Chem 206 Winter 2008 section 01

GENERAL CHEMISTRY II
MIDTERM EXAMINATION

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

This test paper includes 4 pages (both sides); some potentially useful information (look at it!) is given on back of the periodic table. Check that your paper is complete before starting. You can remove the periodic table if you wish. Answer all questions in the space provided. Calculators are permitted; cell phones and electronic dictionaries are not allowed. You have 75 min to complete the test.
I suggest you scan the whole test quickly before starting & do the 'easy' stuff first. **GOOD LUCK!**
Suggestion: spend 1 min / mark ⇨ 25 min left to finish uncertain problems & check.

LAST NAME: _____ FIRST NAME: _____

STUDENT NUMBER: _____

Mark breakdown:

Page 2.	/ 10
Page 3.	/ 11
Page 4.	/ 10
Page 5.	/ 10
TOTAL:	/ 40 (max. = 41)
PERCENT:	%
EARNED toward FINAL GRADE:	/ 20

BLANK PAGE (use for extra work if necessary)

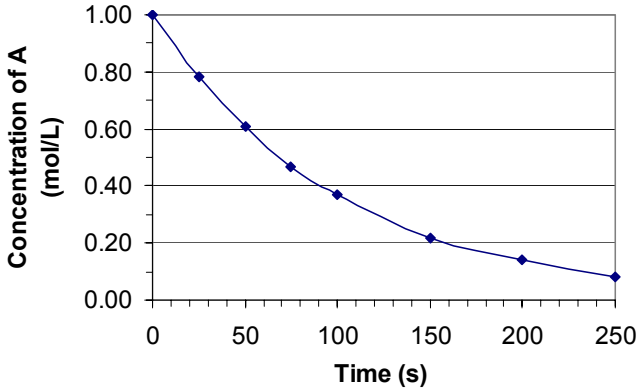
 # 1. (4 marks) TRUE OR FALSE? Circle T or F to describe the following three statements.

T / F When hydrogen sulfide gas dissolves in water, H_2S molecules form hydrogen bonds with H_2O molecules.

T / F When a reaction with $\Delta n_{gases} < 0$ takes place at constant pressure, the surroundings perform work on the system.

Refer to the graph shown here for reaction **2 A → B**:

T / F The reaction **2 A → B** is first order with respect to the concentration of reactant A.



 # 2. (6 marks) Complete the table: circle the substance/solution with the desired property & explain briefly.

Desired property	***Substances to choose from*** *(PURE unless given concentration…)*	***How you decided (briefly!)***
Highest vapour pressure at 25°C	CH_4 CH_3CH_3 $CH_3CH_2CH_3$	
Highest temperature after absorbing 100 kJ of heat	Ti(s) Al(s) SiO_2(s) C_s = 0.52 0.90 0.74 J/(g·°C)	
Highest osmotic pressure	1 M H_2SO_4 1 M $C_6H_{12}O_6$ 1 M NaCl	

 # 3. (11 marks) Metallic tungsten (W) is produced on large scale by the reduction of WO_3 with hydrogen:

$$WO_{3(s)} + 3\ H_{2(g)} \rightarrow\ W_{(s)} + 3\ H_2O_{(g)}$$

Thermodynamic data at 298 K		
Substance	**ΔG°_f (kJ/mol)**	**ΔH°_f (kJ/mol)**
$WO_3(s)$	-763.1	-839.9
$H_2O(g)$	-228.6	-241.8

a) **(4 marks)** Is this reaction spontaneous at 25°C? Show calculations and explain briefly.

b) **(5 marks)** Calculate the value of ΔS°_{rxn} at 25°C.

c) **(2 marks)** At higher temperatures, will this reaction have higher yield or lower yield? Explain briefly.

 # 4. (10 marks) Ice cream is made by freezing a liquid mixture that (in a simplified view) can be considered a solution of sucrose ($C_{12}H_{22}O_{11}$) in water.

Calculate the temperature at which the first ice crystals begin to appear when you cool a mixture that consists of 34% (by mass) sucrose in water.

 # 5. (10 marks) In basic solution, chlorine dioxide yields chlorate ions and chlorite ions:

$$2\ ClO_2(aq) + 2\ OH^-(aq) \rightarrow ClO_3^-(aq) + ClO_2^-(aq) + H_2O(\ell)$$

To investigate the reaction's kinetics, the initial reaction rate was measured in three separate experiments (data shown in table):

Kinetic data at 298 K			
Run	$[ClO_2]_o$ $mol \cdot L^{-1}$	$[OH^-]_o$ $mol \cdot L^{-1}$	Initial rate $mol \cdot L^{-1} \cdot s^{-1}$
1	0.060	0.030	0.0248
2	0.020	0.030	0.00276
3	0.020	0.090	0.00828

a) **(6 marks)** Determine the rate law and the value of the rate constant at this temperature. Show your work.

b) **(4 marks)** Compare the reaction equation to your experimentally determined rate law. What conclusions (if any) can you make about the mechanism of this reaction? Explain briefly.

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

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

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

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

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

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

$P^o_{(298\ K)} = 23.8$ 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, $S = k\ P$)

$P = \chi\ P^o$

$\Delta T = K\ m$

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**