add a catalyst → changes Ea so k

$\Big\}\ k = Ae^{-Ea/RT}$

③ Δ[ ] → rate law says $\text{rate} = k\underline{[\ ]}$

7. Consider a flask that contains O_2 gas at a pressure of 2 atm. In your own words, explain how (i.e. up or down) and why pressure changes as each of the following are changed:

a. Temperature is increased

P increases → more collisions with wall

b. Volume is decreased

P increases → more collisions with wall

c. O_2 gas is removed from the flask

P decreases → fewer collisions

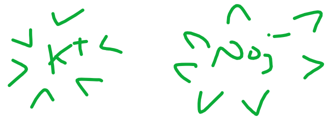
d. N_2 gas is added to the flask. No chemical reaction occurs.

P increases → more collisions

8. Clearly explain why potassium nitrate will dissolve in water. Your answer should include foundational chemical concepts, not just reciting solubility rules.

K^+ will interact favorably with (−) dipole of H_2O

NO_3^- will interact with (+) dipole of H_2O



9. 480 mL of water is added to a 386 mM solution of Na_2SO_4. If the $[Na^+]$ after dilution is 300 mM, what was the original volume of the sodium sulfate solution?

$\boxed{Na_2SO_4 = 150\text{ mM}}$

$V_2 = 480 + X$

$V_1 = X$

$M_1 = 386\text{ mM}$

$M_2 = 150\text{ mM}$

$(480+X)150 = 386X$

$72000 + 150X = 386X$

$72000 = 236X$

$\boxed{X = 305\text{ mL}}$

10. Barium sulfate can be made when magnesium sulfate is mixed together with barium chloride.

a. Write a balanced reaction.

$$BaCl_2(aq) + MgSO_4(aq) \rightarrow MgCl_2(aq) + BaSO_4(s)$$

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**.

$$BaCl_2: \quad 5g\,BaCl_2 \left| \frac{mol}{208.23g} \right| \frac{1\,BaSO_4}{1\,BaCl_2} \left| \frac{233.4g}{mol} \right. = 5.6g$$

$$MgSO_4: \quad 5g\,MgSO_4 \left| \frac{mol}{104.38g} \right| \frac{1\,BaSO_4}{1\,MgSO_4} \left| \frac{233.4g}{mol} \right. = 11.2g$$

$$5.6g(0.9) = \boxed{5.04g}$$

11. For each pair, identify which compound will be more soluble in water. **Clearly justify your answer.**

[✓ H_2O] or H_2S

H_2O dissolves itself

NCl_3 or [✓ PCl_3]

polar

[✓ $(NH_4)_2CO_3$] or $CaCO_3$

solubility

NH_4

12. Given the following data,
   a. Determine the rate law – make sure to include values for the order with respect to each reactant and the value of the rate constant with the correct units.
   b. Determine the rate of the reaction when the concentration of all reactants is 0.35 M.

Experiment	$[O_2]$ (mM)	$[H_2]$ (mM)	Rate (mM min^{-1})
1	0.468	0.147	0.007551
2	0.468	0.884	0.045306
3	1.404	0.884	1.223274

$$\frac{0.007551}{0.045306} = \left(\frac{0.147}{0.884}\right)^x$$

$$0.167 = 0.167^x$$

$$x = 1$$

$$\frac{0.045306}{1.223274} = \left(\frac{0.468}{1.404}\right)^y$$

$$0.037 = 0.333^y$$

$$\ln 0.037 = y \ln 0.333$$

$$y = 3$$

$$1.223274 = k\ 1.404\,mM^3\ 0.884\,mM$$

$$k = 0.986\ mM^{-3}\ min^{-1}$$

a $\rightarrow$ $rate = 0.5\ mM^{-3}min^{-1}\ [O_2]^3[H_2]$

b $rate = 0.5\frac{mn}{mn}(350\ mM)^3(350\ mM)$

$$rate = 7.50\times10^9\ \frac{mM}{min}$$

13. Consider the following reaction:

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

88.6 mL of 3.18 M HNO_3 is added to a flask containing 2604 mg of solid copper. If the reaction occurs in a 4.00 L flask held at 100 °C, determine each of the following (make sure to include units!): No credit will be awarded without your work clearly shown.

