Surname (last name):_______________________________

Given name (first name):________________________________

Student number:______________________

Course: 1311 C (Dr. Murugesu)

Chemistry 1311C
Midterm 1
October 20th, 2011

Please keep your work covered and keep your eyes on your own paper! Cheating or any appearance of cheating will result in an F in the course and possible expulsion from the University.

A periodic table, formula sheet. You may rip these 2 pages off of the exam and use them to cover your work.

You have 80 minutes to complete the exam.

For each question, please write your final answer in the space provided.

Question	1	2	3	4	5	6-bonus	Totale
Points	10	10 (+2)	5	10	5	(+5)	40(+7)
Note							

1. Elemental analysis of an organic liquid (100g) composed of carbon, hydrogen and nitrogen, $C_xH_yN_z$, with a fishy odour gives the following elemental mass percentages: C 71.22 %; N 13.84 %. Vaporization of 250 mg of the compound in a 150 mL bulb at 150 C give a pressure of 435 torr.
   a) (5 points) Determine the empirical formula for this compound.
   b) (5 points)What is the molecular formula?

100g sample
C 71.22g, 12 g/mole moles: 71.22/12 = 5.935 moles
N 13.84 g, 14 g/mole: 13.84/14 = 0.9886 moles
H: 100g-71.22g-13.84g = 14.94 g, 1g/mole: 14.94/1 = 14.94

Divide each by smallest number of moles in hopes of getting whole numbers:

C 5.935 moles/0.9886=6.0
N 0.9886 moles/0.9886 = 1
H: 14.94/0.9886=15.1

$C_6H_{15}N$

Empirical Formula: ___ $C_6H_{15}N$_______________

Mass = 250 x 10^{-3} g
V =0.15L
T =150+273 = 423 K
P =435 torr/760 = 0.573 atm

n_{CxHyNz}=PV/RT = 0.573*0.15/(0.08206*423) = 2.476x10^{-3}

MM = g/mole = 250x10^{-3} g/2.476x10^{-3} moles = 100.96 g/mole

MM of empirical formula = 6(12)+15(1) +14 =101

MM_{expt}/ $MM_{empirical}$ =100.96/101 =1

$C_6H_{15}N$
Molecular Formula:_____ $C_6H_{15}N$______________

2. You have two solutions, the first containing 100.0 ml of 1.50 M calcium nitrate ($Ca(NO_3)_2$) and the second containing 75.0 ml of 3.00 M ammonium sulphate $(NH_4)_2SO_4$.

a) (3 points)Identify the ions present in each of the solutions (give the chemical formula for the ions, including appropriate charge).

Ca^{2+} NO_3^- NH_4^+ SO_4^{2-}

b) (1 point) Will a precipitation reaction occur?

Answer: ____yes_______________

c) (1 point) If so, which species precipitates?

Precipitate: ____ $CaSO_4$____________

d) (1 point) Write the net ionic equation:

$Ca^{2+}(aq) + SO_4^{2-}(aq) \rightarrow CaSO_4(s)$

e) (4 points) What is the mass of the precipitate?

Moles Ca^{2+} : 0.100L x 1.5 M = 0.15 moles
Moles SO_4^{2-}: 0.075 L x 3M = 0.225 moles
Ca^{2+} is limiting
Moles $CaSO_4$ = 0.15 moles
Mass $CaSO_4$ = 0.15 moles x (40 +32+4(16))g/mole = 20.4 g

Bonus (2 points) What is the concentration of NH_4^+ in the solution at the end of the reaction?

Moles of NH_4^+ = 0.225 moles SO_4^{2-} x 2 NH_4^+/1 SO_4^{2-} = 0.45 moles

Concentration = moles /L = 0.45 moles / (0.175 L) = 2.57 M

3. a) (2.5 points) What mass of K_2CrO_4 is needed to prepare exactly 0.25L of a 0.250M K_2CrO_4 solution in H_2O?

Petrucci P125 10th edition

b) (2.5 points) A solution is prepared by dissolving 25.0 mL ethanol, CH_3CH_2OH (d=0.789 g/mL), in enough water to produce 250.0 mL solution. What is the molarity of ethanol in solution?

Petrucci p124 10th edition

4. (10 points) A piece of sodium metal reacts completely with water as

$$2Na(s) + 2H_2O\ (l) \rightarrow 2NaOH\ (aq) + H_2(g)$$

The hydrogen generated is collected over water at 25 °C. The volume of the gas collected is 246 ml at 1.0 atm. Calculate the number of grams of Na used in the reaction. The vapour pressure of water at 25 °C is 23.8 mm Hg.

