COURSE	NUMBER	SECTION
GENERAL CHEMISTRY II	CHEM 206	/4 01 & 52
EXAMINATION	**DATE**	**TIME**
Final Examination	April 19, 2008	0900-1200
INSTRUCTOR		
Drs. C. Rogers & E. Ghobadi		
MATERIALS ALLOWED	**NOT ALLOWED**	
Calculator (non-programmable)	Notes, cell phones, pagers, electronic dictionaries…	

Chem 206 --- GENERAL CHEMISTRY II

LAST NAME: _____ FIRST NAME: _____

STUDENT NUMBER: _____ SIGNATURE: _____

Instructions: PLEASE READ THIS PAGE WHILE WAITING TO START!

- ***Make sure your exam has 11 pages, including this cover page & a periodic table.***
- ***Write your student ID number on all pages.***
- ***Write all answers <u>legibly</u> in the space provided (use the backs of pages for rough work).***
- ***For full marks: you <u>must</u> show formulae, units & comments throughout your calculations.***
- ***You may detach the periodic table and "potentially useful information" page.***
- ***Read ALL questions quickly BEFORE starting the exam; do the "easy" questions first.***
- ***Suggestion: spend 20 minutes per page to have 20 minutes left to check your work.***

<u>Mark breakdown</u>*:*

Page 2.	/ 18
Page 3.	/ 10
Page 4.	/ 9
Page 5.	/ 15
Page 6.	/ 12
Page 7.	/ 13
Page 8.	/ 10
Page 9.	/ 9

TOTAL: / 95 (MAXIMUM MARK = 96)

 # 1. **(8 marks) CIRCLE YOUR CHOICE.** Determine if the following salts produce an **acidic, basic, or neutral solution** when dissolved in water. The data in the table may be of use.

Species	K_a
HF	7.2×10^{-4}
$HC_2H_3O_2$	1.8×10^{-5}
NH_4^+	5.6×10^{-10}

a) KNO_3 **acidic basic neutral**

b) $NaC_2H_3O_2$ **acidic basic neutral**

c) NH_4Cl **acidic basic neutral**

d) NH_4F **acidic basic neutral**

 # 2. **(4 marks) CIRCLE YOUR CHOICE.** For a certain chemical process, q = -30 kJ and w = -25 kJ. Identify the following statements as true or false.

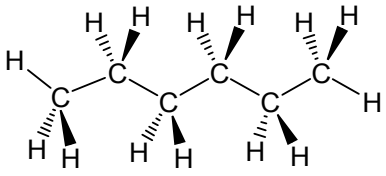
T / F Heat flows from the system to the surroundings.

T / F The surroundings performs work on the system.

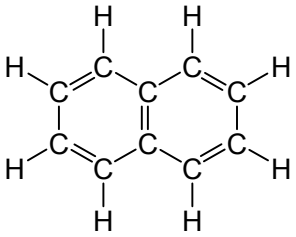
T / F ΔE = -5 kJ.

T / F The chemical process likely involves gases.

 # 3. **(6 marks) CIRCLE YOUR CHOICE +….** For each molecule shown below (a & b), would you expect a greater solubility in water or in hexane, C_6H_{14} (shown at right)? Name the most important type of intermolecular force that exists between the solute and the solvent you circled.

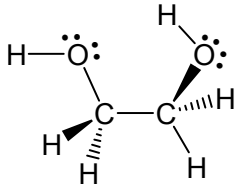


a) Naphthalene: higher solubility in… **water hexane**



Most important solute-solvent interaction:

b) Ethylene glycol: higher solubility in… **water hexane**



Most important solute-solvent interaction:

 # 4. (6 marks) The rate law for the reaction between A and B is found by experiment to be: $rate = k\,[A]^2\,[B]$.

Which of the mechanisms below (I, II, III) give this rate law? **CIRCLE YOUR CHOICE(S) + comment briefly.**

