UNIVERSITY OF SWAZILAND

Department of Chemistry

INTRODUCTORY CHEMISTRY II
C112

FINAL EXAM

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** .

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

1. A. Write the name of the following compound: $CH_3(CH_2)_3C(CH_3)_2CH$ with $HCCH_3$ double-bonded

B. Write acceptable structures for four isomers of formula C_4H_8O

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

i. 2-propanol + formic (methanoic) acid →

ii. cyclohexene + bromine(molecular) →

iii. 3-ethyl-3-pentanol + {heat and acid} →

iv. 3-hexene + hydrogen chloride →

v. bromomethane + hydroxide ion →

vi. 6-methylnonanal + {oxidizing agent} →

D. Write a complete balanced equation for the complete combustion of 1,4-dimethylbenzene

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

i. octane or cyclohexane
ii. sodium acetate or ethyl acetate
iii. butanol or diethyl ether
iv. silver or butanoic acid
v. benzene or argon
vi. carbon(dianmond) or 1,3,5.7-tetrapropylcyclodecane

2. A. Consider the equilibrium: $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ When 0.600 mol of N_2 and 1.800 mol of H_2 were placed in an otherwise empty 1.00 liter vessel at a certain specified temperature, and allowed to react, it was found that the equilibrium concentration of NH_3 was 0.048 M. Calculate the value of K_c for this reaction.

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

C. At a certain high temperature, 3.00 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 $K_c = 16$. 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	0.119
3	0.060 M	0.060 M	0.020 M	0.476
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. What, if anything, would **increase** the ***rate constant*** of a particular reaction?

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

i. a 0.12 M solution of HNO_3 (nitric acid)

ii. a 0.020 M solution of $Ba(OH)_2$ (barium hydroxide)

iii. a 0.24 M solution of CH_3COOH (acetic acid)

iv. a 0.48 M solution of NH_3 (ammonia)

B. If it takes 48.64 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		5.0×10^{-10} M			
#3			3.8×10^{-3} M		

D. Write the conjugate **acid** of water and the conjugate **base** of acetic acid.

E. Aqueous solutions of which of the following would be basic and which would be acidic?
i. NaCl ii. $CoCl_3$ iii. ethanol iv. KCN v. NH_4NO_3 vi. trimethylamine

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

5. A. Calculate the solubility (in moles per liter), of $PbCl_2$ in pure water. The K_{sp} of $PbCl_2$ is 2.4×10^{-4}

B. Calculate the K_{sp} of Ag_2SO_4 which has a solubility of 1.5×10^{-2} M in pure water.

C. Calculate the solubility of Ag_2SO_4 in a 0.040 M solution of Na_2SO_4.

D. For a solution containing both silver 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 0.010M solution of $NaCrO_4$ were slowly added to that solution. The K_{sp} of $PbCrO_4$ is 1.8×10^{-14} and that of Ag_2CrO_4 is 1.1×10^{-12}.

6. A. Calculate the energy of activation of a reaction which has rate constants of 6.82×10^{-3} M/s at 37°C and 9.88×10^{-2} M/s at 127°C.

B. Draw the potential energy diagram (graph) for this reaction which has an ***enthalpy*** of reaction of −30.6 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: $2X_{(g)} + Y_{(g)} \rightleftharpoons 3Z_{(g)}$
Which way will the equilibrium shift if

i. some Z is added? ii. some Y is removed?
iii. the reaction is cooled down? iv. 0.10 mole X is added and 0.10 mole Z is removed?
v. the volume is increased? vi. a catalyst is added?

7. A. Calculate the number of milliliters of 0.20 M KOH it will require to just neutralize 25.0 mL of 0.50 M acetic acid.

B. For the titration of 25.0 mL of 0.500 M acetic acid with 0.200 M KOH, 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 formate [HCO_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 propyne and indicate what kinds of atomic orbitals are overlapping for each carbon-carbon bond.

C. Write the electronic configuration for the tin (IV) ion and then write the Lewis structure for tin (IV) sulfate

D. Indicate the VSEPR shape of each central atom of the conjugate acid of methylamine.

9. A. A buffer solution is prepared by dissolving 1.00 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 0.20 moles of HCl is added per liter of the buffer solution in part B—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 252.8829	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*

Name	Symbol	Atomic Number	Atomic Weight
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
Unnilnoveum	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.