T=273+25 = 298 K

V =246 ml =0.246 L

P_T= 1 atm = PH_2 + $P_{water\ vapour}$

$P_{water\ vapour}$ = 23.8mm Hg/760 = 0.0313 atm

PH_2 = 1 atm-0.0313atm=0.969 atm

N_{H2}=PV/RT = 0.969(.246L)/(0.08206*298) = 9.7×10^{-3} moles of H_2

Now look at balance chemical reaction:

Moles Na = 9.7×10^{-3} moles of H_2 x 2 Na/1 H_2 = 1.95×10^{-3} moles of Na

Mass Na = moles x MM(Na) = 1.95×10^{-3} moles of Na x 23 g/mole = 0.448 g

5. a) (2.5 points) The pressure inside a hydrogen-filled container was 2.10 atm at 21°C . What would the pressure be if the container was heated to 93°C?

The amount of hydrogen in the container and its volume remains the same, so the quantity is constant, use the (P/T)ini =(P/T)final to solve the problem

Answer Pfinal =2.61 ATM

b) (2.5 points)At standard temperature and pressure (0 °C and 1.00 atm), 1.00 mol of an ideal gas occupies a volume of 22.4 L. What volume would the same amount of gas occupy at the same pressure and 65 °C?

The amount of gas and the pressure remains the same so the quantity V/T is constant so use (V/T)ini = (V/T) final to solve: V final = 27.7

6. (Bonus 5 points) In an enclosed flask, dinitrogen tetroxide slowly warms up to form dinitrogen tetroxide gas and nitrogen dioxide gas. At 298 K the equilibrium is reached. If the initial concentration of dinitrogen tetroxide is 0.50 M, and no nitrogen dioxide is initially present, what are the equilibrium concentrations? Kc = 0.0059 at 298 K

$$N_2O_4\,(g) \rightleftharpoons 2NO_2\,(g) \qquad K_c = \frac{[NO_2]^2}{[N_2O_4]}$$

	$[N_2O_4]$	$[NO_2]$
Initial	0.50	0
Change	-x	+2x
Equilibrium	0.50 - x	0 + 2x

Substitute equilibrium concentrations into K_c expression

$K_C = 0.0059 = \frac{(2x)^2}{(0.50 - x)}$

Solve the K_c expression for x:

$0.0059\ (0.50-x\ ) = (2x)^2$

$0.0029 - 0.0059x = 4x^2$

$4x^2 + 0.0059x - 0.0029 = 0$

Solving Quadratic Equations: $ax^2 + bx + c = 0$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

a = 4 b = 0.0059 c = -0.0029

$$x = \frac{-0.0059 \pm \sqrt{0.0059^2 - 4(4)(-0.0029)}}{2(4)}$$

$$x = -0.00074 \pm \frac{\sqrt{0.046}}{8} = -0.00074 \pm 0.027$$

x = 0.026 or -0.028

A negative value is not possible ($[NO_2]$ cannot decrease if there is none there to start with!), therefore, x = 0.026

Use the determined value for x to determine equilibrium concentrations

	$[N_2O_4]$	$[NO_2]$
Equilibrium	0.50 - x	2x
	0.50 - 0.026	2(0.026)
	0.47 M	0.052 M

Substitute the calculated concentrations into the K_C expression to check the answer.

$K_c = \frac{(0.052)^2}{(0.47)} = 0.0058$

In the problem we were given K_C = 0.0059.

EQUATIONS SHEET

$\Delta H^o_{rxn} = \Sigma n \Delta H^o_f \text{ (products)} - \Sigma m \Delta H^o_f \text{ (reactants)}$

$\Delta S^o_{rxn} = \Sigma n S^o \text{ (products)} - \Sigma m S^o \text{ (reactants)}$

$PV = nRT$ $\Delta G = \Delta H - T\Delta S$ $\Delta G^o = -RT\ln K$

$\upsilon_{rms} = (3RT/MM)^{1/2}$ $\Delta E = q + w$ $\Delta G = \Delta G^o + RT\ln Q$

$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$ $q = ms\Delta T$ $q = C\Delta T$

$w = -P\Delta V$ $[A] = -kt + [A]_o$ $t_{1/2} = 0.693/k$

$\ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$ $1/[A] = kt + 1/[A]_o$ $\ln[A] = -kt + \ln[A]_o$