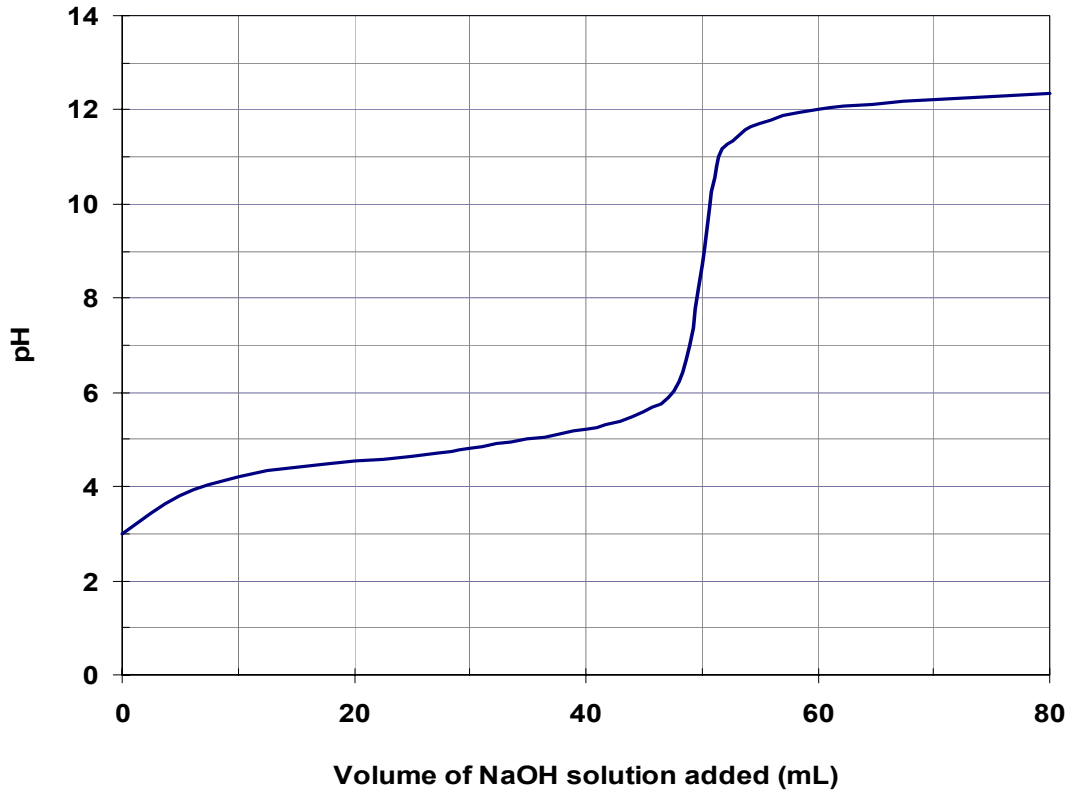
I. $A + B \rightleftharpoons E$ (fast)
$E + B \rightarrow C + D$ (slow)

II. $A + B \rightleftharpoons E$ (fast)
$E + A \rightarrow C + D$ (slow)

III. $A + A \rightarrow E$ (slow)
$E + B \rightarrow C + D$ (fast)

 # 5. (4 marks) LABEL THE DIAGRAM. Consider the titration curve of a weak acid, HA, with a strong base (shown below). On the curve, clearly indicate the points/areas that correspond to:

a) the equivalence point
b) the half-neutralization (half-equivalence) point
c) the region where the solution has maximum buffering capacity
d) the region where the solution's pH depends only on the amount of excess base added.



 # 6. (9 marks) Thyroxine is an important hormone that controls the rate of metabolism in the body, and it can be isolated from the thyroid gland. When 0.455 g of thyroxine is dissolved in 10.0 g of benzene, the freezing point of the solution is 5.2 °C. What is the molar mass of thyroxine, assuming that it is a nonelectrolyte? Show your calculations and briefly explain your answer.

Note: Potentially useful information about benzene: C_6H_6, MM 78.12 g/mol
m.p. 5.5 °C, b.p. 80.1 °C
K_f 5.12 °C·kg/mol, K_b 2.53 °C·kg/mol

 # 7. Consider the following reaction occurring at 298 K:

$$BaCO_{3(s)} \rightleftharpoons BaO_{(s)} + CO_{2(g)}$$

Thermodynamic data for 298 K		
Species	ΔH^o_f **(kJ·mol^{-1})**	S^o_f **(J·mol^{-1}·K^{-1})**
$BaCO_3(s)$	-410.9	72.33
BaO(s)	-127.0	96.11
$CO_2(g)$	-240.1	59.0

a) **(6 marks)** Show that the reaction is not spontaneous under standard conditions.

b) **(5 marks)** If $BaCO_3$ is placed in an evacuated flask, what partial pressure of CO_2 will be present when the reaction reaches equilibrium?

b) **(4 marks)** Can the reaction be made more product-favoured by an increase or decrease in temperature? If so, what temperature is required to produce a $CO_{2(g)}$ partial pressure of 1.0 atm? Explain briefly.

 # 8. A buffer solution is made by adding 5.05 g of KOH (56.1 g/mol) to 500.0 mL of 0.400 M benzoic acid, $HC_7H_5O_2$ ($K_a = 6.6\times10^{-5}$). For the questions below, show all relevant chemical reactions and work.

a) (6 marks) Calculate the pH of the resulting buffer (total volume is 500.00 mL).

b) (6 marks) Calculate the pH of the solution that results when 100.0 mL of 0.150 M HCl is added to the above buffer (total volume is 600.00 mL).

 # 9. At a certain temperature, a system described by the reaction equation: $CO_{(g)} + Cl_{2(g)} \rightleftharpoons COCl_{2(g)}$ is at equilibrium, with partial pressures as follows: P_{CO} = 0.30 atm, P_{Cl_2} = 0.10 atm, P_{COCl_2} = 0.60 atm.

