Concordia University CHEM 206

Winter 2009, Dr. C. Rogers, Section 01

LAST NAME:

FIRST NAME:

STUDENT ID:

Chem 206 - GENERAL CHEMISTRY II

MIDTERM EXAMINATION

INSTRUCTIONS: ***PLEASE READ THIS PAGE WHILE WAITING TO START YOUR EXAM.***

- This test includes 4 pages (both sides). Read over the whole test quickly before starting.
- Calculators are permitted; cell phones and other electronic devices are not allowed.
- Potentially useful information (look at it…) is given on back of the periodic table.
- You can remove the periodic table if you wish.
- Answer all questions in the space provided.
- You have 70 min to complete the test.

- **GOOD LUCK!**

Mark breakdown:

Page 2.	/ 11
Page 3.	/ 8
Page 4.	/ 8
Page 5.	/ 5
Page 6.	/ 9
TOTAL:	/ 40 (max. = 41)
PERCENT:	%
EARNED toward FINAL GRADE:	/ 20

 # 1. (5 marks) TRUE OR FALSE? Circle T or F to describe each of the following statements.

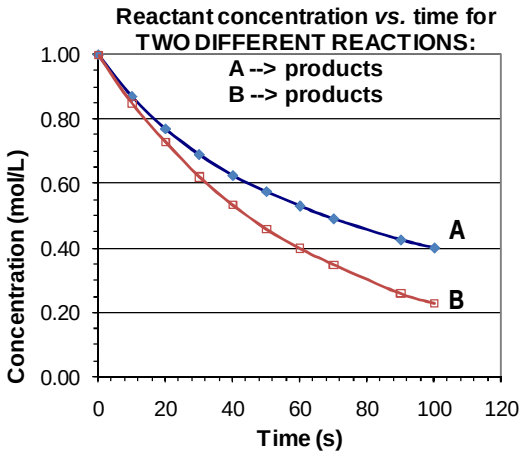
T / F If a solution of a gas-phase solute is suddenly exposed to a higher partial pressure of the gas, the concentration of dissolved gas will begin to decrease.

T / F A proposed mechanism is *consistent with experiment* if the experimentally observed rate law is the same as the rate law predicted for the first step in the mechanism.

T / F The rate-limiting step of a reaction is the elementary step with the largest activation energy.

T / F The freezing point of salt water is lower than the freezing point of fresh water.

T / F From the graph, curve A corresponds to a first-order reaction whereas curve B does not.



 # 2. (6 marks) In the table, circle the substance with the desired property and provide a brief explanation.

Desired property	**Choices** (= pure substances!)	**Brief explanation** ***(in point form – key words only)***
Higher boiling point	**NH_3** ***vs.*** **PH_3**	
Higher vapour pressure	**H_2S** ***vs.*** **H_2Se**	
Higher solubility in water	**I_2** ***vs.*** **$NaNO_3$**	

 # 3. (8 marks) Zinc metal reacts with hydrochloric acid according to the following balanced equation:

$$Zn_{(s)} + 2\ HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$$

a) (7 marks) When 0.103 g of Zn(s) is combined with enough HCl to make 50.0 mL of solution in a perfectly insulated coffee-cup calorimeter, all of the zinc reacts. The temperature of the solution increases from 22.5 °C to 23.7 °C. Determine the enthalpy change for this reaction (per mole of zinc).
[Note: assume the solution is dilute enough to be treated as "pure water" in your calculations.]

b) (1 mark) Is work done on/by the system during this reaction? Explain with a few key words.

 # 4. (8 marks) Imagine you are studying a complex metal-containing compound with formula: $Co(NH_3)_6Cl_3$. You wish to learn if this compound is covalent (*i.e.,* nonelectrolyte) or if it contains ions (*i.e.,* electrolyte), so you perform the following experiment:

- You prepare an aqueous solution of well-defined concentration: 0.00207 M
- You carefully measure the solution's osmotic pressure at 298 K: 0.201 atm

Use this data and relevant reference data from the information page to:

(1) determine the osmotic pressure expected if the compound is a nonelectrolyte
(2) determine the observed van't Hoff factor, **i** , of this compound using the data above
(3) conclude whether the compound is covalent or if it contains ions.

Show all calculations and include brief explanatory comments.

 # 5. (5 marks) Geologists can estimate the age of ancient rocks by their uranium-238 content. The radioactive U-238 is incorporated in the rock as it hardens and then decays with first-order kinetics and half-life of 4.5 billion years (*i.e.,* 4.5×10^9 years). The amount of U-238 present when the rock formed can be deduced by the quantities of U-238 decay products present in the rock; this original amount of U-238 is then compared to the amount currently contained in the rock to estimate the rock's age.

Suppose a rock is found to contain 83.2% of the U-238 it contained when it was formed. How old is the rock? Your answer must include calculations (not only approximations) and brief explanatory comments.

 # 6. (9 marks) Nitrogen dioxide, a pollutant in the atmosphere, can combine with water to form nitric acid. One of the possible reactions occurring in clouds is shown below.

$$3\ NO_2(g)\ +\ H_2O(\mathbf{l})\ \rightarrow\ 2\ HNO_3(aq)\ +\ NO(g)$$

Thermodynamic data at 298 K		
Substance	**ΔH_f^o (kJ/mol)**	**S_f^o (J/mol·K)**
$NO_2(g)$	33.1	240.04
$H_2O(\mathbf{l})$	-285.83	69.95
$HNO_3(aq)$	-207.36	146.4
$NO(g)$	90.29	210.76

a) **(7 marks)** Calculate the Gibbs free energy change for this reaction at 298 K. Show full calculations. Is this reaction spontaneous at this temperature? Explain very briefly.

b) **(2 marks)** If the quantity of NO_2 that reaches the clouds is constant throughout the year (*not true...*), could the following statement be true? Explain briefly.

"Nitrogen dioxide contributes more to acid rain in the summer months."

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

1 Calorie = 1 kcal = 4.184 kJ

Data:

Properties of liquid water:

b.p. (at 1 atm) = 100.00°C

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

$\Delta H^o_{vap} = 40.7\ kJ \cdot mol^{-1}$

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

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

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

$P^o_{(298\ K)} = 23.8$ mm Hg

Properties of solid water:

m.p. (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:

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

$PV = nRT$

$C = k\ P$ (or, $S = k\ P$)

$P = \chi\ P^o$

$\Delta T = K\ m$

$\pi V = nRT$

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

$[A]_t = -k\ t + [A]_o$

$\ln[A]_t = -k\ t + \ln[A]_o$

$1/[A]_t = k\ t + 1/[A]_o$

Periodic Table of the Elements

1												13	14	15	16	17	18
1 **H** 1.008	2																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**