Concordia University CHEM 206

Winter 2009, Dr. C. Rogers, Section 52

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.

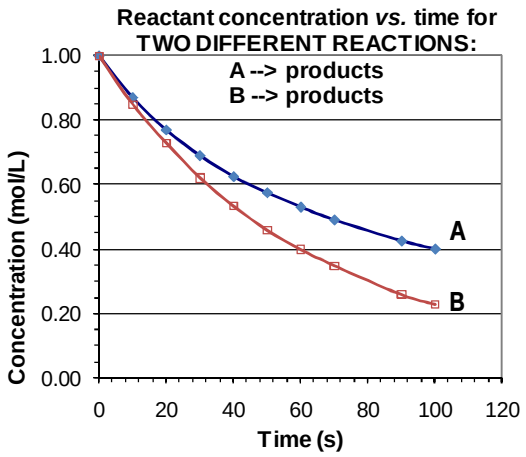
T / F If a solution of a gas-phase solute is suddenly exposed to a lower partial pressure of the gas, the concentration of dissolved gas will begin to decrease.

T / F This reaction likely proceeds via a multi-step mechanism: $C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4H_2O$.

T / F The last elementary step in any multi-step reaction limits the rate of the overall reaction.

T / F The melting point of clean snow is lower than the melting point of dirty snow.

T / F From the graph, curve B corresponds to a first-order reaction whereas curve A 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	**NaCl** ***vs.*** **HCl**	
Higher vapour pressure	**CH_3OH** ***vs.*** **CH_3SH**	
Higher solubility in water	**Br_2** ***vs.*** **ICl**	

 # 3. (8 marks) Instant cold packs contain ammonium nitrate and water separated by a thin plastic divider. When the divider is broken, the ammonium nitrate dissolves via an endothermic process according to the following equation:

$$NH_4NO_3(s) \rightarrow NH_4^+(aq) + NO_3^-(aq)$$

a) (7 marks) To study this process, 1.25 g of NH_4NO_3 was dissolved in enough water to make 25.0 mL of solution in a perfectly insulated coffee-cup calorimeter. The solution's temperature decreased from 25.8 °C to 21.9 °C. Use these data to find the enthalpy change for this process (per mole of NH_4NO_3).
[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 process? Explain with a few key words.

 # 4. (8 marks) Imagine you are studying a complex metal-containing compound with formula: $Fe(NH_3)_6Cl_2$. 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: 0.0207 **m**
- You very carefully measure the solution's melting point : - 0.116 °C

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

(1) determine the melting point 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) Anthropologists can estimate the age of a bone or other organic matter by its carbon-14 content (radioactive isotope, ^{14}C, half-life 5730 years). The ^{14}C in a living organism is constant until the organism dies, after which time the ^{14}C decays with first-order kinetics.

Suppose a bone from an ancient human contains 19.5% of the ^{14}C found in living organisms. How old is the bone? Your answer must include calculations (not only approximations) and brief explanatory comments.

 # 6. (9 marks) Our atmosphere is composed primarily of nitrogen and oxygen, which coexist at 25°C without reacting to any significant extent. However, the two gases can react to form nitrogen monoxide, an atmospheric pollutant, according to the following equation:

$$N_2(g) + O_2(g) \rightarrow 2\ NO(g)$$

Thermodynamic data at 298 K		
Substance	**ΔH_f^o (kJ/mol)**	**S_f^o (J/mol·K)**
$N_2(g)$	0	191.56
$O_2(g)$	0	205.07
$NO(g)$	91.3	210.76

a) **(7 marks)** Determine whether or not this reaction is spontaneous at 298 K. Show full calculations and explanatory comments.

b) **(1 mark)** Does your conclusion from part (a) agree with the fact that N_2 and O_2 do not react significantly in the atmosphere? If so, explain how (key words only). If not, explain what this discrepancy might tell you about the reaction (key words only).

c) **(1 mark)** Automotive exhaust systems are a significant source of atmospheric NO pollution. Can you think of any reason why? Explain with a few key words.

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**