NAME:_____ Section:_____ Student Number:_____

Spring 2017 **Chemistry 2000 Midterm #2A** ____/ 50 marks

INSTRUCTIONS:
1) Please read over the test carefully before beginning. You should have 5 pages of questions, a blank "overflow" page and two pages of data sheets with periodic table.
2) If your work is not legible, it will be given a mark of zero.
3) Marks will be deducted for incorrect information added to an otherwise correct answer.
4) Marks will be deducted for improper use of significant figures and for missing or incorrect units.
5) Show your work for all calculations. Numerical answers without supporting calculations will not be given full credit.
6) You may use a calculator but only for the purposes of calculation. No text-capable calculators are allowed.
7) You have 90 minutes to complete this test.

Confidentiality Agreement:
I agree not to discuss (or in any other way divulge) the contents of this exam until after 8:00 pm Mountain Time on Thursday, March 23rd, 2017. I understand that breaking this agreement would constitute academic misconduct, a serious offense with serious consequences. The minimum punishment would be a mark of 0/50 on this exam and removal of the "overwrite midterm mark with final exam mark" option for my grade in this course; the maximum punishment would include expulsion from this university.

Signature: _____ Date: _____
Course: CHEM 2000 (General Chemistry II)
Semester: Spring 2017
The University of Lethbridge

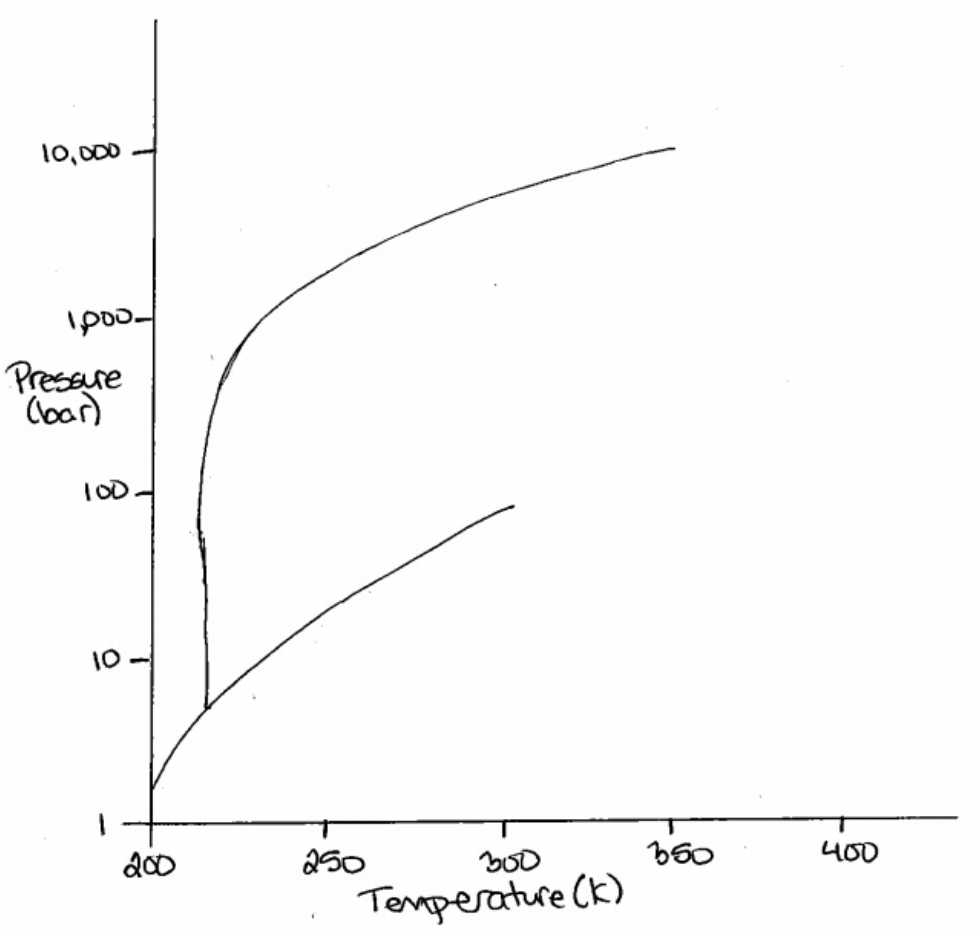
Question Breakdown

Q1	/ 5
Q2	/ 11
Q3	/ 9
Q4	/ 5
Q5	/ 8
Q6	/ 12

Total	/ 50

NAME:_____ Section:_____ Student Number:_____

1. Consider the unlabeled phase diagram below. **[5 marks]**



(a) On the diagram, label: *[3 marks]*

- the critical point
- the triple point
- regions corresponding to the <u>four</u> states of matter discussed in class