a. The total pressure once the reaction is complete. 0.63 atm

b. The concentration of $Cu(NO_3)_2$ that is produced. 0.46 M (0.01 If 4 L used)

c. The mass of Cu (s) remaining. 0 g

d. The concentration of HNO_3 remaining. 1.33 M (or 0.025 M)

$$\frac{2.604\ g\ Cu}{} \left| \frac{mol}{63.55\ g} \right| \frac{2\ mol\ NO_2}{1\ mol\ Cu} = 0.08195\ mol\ NO_2$$

$$\frac{88.6\ mL}{} \left| \frac{10^{-3}\ L}{1\ mL} \right| \frac{3.18\ mol\ HNO_3}{L} \left| \frac{2\ mol\ NO_2}{4\ mol\ HNO_3} \right. = 0.1408\ mol\ NO_2$$

Cu is L.R. → 0 left

$$P = \frac{nRT}{V} = \frac{0.08195\ mol\ (0.08206\ \frac{L\,atm}{mol \cdot K})(373.15\ K)}{4\ L} = 0.63\ atm$$

$$\frac{0.08195\ mol\ NO_2}{} \left| \frac{1\ Cu(NO_2)_2}{2\ NO_2} \right. = \frac{0.040975\ mol\ Cu(NO_2)_2}{0.0886\ L}\ 0.46\ M$$

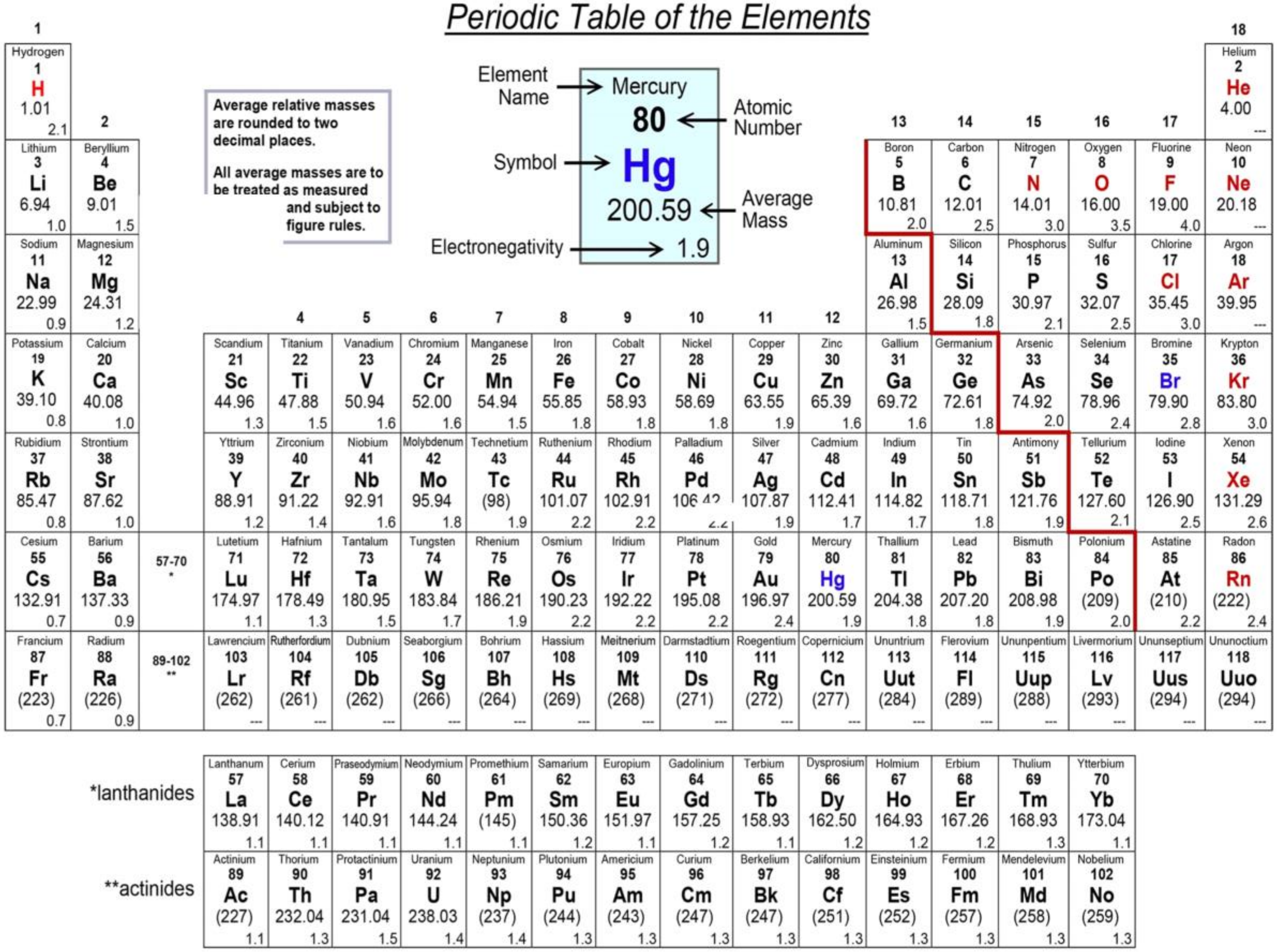
$$\frac{0.08195\ mol\ NO_2}{} \left| \frac{4\ HNO_3}{2\ NO_2} \right. = 0.164\ mol\ HNO_3\ used$$