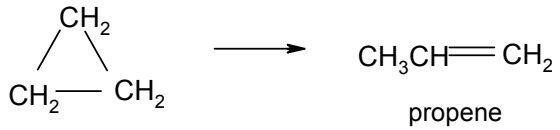
a) **(2 marks)** Calculate K_p for the reaction at this temperature.

b) **(8 marks)** Imagine an additional pressure of $Cl_{2(g)}$ = 0.40 atm is then added to the flask. Find the partial pressure of CO in the flask when the system re-establishes equilibrium.

c) **(3 marks)** Does the change in P_{CO} experienced by the system while it returns to equilibrium agree with Le Châtelier's principle? Explain.

 # 10. (10 marks) The pH of a saturated solution of nickel hydroxide, $Ni(OH)_2$, is 8.83. Calculate the K_{sp} for nickel hydroxide. (Show all relevant chemical reactions and work.)

 # 11. The isomerization of cyclopropane to form propene (shown below) is a first order reaction. At 760 K, 85% of cyclopropane changes to propene in 79.0 minutes.



cyclopropane propene

a) **(5 marks)** Calculate the reaction's rate constant (k) at this temperature. Include units.

b) **(4 marks)** Calculate the reaction's half-life ($t_{1/2}$) at this temperature.

POTENTIALLY USEFUL INFORMATION

Constants:

$R = 8.314\ J \cdot mol^{-1}K^{-1} = 0.08206\ L \cdot atm \cdot mol^{-1}K^{-1}$

1 atm = 760 mm Hg = 760 torr = 101.325 kPa

Data:

Properties of liquid water:

bp (at 1 atm) = 100.00°C

$C_{H_2O(l)} = 4.184\ J \cdot g^{-1}K^{-1}$

$d_{H_2O(l)} = 1.00\ g \cdot mL^{-1}$

$K_{f\ H_2O} = 1.86\ °C \cdot kg \cdot mol^{-1}$

$K_{b\ H_2O} = 0.52\ °C \cdot kg \cdot mol^{-1}$

$K_w = 10^{-14}$

Properties of solid water:

mp (at 1 atm) = 0.00°C

$C_{H_2O(s)} = 2.06\ J \cdot g^{-1}K^{-1}$

$d_{H_2O(s)} = 0.917\ g \cdot mL^{-1}$

Formulae:

$\Delta G^o = \Delta H^o - T\Delta S^o$

$\Delta G = \Delta G^o + RT \ln Q$

$\Delta G^o = -RT \ln K_{eq}$

$PV = nRT$

$C = k\,P \quad (\text{or, } S = k\,P)$

$P = \chi\, P^o$

$\Delta T = K\, m$

$\pi V = nRT$

$k = A\, e^{(-Ea/RT)}$

$[A]_t = -kt + [A]_o$

$\ln[A]_t = -kt + \ln[A]_o$

$1/[A]_t = kt + 1/[A]_o$

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

$pH = -\log[H_3O^+]$

$$pH = pK_a + \log\frac{[A^-]}{[HA]}$$

Periodic Table of the Elements

1																	18
1 **H** 1.008	2											13	14	15	16	17	2 **He** 4.00
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31	3	4	5	6	7	8	9	10	11	12	13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.61	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (97.91)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	**La-Lu**	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.2	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** 208.98	85 **At** 209.99	86 **Rn** 222.02
87 **Fr** 223	88 **Ra** 226.03	**Ac-Lr**	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)									

57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.35	63 **Eu** 151.97	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97
89 **Ac** 227.03	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (245)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

Electronegativity Values of the Elements

H 2.1																	**He**
Li 1.0	**Be** 1.5											**B** 2.0	**C** 2.5	**N** 3.0	**O** 3.5	**F** 4.0	**Ne**
Na 0.9	**Mg** 1.2											**Al** 1.5	**Si** 1.8	**P** 2.1	**S** 2.5	**Cl** 3.0	**Ar**
K 0.8	**Ca** 1.0	**Sc** 1.3	**Ti** 1.5	**V** 1.6	**Cr** 1.6	**Mn** 1.5	**Fe** 1.8	**Co** 1.9	**Ni** 1.9	**Cu** 1.9	**Zn** 1.6	**Ga** 1.6	**Ge** 1.8	**As** 2.0	**Se** 2.4	**Br** 2.8	**Kr**
Rb 0.8	**Sr** 1.0	**Y** 1.2	**Zr** 1.4	**Nb** 1.6	**Mo** 1.8	**Tc** 1.9	**Ru** 2.2	**Rh** 2.2	**Pd** 2.2	**Ag** 1.9	**Cd** 1.7	**In** 1.7	**Sn** 1.8	**Sb** 1.9	**Te** 2.1	**I** 2.5	**Xe**
Cs 0.7	**Ba** 0.9	**La-Lu**	**Hf** 1.3	**Ta** 1.5	**W** 1.7	**Re** 1.9	**Os** 2.2	**Ir** 2.2	**Pt** 2.2	**Au** 2.4	**Hg** 1.9	**Tl** 1.8	**Pb** 1.9	**Bi** 1.9	**Po** 2.0	**At** 2.2	**Rn**