(b) A sample of this substance is initially at 200 K and 10 bar. The temperature is raised to 300 K while the pressure is maintained at 10 bar. What phase change(s) will occur? *[1 mark]*

(c) A sample of this substance is initially at 200 K and 1 bar. The pressure is raised to 10 bar while the temperature is maintained at 200 K. What phase change(s) will occur? *[1 mark]*

NAME:_____ Section:_____ Student Number:_____

2. Two chlorine atoms react to form a chlorine molecule under standard conditions: **[11 marks]**

$$2\,Cl_{(g)} \rightarrow Cl_{2(g)}$$

(a) What information does the phrase "standard conditions" give you about the conditions under which this reaction is being studied? *[2 marks]*

(b) Is $\Delta_r G°$ positive, negative or zero for this reaction? Briefly, justify your answer. *[2 marks]*

(c) Is $\Delta_r S°$ positive, negative or zero for this reaction? Briefly, justify your answer. *[2 marks]*

(d) Is $\Delta_r H°$ positive, negative or zero for this reaction? Briefly, justify your answer. *[2 marks]*

(e) Will there be any temperature at which this reaction is not favoured in the forward direction? If 'yes', will it be high or low temperatures (and why)? If 'no', why not? *[3 marks]*

NAME:_____ Section:_____ Student Number:_____

3. Fill in each blank with the word or short phrase that best completes the sentence. **[9 marks]**

(a) The term for "heat at constant pressure" is _____.

(b) The only time that Q = K is when _____.

(c) If Q > K, we can expect that the reaction will proceed in the _____ direction.

(d) The entropy of _____ increases in every thermodynamically allowed process.

(e) The _____ half reaction occurs at the cathode of an electrochemical cell.

(f) The activity of a pure solid is _____.

(g) The activity of $Cl^-_{(aq)}$ in an ideal 0.1 M solution of $MgCl_{2(aq)}$ is _____.

(h) Henry's law states that the concentration of dissolved gas in a solution is directly proportional to _____.

(i) The third law of thermodynamics states that _____.

4. In the qualitative analysis lab, you used aqua regia, a mixture of concentrated $HNO_{3\,(aq)}$ and $HCl_{(aq)}$ to isolate for certain Group II/III cations. The use of aqua regia was originally developed by alchemists to "dissolve" gold but, in reality, this is just a redox reaction under acidic conditions. The incomplete and unbalanced equation is shown below: **[5 marks]**

$$Au_{(s)} + NO^-_{3\,(aq)} + Cl^-_{(aq)} \rightarrow AuCl^-_{4\,(aq)} + NO_{2\,(g)}$$

(a) Balance the equation using either the half reaction method or the oxidation method. *[3 marks]* Show your work.

(b) Identify the oxidizing agent. *[1 mark]*

(c) Identify the reducing agent. *[1 mark]*

NAME:_____ Section:_____ Student Number:_____

5. Consider the following electrochemical cell, run at 25.00°C: **[8 marks]**

$$Cu_{(s)} \mid Cu^{2+}_{(aq)}(0.0100\ M) \parallel Ag^{+}_{(aq)}(0.500\ M) \mid Ag_{(s)}$$

(a) Write a balanced chemical equation for the reaction that proceeds in this electrochemical cell. *[1 mark]*

(b) Calculate the cell potential for this electrochemical cell. *[7 marks]*

NAME:_____ Section:_____ Student Number:_____

6. The K_a value for $HF_{(aq)}$ at 25.00 ℃ is 6.8×10^{-4}. **[12 marks]**

$$HF_{(aq)} \rightleftharpoons H^+_{(aq)} + F^-_{(aq)} \qquad K_a = 6.8 \times 10^{-4}$$

(a) Calculate ΔG° for the reaction above. *[2 marks]*

(b) Calculate $\Delta_f G°$ for $HF_{(aq)}$. *[3 marks]*

(c) Calculate the K_a value for $HF_{(aq)}$ at 50.00 ℃. *[6 marks]*

(d) Is $HF_{(aq)}$ a stronger acid at 50.00 ℃ or at 25.00 ℃? How do you know? *[1 mark]*
In other words, at which temperature is the reaction more product-favoured?