$P_A = X_A P_A^o$ $P_A = X_A P_{Total}$ $P_{total} = P_1 + P_2 + \ldots$ $K_P = K_C(RT)^{\Delta n}$

$\text{Solubility} = k_H P_{gas}$ $KE = (3/2)\, RT$ $d = [P(MM)/RT]$

$pH = -\log[H_3O^+]$ $pOH = -\log[OH^-]$ $pH + pOH = 14$

$K_w = K_a \times K_b$ $pH = pKa + \log\frac{[\text{conjugate base}]}{[\text{acid}]}$

$E^o_{cell} = E^o_{reduction} + E^o_{oxidation}$ Charge (C) = current (A) x time (s)

$E^o = (0.0257/n)\ln K$ $E = E^o - (0.0257/n)\ln Q$ $\Delta G = -nFE_{cell}$

$E = hc/\lambda$ $E = h\nu$ $c = \lambda\nu$

$\Delta E = R_H\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)$

<u>Constants:</u> <u>Conversion Factors :</u>

Avogadro's Number (N_A)	6.02×10^{23}	$1\ A = 1\ C\ s^{-1}$
Faraday's constant (F)	$96{,}500\ C/mol\ e^-$	$1\ C = 1\ J\ V^{-1}\ mol^{-1}$
Universal Gas Constant (R)	$8.314\ J\ mol^{-1}\ K^{-1}$	
	$8.314\ kg\ m^2\ mol^{-1}\ K^{-1}\ s^{-2}$	
	$0.08206\ L\ atm\ mol^{-1}\ K^{-1}$	$1\ nm = 10^{-9}\ m$
Planck's constant (h)	$6.626 \times 10^{-34}\ J\ s$	1 atm = 760 torr
Rydberg Constant (R_H)	$2.18 \times 10^{-18}\ J$	= 760 mm Hg
Speed of light(c)	$3.00 \times 10^{8}\ m/s$	= 101.3 kPa

$ax^2 + bx + c = 0;\quad x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Symbol — Atomic number — Relative atomic mass — Electronegativity — Most frequent oxidation number — Name

