UNIVERSITY OF SWAZILAND

Department of Chemistry

INTRODUCTORY CHEMISTRY II
C112

FINAL EXAM (*Supplimental*)

Second term (semester) 2007-08

Notes:
Do not open this exam until told to do so.
This exam consists of 9 questions:
you are to work three of the first 4 (section I), and
two of the final 5 (section II).
[If you do not work three of the first four, you will lose 20 marks
for each one fewer you do not work:
if you work more than 4, only the first 3 will be marked.
For the total exam, only the first five attempted will be marked.]
Each question is worth 20 marks.
Be sure to indicate on your answer sheets which questions you are answering.
Begin each question on a fresh sheet on your answer scripts.
Show your work and express your answers clearly to the correct number of significant figures.
Non-programmable calculators are permitted to be used.

A periodic chart is included with this exam and
some important chemical constants are given below on this page:

$N_A = 6.0221367 \times 10^{23}$ **items/mol**
$R = 8.206 \times 10^{-2}$ **(L)(atm)/(mol)(K)**
$= 8.314$ **J/(mol)(K)**
$h = 6.6256 \times 10^{-34}$ **(J)(s)**
$c = 2.9979 \times 10^{8}$ **m/s**

Introductory Chemistry II
C 112

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Section I: Attempt **three** out of these four problems.

1. A. Write an acceptable structure for *cis*-7-ethyl-3-methyl-4-decene.

B. Write acceptable structures for four isomers of formula $C_4H_{10}O$

C. Write the structure **and** name for the principal organic product in each of the following reactions:

i. 2-butanol + acetic acid →

ii. 2-hexene + bromine(molecular) →

iii. 2,6-dimethylcyclohexanol + {heat and acid} →

iv. cyclohexene + hydrogen(molecular) + [catalyst] →

v. benzene + HNO_3 + $[H_2SO_4(cat)]$ →

vi. 3-methylheptanal + {oxidizing agent} →

D. Write a complete balanced equation for the complete combustion of toluene (methylbenzene).

E. Indicate which one of each of the following pairs of substances would be expected to have the higher boiling point:

i. 1,3,5,7-tetrapropylcyclodecane or cyclopropane
ii. barium acetate or butyl acetate
iii. 2-propanol or ethylmethylether
iv. metallic gold or cyclohexanol
v. neon or benzene
vi. SiO_2 or 3-ethylpentane

2. A. Consider the equilibrium: $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ When 1.200 mol of NH_3 was placed in an otherwise empty 1.00 liter vessel at a certain specified temperature, and allowed to come to equilibrium, it was found that the equilibrium concentration of NH_3 was 0.048 M. Calculate the value of K_c for this reaction at this temperature.

B. At 350°C, $K_c = 70$ for the equilibrium: $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$
At **equilibrium**, the concentration of I_2 is found to be 1.32 M and that of H_2 is 0.100 M. Calculate the equilibrium concentration of HI.

C. At a certain high temperature, 2.00 moles **each** of gaseous iodine and gaseous hydrogen were introduced into an otherwise empty 1.00 L container--they reacted with each other and were allowed to come to equilibrium with the one product, gaseous hydrogen iodide [the same reaction as in part B, above]. At this temperature $K_c = 9.00$. Calculate the equilibrium concentration of all reactants and products.

3. The following data apply to the reaction between A, B, and C at a constant temperature:

exp	$[A]_o$	$[B]_o$	$[C]_o$	R_o (M/s)
1	0.020 M	0.030 M	0.020 M	0.0398
2	0.060 M	0.030 M	0.020 M	0.358
3	0.060 M	0.060 M	0.020 M	0.715
4	0.020 M	0.030 M	0.040 M	0.0401
5	0.050 M	0.050 M	0.050 M	(??)

A. Derive the informed rate law including the orders of reaction and the value of the ***rate constant***, for this reaction.