NAME:_____ Section:_____ Student Number:_____

Overflow Page

If you use this page for any answers, please clearly indicate which question is being answered and make sure you note on the page for the question itself that the answer continues here

Some Useful Constants and Formulae

Fundamental Constants and Conversion Factors

Atomic mass unit (u)	$1.660\ 539 \times 10^{-27}$ kg	Kelvin temperature scale	0 K = -273.15 ˚C
Avogadro's number (N_A)	$6.022\ 141 \times 10^{23}$ mol^{-1}	K_w (at 25 °C)	10^{-14}
Boltzmann constant (k_B)	$1.380\ 649 \times 10^{-23}$ $J \cdot K^{-1}$	Planck's constant (h)	$6.626\ 070 \times 10^{-34}$ $J \cdot Hz^{-1}$
Charge of electron	$-1.602\ 176 \times 10^{-19}$ C	Speed of light in vacuum (c)	$2.997\ 925 \times 10^{8}$ $m \cdot s^{-1}$
Faraday's constant (F)	96 485 $C \cdot mol^{-1}$	Volume conversion	1000 L = 1 m^3
Ideal gas constant (R)	8.314 462 $J \cdot mol^{-1} \cdot K^{-1}$	Pressure conversions	1 bar = 100 kPa
	8.314 462 $m^3 \cdot Pa \cdot mol^{-1} \cdot K^{-1}$		1 atm = 1.01325 bar

Formulae

$$\overline{K} = \frac{1}{2} m \overline{v^2} = \frac{3}{2} RT \qquad v_{rms} = \sqrt{\overline{v^2}} = \sqrt{\frac{3RT}{M}} \qquad PV = nRT$$

$$S = k_B \ln \Omega \qquad \Delta S = \frac{q_{rev}}{T} \qquad \Delta_r G = \Delta_r H - T\Delta_r S \qquad x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\Delta_r G = \Delta_r G^\circ + RT \ln Q \qquad \Delta_r G^\circ = -RT \ln K \qquad \ln\left(\frac{K_2}{K_1}\right) = \frac{\Delta_r H^o}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$P_A = X_A P_A^\bullet \qquad [A] = k_H P_A \qquad X = \frac{n}{\sum n} \qquad \Delta_r G = -\upsilon_e F E \qquad E = E^\circ - \frac{RT}{\upsilon_e F} \ln Q$$

$$pH = -\log a_{H^+} \qquad pK_a = -\log K_a \qquad pK_b = -\log K_b \qquad K_w = K_a \cdot K_b \qquad pH = pK_a + \log\left(\frac{a_{A^-}}{a_{HA}}\right)$$

$$\Delta H^0_{rxn} = \sum(\Delta H^0_f(products) - \sum(\Delta H^0_f(reactants) \qquad \Delta S^0_{rxn} = \sum(S^0(products) - \sum(S^0(reactants)$$

$$\Delta G^0_{rxn} = \sum(\Delta G^0_f(products) - \sum(\Delta G^0_f(reactants)$$

Activities

Solid	$a = 1$
Pure liquid	$a = 1$
Ideal Solvent	$a = X$
Ideal Solute	$a = \frac{c}{c^\circ}$
Ideal Gas	$a = \frac{P}{P^\circ}$