Key
H 1 1.00794 2.1 1+ Hydrogen

	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII	9 VIII	10 VIII	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	*H 1* 1.00794 2.1 1+ Hydrogen																	*He 2* 4.002602 - - Helium
2	**Li 3** 6.941 1.0 1+ Lithium	**Be 4** 9.012182 1.5 2+ Beryllium											**B 5** 10.811 2.0 3+ Boron	**C 6** 12.011 2.5 4+,4- Carbon	*N 7* 14.00674 3.0 3+,3- Nitrogen	*O 8* 15.9994 3.5 2- Oxygen	*F 9* 18.9984032 4.0 1- Fluorine	*Ne 10* 20.1797 - - Neon
3	**Na 11** 22.989768 0.9 1+ Sodium	**Mg 12** 24.3050 1.2 2+ Magnesium											**Al 13** 26.981539 1.5 3+ Aluminum	**Si 14** 28.0855 1.8 4+ Silicon	**P 15** 30.973762 2.1 5+ Phosphorus	**S 16** 32.066 1.8 4+ Sulfur	*Cl 17* 35.4527 3.0 1- Chlorine	*Ar 18* 39.948 - - Argon
4	**K 19** 39.0983 0.8 1+ Potassium	**Ca 20** 40.078 1.0 2+ Calcium	**Sc 21** 44.955910 1.3 3+ Scandium	**Ti 22** 47.88 1.5 4+ Titanium	**V 23** 50.9415 1.6 5+ Vanadium	**Cr 24** 51.9961 1.6 3+ Chromium	**Mn 25** 54.93805 1.5 2+ Manganese	**Fe 26** 55.847 1.8 3+ Iron	**Co 27** 58.9332 1.8 2+ Cobalt	**Ni 28** 58.6934 1.8 2+ Nickel	**Cu 29** 63.546 1.9 2+ Copper	**Zn 30** 65.39 1.6 2+ Zinc	***Ga 31*** 69.723 1.6 3+ Gallium	**Ge 32** 72.61 1.6 4+ Germanium	**As 33** 74.92159 2.0 3+,3- Arsenic	**Se 34** 78.96 2.4 4+ Selenium	***Br 35*** 79.904 2.8 1- Bromine	*Kr 36* 83.80 - - Krypton
5	**Rb 37** 85.4678 0.8 1+ Rubidium	**Sr 38** 87.62 1.0 2+ Strontium	**Y 39** 88.90585 1.3 3+ Yttrium	**Zr 40** 91.224 1.4 4+ Zirconium	**Nb 41** 92.90638 1.6 5+ Niobium	**Mo 42** 95.94 1.8 6+ Molybdenum	Tc 43 98.9063 1.9 7+ Technetium	**Ru 44** 101.57 2.2 3+,4+ Ruthenium	**Rh 45** 102.9055 2.2 3+ Rhodium	**Pd 46** 106.42 2.2 2+ Palladium	**Ag 47** 107.8682 1.9 1+ Silver	**Cd 48** 112.411 1.7 2+ Cadmium	**In 49** 114.82 1.7 3+ Indium	**Sn 50** 118.71 1.8 4+ Tin	**Sb 51** 121.757 1.9 3+,3- Antimony	**Te 52** 127.60 2.1 4+ Tellurium	**I 53** 126.90447 2.5 1- Iodine	*Xe 54* 131.29 - - Xenon
6	***Cs 55*** 132.90543 0.7 1+ Cesium	**Ba 56** 137.327 0.9 2+ Barium	**La 57** 138.9055 1.1 3+ Lanthanum	**Hf 72** 178.49 1.3 4+ Hafnium	**Ta 73** 180.9479 1.5 5+ Tantalum	**W 74** 183.85 1.7 6+ Tungsten	**Re 75** 186.207 1.9 7+ Rhenium	**Os 76** 190.2 2.2 4+ Osmium	**Ir 77** 192.22 2.2 4+ Iridium	**Pt 78** 195.08 2.2 4+ Platinum	**Au 79** 196.96654 2.4 3+ Gold	***Hg 80*** 200.59 1.9 2+ Mercury	**Tl 81** 204.3833 1.8 1+ Thallium	**Pb 82** 207.2 1.8 2+ Lead	**Bi 83** 208.98037 1.9 3+ Bismuth	**Po 84** 208.9824 2.0 2+ Polonium	**At 85** 209.9871 2.2 1- Astatine	*Rn 86* 222.0176 - - Radon
7	***Fr 87*** 223.0197 0.7 1+ Francium	**Ra 88** 226.0254 0.9 2+ Radium	**Ac 89** 227.0278 1.1 3+ Actinium	Rf 104 261.11 - - Rutherfordium	Db 105 262.11 - - Dubnium	Sg 106 263.12 - - Seaborgium	Bh 107 262.12 - - Bohrium	Hs 108 264 - - Hassium	Mt 109 266.1378 - - Meitnerium	Uun 110 269 - - Ununnilium	Uuu 111 272 - - Unununium	Uu 112 277 - - Ununbium		Uuq 114 289 - - Ununquadium		Uuh 116 289 - - Ununhexium		Uuo 118 293 - - Ununoctium

6	**Ce 58** 140.115 1.1 3+ Cerium	**Pr 59** 140.90765 1.1 3+ Praseodymium	**Nd 60** 144.24 1.1 3+ Neodymium	Pm 61 144.9127 1.1 3+ Promethium	**Sm 62** 150.36 1.2 3+ Samarium	**Eu 63** 151.965 1.2 3+ Europium	**Gd 64** 157.25 1.2 3+ Gadolinium	**Tb 65** 168.92534 1.2 3+ Terbium	**Dy 66** 162.50 1.2 3+ Dysposium	**Ho 67** 164.93032 1.2 3+ Holmium	**Er 68** 167.26 1.2 3+ Erbium	**Tm 69** 168.93421 1.2 3+ Thulium	**Yb 70** 173.04 1.1 3+ Ytterbium	**Lu 71** 174.967 1.2 3+ Lutetium
7	**Th 90** 232.0381 1.3 4+ Thorium	**Pa 91** 231.03588 1.5 5+ Protactinium	**U 92** 238.0289 1.4 6+ Uranium	Np 93 237.082 1.3 5+ Neptunium	Pu 94 244.0642 1.3 4+ Plutonium	Am 95 243.0614 1.3 3+ Americium	Cm 96 247 1.3 3+ Curium	Bk 97 247.0703 1.3 3+ Berkelium	Cf 98 251.0796 1.3 3+ Californium	Es 99 252.03 1.3 - Einsteinium	Fm 100 257.0951 1.3 - Fermium	Md 101 258.01 1.3 - Mendelevium	No 102 259.1009 1.3 - Nobelium	Lr 103 260.1053 - - Lawrencium

Under normal conditions, bold symbols correspond to solid state, bold italic correspond to liquid state, italic correspond to gaseous state and normal correspond to synthetic elements.

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