$$\frac{0.0886\ L}{} \left| \frac{3.18\ mol}{L} \right. = 0.2817\ mol\ start$$

$$\frac{0.2817 - 0.164}{0.0886} =$$

1.33 M HNO_3 left

Periodic Table of the Elements



Average relative masses are rounded to two decimal places.

All average masses are to be treated as measured and subject to figure rules.

Element Name → Mercury
80 ← Atomic Number
Symbol → Hg
200.59 ← Average Mass
Electronegativity → 1.9

1	2			4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Hydrogen 1 **H** 1.01 2.1																		Helium 2 **He** 4.00 ---
Lithium 3 **Li** 6.94 1.0	Beryllium 4 **Be** 9.01 1.5												Boron 5 **B** 10.81 2.0	Carbon 6 **C** 12.01 2.5	Nitrogen 7 **N** 14.01 3.0	Oxygen 8 **O** 16.00 3.5	Fluorine 9 **F** 19.00 4.0	Neon 10 **Ne** 20.18 ---
Sodium 11 **Na** 22.99 0.9	Magnesium 12 **Mg** 24.31 1.2												Aluminum 13 **Al** 26.98 1.5	Silicon 14 **Si** 28.09 1.8	Phosphorus 15 **P** 30.97 2.1	Sulfur 16 **S** 32.07 2.5	Chlorine 17 **Cl** 35.45 3.0	Argon 18 **Ar** 39.95 ---
Potassium 19 **K** 39.10 0.8	Calcium 20 **Ca** 40.08 1.0		Scandium 21 **Sc** 44.96 1.3	Titanium 22 **Ti** 47.88 1.5	Vanadium 23 **V** 50.94 1.6	Chromium 24 **Cr** 52.00 1.6	Manganese 25 **Mn** 54.94 1.5	Iron 26 **Fe** 55.85 1.8	Cobalt 27 **Co** 58.93 1.8	Nickel 28 **Ni** 58.69 1.8	Copper 29 **Cu** 63.55 1.9	Zinc 30 **Zn** 65.39 1.6	Gallium 31 **Ga** 69.72 1.6	Germanium 32 **Ge** 72.61 1.8	Arsenic 33 **As** 74.92 2.0	Selenium 34 **Se** 78.96 2.4	Bromine 35 **Br** 79.90 2.8	Krypton 36 **Kr** 83.80 3.0
Rubidium 37 **Rb** 85.47 0.8	Strontium 38 **Sr** 87.62 1.0		Yttrium 39 **Y** 88.91 1.2	Zirconium 40 **Zr** 91.22 1.4	Niobium 41 **Nb** 92.91 1.6	Molybdenum 42 **Mo** 95.94 1.8	Technetium 43 **Tc** (98) 1.9	Ruthenium 44 **Ru** 101.07 2.2	Rhodium 45 **Rh** 102.91 2.2	Palladium 46 **Pd** 106.42 2.2	Silver 47 **Ag** 107.87 1.9	Cadmium 48 **Cd** 112.41 1.7	Indium 49 **In** 114.82 1.7	Tin 50 **Sn** 118.71 1.8	Antimony 51 **Sb** 121.76 1.9	Tellurium 52 **Te** 127.60 2.1	Iodine 53 **I** 126.90 2.5	Xenon 54 **Xe** 131.29 2.6
Cesium 55 **Cs** 132.91 0.7	Barium 56 **Ba** 137.33 0.9	57-70 *	Lutetium 71 **Lu** 174.97 1.1	Hafnium 72 **Hf** 178.49 1.3	Tantalum 73 **Ta** 180.95 1.5	Tungsten 74 **W** 183.84 1.7	Rhenium 75 **Re** 186.21 1.9	Osmium 76 **Os** 190.23 2.2	Iridium 77 **Ir** 192.22 2.2	Platinum 78 **Pt** 195.08 2.2	Gold 79 **Au** 196.97 2.4	Mercury 80 **Hg** 200.59 1.9	Thallium 81 **Tl** 204.38 1.8	Lead 82 **Pb** 207.20 1.8	Bismuth 83 **Bi** 208.98 1.9	Polonium 84 **Po** (209) 2.0	Astatine 85 **At** (210) 2.2	Radon 86 **Rn** (222) 2.4
Francium 87 **Fr** (223) 0.7	Radium 88 **Ra** (226) 0.9	89-102 **	Lawrencium 103 **Lr** (262) ---	Rutherfordium 104 **Rf** (261) ---	Dubnium 105 **Db** (262) ---	Seaborgium 106 **Sg** (266) ---	Bohrium 107 **Bh** (264) ---	Hassium 108 **Hs** (269) ---	Meitnerium 109 **Mt** (268) ---	Darmstadtium 110 **Ds** (271) ---	Roegentium 111 **Rg** (272) ---	Copernicium 112 **Cn** (277) ---	Ununtrium 113 **Uut** (284) ---	Flerovium 114 **Fl** (289) ---	Ununpentium 115 **Uup** (288) ---	Livermorium 116 **Lv** (293) ---	Ununseptium 117 **Uus** (294) ---	Ununoctium 118 **Uuo** (294) ---