B. Calculate the initial rate for experiment #5.

C. State the (overall) order of this reaction.

C. What, if anything, would **decrease** the ***rate constant*** of a particular reaction?

4. A. Calculate the pH of each of the following solutions:

i. a 0.25 M solution of CH_3COOH (acetic acid)

ii. a 0.010 M solution of $Ba(OH)_2$ (barium hydroxide)

iii. a 0.25 M solution of HNO_3 (nitric acid)

iv. a 0.050 M solution of NH_3 (ammonia)

B. If it takes 28.64 milliliters of a 0.200 M solution of NaOH to exactly neutralize 25.37 milliliters of a hydrochloric acid solution, calculate the molarity of the hydrochloric acid solution.

C. Reconstruct the following grid on your scripts sheets and fill in the blanks.

solution	pH	$[H^+]$	$[OH^-]$	pOH	acidic/basic?
#1	4.44				
#2		6.0×10^{-10}M			
#3			3.8×10^{-4}M		

D. Write the conjugate **acid** of methylamine and the conjugate **base** of formic (methanoic) acid.

E. Aqueous solutions of which one(s) of the following would be basic and which one(s) would be acidic?
i. KBr ii. $AlCl_3$ iii. methanol iv. $NaC_2H_3O_2$ v. NH_4NO_3 vi. KOH vii. HCl

Section II; Attempt **two** of the following problems. [Your choice]

5. A. Calculate the solubility, (in moles per liter), of Ag_2SO_4 in pure water. The K_{sp} of Ag_2SO_4 is 1.4×10^{-5}

B. Calculate the K_{sp} of $BaSO_4$ which has a solubility of 1.05×10^{-5} M in pure water.

C. Calculate the solubility of Ag_2SO_4 in a 1.00 M solution of Na_2SO_4.

D. A. 20.0 mL of a 0.0024 M solution of $AgNO_3$ is mixed with 10.0 mL of a 0.0010 M solution of K_2SO_4.
i. what salt is most likely to precipitate?
ii. make calculations to predict whether or not that salt will, indeed, precipitate.

E. For a solution containing both barium and lead aqueous ions, both at a concentration of 0.10M, make calculations to predict which salt would be expected to precipitate first if a dilute solution of Na_2CO_3 were slowly added. The K_{sp} of $PbCO_3$ is 3.3×10^{-14} and that of $BaCO_3$ is 8.1×10^{-9}.

6. A. Calculate the energy of activation of a reaction which has rate constants of 3.41×10^{-3} M/s at 57°C and 9.88×10^{-2} M/s at 127°C.

B. Draw the potential energy diagram (graph) for this (one step) reaction which has an ***enthalpy*** of reaction of +26.4 kJ. Clearly indicate all quantities and label all other parts of the graph.

C. This reaction (in parts A & B, above) can be shown this way: $2X_{(g)} + Y_{(g)} \rightleftharpoons 2Z_{(g)}$
Which way will the equilibrium shift if
i. some Z is added? ii. some Y is removed? iii. 0.10 mole X is added and 0.10 mole Z is removed?
iv. the reaction is cooled down? v. a catalyst is added? vi. the volume is increased?

7. A. Calculate the number of milliliters of 0.20 M NaOH it will require to just neutralize 20.00 mL of 0.50 M HCl.

B. For the titration of 20.00 mL of 0.500 M HCl with 0.200 M NaOH, calculate the pH
i. initially ii. at the ½-way point iii. at the stoichometric (equilvalence) point

C. Sketch the pH titration curve for the titration in part B

8. A. Write the Lewis electron dot structure for methyl acetate [$CH_3CO_2CH_3$] and indicate the shape and bond angles around each central atom and the hybridization for each non-hydrogen atom.

B. Write the Lewis structure of propene and indicate what kinds of atomic orbitals are overlapping for each carbon-carbon bond. Indicate the number of pi bonds and sigma bonds in this molecule.

C. Write the electronic configuration for the tin (IV) ion and then write the Lewis structure for tin (IV) sulfate. Indicate the formal charge for each atom in the sulfate ion.