CHEM 2000 Standard Periodic Table

1												13	14	15	16	17	18
1.0079 **H** 1	2											10.811 **B** 5	12.011 **C** 6	14.0067 **N** 7	15.9994 **O** 8	18.9984 **F** 9	4.0026 **He** 2
6.941 **Li** 3	9.0122 **Be** 4											26.9815 **Al** 13	28.0855 **Si** 14	30.9738 **P** 15	32.066 **S** 16	35.4527 **Cl** 17	20.1797 **Ne** 10
22.9898 **Na** 11	24.3050 **Mg** 12	3	4	5	6	7	8	9	10	11	12						39.948 **Ar** 18
39.0983 **K** 19	40.078 **Ca** 20	44.9559 **Sc** 21	47.88 **Ti** 22	50.9415 **V** 23	51.9961 **Cr** 24	54.9380 **Mn** 25	55.847 **Fe** 26	58.9332 **Co** 27	58.693 **Ni** 28	63.546 **Cu** 29	65.39 **Zn** 30	69.723 **Ga** 31	72.61 **Ge** 32	74.9216 **As** 33	78.96 **Se** 34	79.904 **Br** 35	83.80 **Kr** 36
85.4678 **Rb** 37	87.62 **Sr** 38	88.9059 **Y** 39	91.224 **Zr** 40	92.9064 **Nb** 41	95.94 **Mo** 42	(98) **Tc** 43	101.07 **Ru** 44	102.906 **Rh** 45	106.42 **Pd** 46	107.868 **Ag** 47	112.411 **Cd** 48	114.82 **In** 49	118.710 **Sn** 50	121.757 **Sb** 51	127.60 **Te** 52	126.905 **I** 53	131.29 **Xe** 54
132.905 **Cs** 55	137.327 **Ba** 56	**La-Lu**	178.49 **Hf** 72	180.948 **Ta** 73	183.85 **W** 74	186.207 **Re** 75	190.2 **Os** 76	192.22 **Ir** 77	195.08 **Pt** 78	196.967 **Au** 79	200.59 **Hg** 80	204.383 **Tl** 81	207.19 **Pb** 82	208.980 **Bi** 83	(210) **Po** 84	(210) **At** 85	(222) **Rn** 86
(223) **Fr** 87	226.025 **Ra** 88	**Ac-Lr**	(265) **Rf** 104	(268) **Db** 105	(271) **Sg** 106	(270) **Bh** 107	(277) **Hs** 108	(276) **Mt** 109	(281) **Ds** 110	(280) **Rg** 111	(285) **Cn** 112	(284) **Nh** 113	(289) **Fl** 114	(288) **Mc** 115	(293) **Lv** 116	(294) **Ts** 117	(294) **Og** 118

138.906 **La** 57	140.115 **Ce** 58	140.908 **Pr** 59	144.24 **Nd** 60	(145) **Pm** 61	150.36 **Sm** 62	151.965 **Eu** 63	157.25 **Gd** 64	158.925 **Tb** 65	162.50 **Dy** 66	164.930 **Ho** 67	167.26 **Er** 68	168.934 **Tm** 69	173.04 **Yb** 70	174.967 **Lu** 71
227.028 **Ac** 89	232.038 **Th** 90	231.036 **Pa** 91	238.029 **U** 92	237.048 **Np** 93	(240) **Pu** 94	(243) **Am** 95	(247) **Cm** 96	(247) **Bk** 97	(251) **Cf** 98	(252) **Es** 99	(257) **Fm** 100	(258) **Md** 101	(259) **No** 102	(262) **Lr** 103

Developed by Prof. R. T. Boeré (updated 2016)

Some Useful Thermodynamic Properties

Substance	$\Delta_f H°\left(\frac{kJ}{mol}\right)$	$\Delta_f G°\left(\frac{kJ}{mol}\right)$	$S°\left(\frac{J}{mol \cdot K}\right)$
$F^-_{(aq)}$	-332.63	-278.79	-13.8
$HF_{(aq)}$	-320.08	*see question 6*	88.7

Half Reaction	$E°(V)$
$Ag^+_{(aq)} + e^- \rightarrow Ag_{(s)}$	+0.80
$Cu^{2+}_{(aq)} + 2\,e^- \rightarrow Cu_{(s)}$	+0.34
$Cu^{2+}_{(aq)} + e^- \rightarrow Cu^+_{(aq)}$	+0.15
$2\,H^+_{(aq)} + 2\,e^- \rightarrow H_{2(g)}$	0