*lanthanides	Lanthanum 57 **La** 138.91 1.1	Cerium 58 **Ce** 140.12 1.1	Praseodymium 59 **Pr** 140.91 1.1	Neodymium 60 **Nd** 144.24 1.1	Promethium 61 **Pm** (145) 1.1	Samarium 62 **Sm** 150.36 1.2	Europium 63 **Eu** 151.97 1.1	Gadolinium 64 **Gd** 157.25 1.2	Terbium 65 **Tb** 158.93 1.1	Dysprosium 66 **Dy** 162.50 1.2	Holmium 67 **Ho** 164.93 1.2	Erbium 68 **Er** 167.26 1.2	Thulium 69 **Tm** 168.93 1.3	Ytterbium 70 **Yb** 173.04 1.1
**actinides	Actinium 89 **Ac** (227) 1.1	Thorium 90 **Th** 232.04 1.3	Protactinium 91 **Pa** 231.04 1.5	Uranium 92 **U** 238.03 1.4	Neptunium 93 **Np** (237) 1.4	Plutonium 94 **Pu** (244) 1.3	Americium 95 **Am** (243) 1.3	Curium 96 **Cm** (247) 1.3	Berkelium 97 **Bk** (247) 1.3	Californium 98 **Cf** (251) 1.3	Einsteinium 99 **Es** (252) 1.3	Fermium 100 **Fm** (257) 1.3	Mendelevium 101 **Md** (258) 1.3	Nobelium 102 **No** (259) 1.3

Equations and constants:

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

$E_n = \frac{-2.18x1\ \ ^{-18}J}{n^2}$ $\quad KE = \frac{1}{2}mv^2$ $\quad E_{coulomb} = 231pm \cdot aJ\,\frac{q_1q_2}{r}$

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

$N_A = 6.022x10^{23}mol^{-1}$ $\quad PV = nRT$ $\quad R = 0.08206\ \frac{L\cdot atm}{mol\cdot K}$

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

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

$k = Ae^{\frac{-E_a}{RT}}$

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+}