9. A. A buffer solution is prepared by dissolving 1.50 mol $HC_2H_3O_2$ (acetic acid) and 0.500 mol $NaC_2H_3O_2$ (sodium acetate) in enough water to make 1.00 liter of solution. Calculate the pH of the solution.

B. Calculate the resulting pH when 0.50 moles of NaOH is added per liter of the buffer solution in part B—assuming no volume change.

C. Calculate the pH change when 0.50 moles of HCl is added per liter of pure water—assuming no volume change.

Periodic Chart of the Elements

1 Group IA	2 IIA	3 IIIA IIIB	4 IVA IVB	5 VA VB	6 VIA VIB	7 VIIA VIIB	8	9 VIIIA VIII	10	11 IB	12 IIB	13 IIIB IIIA	14 IVB IVA	15 VB VA	16 VIB VIA	17 VIIB VIIA	18 VIIIA
1 **H** 1.0079																	2 **He** 4.00260
3 **Li** 6.941	4 **Be** 9.01218											5 **B** 10.81	6 **C** 12.011	7 **N** 14.0067	8 **O** 15.9994	9 **F** 18.9984	10 **Ne** 20.179
11 **Na** 22.9898	12 **Mg** 24.305											13 **Al** 26.9815	14 **Si** 28.0855	15 **P** 30.9738	16 **S** 32.06	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.0983	20 **Ca** 40.08	21 **Sc** 44.9559	22 **Ti** 47.88	23 **V** 50.9415	24 **Cr** 51.996	25 **Mn** 54.9380	26 **Fe** 55.847	27 **Co** 58.9332	28 **Ni** 58.69	29 **Cu** 63.546	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.9216	34 **Se** 78.69	35 **Br** 79.904	36 **Kr** 83.80
37 **Rb** 85.4678	38 **Sr** 87.62	39 **Y** 88.9059	40 **Zr** 91.224	41 **Nb** 92.9064	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.906	46 **Pd** 106.42	47 **Ag** 107.868	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.75	52 **Te** 127.60	53 **I** 126.905	54 **Xe** 131.29
55 **Cs** 132.905	56 **Ba** 137.33	57 **La** ★ 138.906	72 **Hf** 178.49	73 **Ta** 180.948	74 **W** 183.85	75 **Re** 186.207	76 **Os** 190.2	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.967	80 **Hg** 200.59	81 **Tl** 204.383	82 **Pb** 207.2	83 **Bi** 208.980	84 **Po** 208.9824	85 **At** 209.9871	86 **Rn** 222.0176
87 **Fr** 223.0197	88 **Ra** 226.025	89 **Ac** ▲ 227.0278	104 [a] **Unq** 261.1087	105 [a] **Unp** 262.1138	106 [a] **Unh** 263.1182	107 [a] **Uns** 262.1229	108 [a] **Uno** —	109 [a] **Une** —									

★ Lanthanide series	58 **Ce** 140.12	59 **Pr** 140.908	60 **Nd** 144.24	61 **Pm** 146.9151	62 **Sm** 150.34	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.925	66 **Dy** 162.50	67 **Ho** 164.930	68 **Er** 167.26	69 **Tm** 168.934	70 **Yb** 173.04	71 **Lu** 174.967
▲ Actinide series	90 **Th** 232.038	91 **Pa** 231.036	92 **U** 238.029	93 **Np** 237.048	94 **Pu** 244.0642	95 **Am** 243.0614	96 **Cm** 247.0703	97 **Bk** 247.0703	98 **Cf** 251.0796	99 **Es** 252.0829	100 **Fm** 257.0951	101 **Md** 258.0986	102 **No** 259.1009	103 **Lr** 260.1053

Name	Symbol	Atomic Number	Atomic Weight
Actinium	Ac	89	227.0278
Aluminum	Al	13	26.98154
Americium	Am	95	243.0614
Antimony	Sb	51	121.75*
Argon	Ar	18	39.948*
Arsenic	As	33	74.9216
Astatine	At	85	209.9871
Barium	Ba	56	137.33
Berkelium	Bk	97	247.0703
Beryllium	Be	4	9.01218
Bismuth	Bi	83	208.9804
Boron	B	5	10.81
Bromine	Br	35	79.904
Cadmium	Cd	48	112.41
Caesium	Cs	55	132.9054
Calcium	Ca	20	40.08
Californium	Cf	98	251.0796
Carbon	C	6	12.011
Cerium	Ce	58	140.12
Chlorine	Cl	17	35.453
Chromium	Cr	24	51.996
Cobalt	Co	27	58.9332
Copper	Cu	29	63.546*
Curium	Cm	96	247.0703
Dysprosium	Dy	66	162.50*
Einsteinium	Es	99	252.0829
Erbium	Er	68	167.26*
Europium	Eu	63	151.96
Fermium	Fm	100	257.0951
Fluorine	F	9	18.998403
Francium	Fr	87	223.0197
Gadolinium	Gd	64	157.25*
Gallium	Ga	31	69.72
Germanium	Ge	32	72.59*
Gold	Au	79	196.9665
Hafnium	Hf	72	178.49*
Helium	He	2	4.00260
Holmium	Ho	67	164.9304
Hydrogen	H	1	1.0079
Indium	In	49	114.82
Iodine	I	53	126.9045
Iridium	Ir	77	192.22*
Iron	Fe	26	55.847*
Krypton	Kr	36	83.80
Lanthanum	La	57	138.9055*
Lawrencium	Lr	103	260.1053
Lead	Pb	82	207.2
Lithium	Li	3	6.941*
Lutetium	Lu	71	174.97
Magnesium	Mg	12	24.305
Manganese	Mn	25	54.9380
Mendelevium	Md	101	258.0986
Mercury	Hg	80	200.59*
Molybdenum	Mo	42	95.94
Neodymium	Nd	60	144.24*
Neon	Ne	10	20.179*
Neptunium	Np	93	237.0482
Nickel	Ni	28	58.70
Niobium	Nb	41	92.9064
Nitrogen	N	7	14.0067
Nobelium	No	102	259.1009
Osmium	Os	76	190.2
Oxygen	O	8	15.9994*
Palladium	Pd	46	106.4
Phosphorus	P	15	30.97376
Platinum	Pt	78	195.09*
Plutonium	Pu	94	244.0642
Polonium	Po	84	208.9824
Potassium	K	19	39.0983*
Praseodymium	Pr	59	140.9077
Promethium	Pm	61	146.9151
Protactinium	Pa	91	231.0359
Radium	Ra	88	226.0254
Radon	Rn	86	222.0176
Rhenium	Re	75	186.207
Rhodium	Rh	45	102.9055
Rubidium	Rb	37	85.4678*
Ruthenium	Ru	44	101.07*
Samarium	Sm	62	150.4
Scandium	Sc	21	44.9559
Selenium	Se	34	78.96*
Silicon	Si	14	28.0855*
Silver	Ag	47	107.868
Sodium	Na	11	22.98977
Strontium	Sr	38	87.62
Sulfur	S	16	32.06
Tantalum	Ta	73	180.9479*
Technetium	Tc	43	98.9063
Tellurium	Te	52	127.60*
Terbium	Tb	65	158.9254
Thallium	Tl	81	204.37*
Thorium	Th	90	232.0381
Thulium	Tm	69	168.9342
Tin	Sn	50	118.69*
Titanium	Ti	22	47.90*
Tungsten	W	74	183.85*
Unnilhexium	Unh	106	263.1182
Unnilenneium	Une	109	—
Unniloctium	Uno	108	—
Unnilpentium	Unp	105	262.1138
Unniquadium	Unq	104	261.1087
Unnilseptium	Uns	107	262.1229
Uranium	U	92	238.029
Vanadium	V	23	50.9414*
Xenon	Xe	54	131.30
Ytterbium	Yb	70	173.04*
Yttrium	Y	39	88.9059
Zinc	Zn	30	65.38
Zirconium	Zr	40	91.22

*These figures are considered reliable to ±1 in the last digit, or ±3 when followed by an asterisk.