Surname (last name): _____

Given name (First name): _____

Student Number: _____

Lab Day (circle one): MON TUE WED THU FRI

Lab TA: _____

CHM 1311 C
Test #2 A
Fall 2009

Please keep your work covered at all times and keep your eyes on your own paper! Cheating or any appearance of cheating will result in an F in the course and possible expulsion from the university.

There are 10 pages in this test. A periodic table and formula sheet are provided at the end. You may rip these pages off of the exam and use them to cover your work during the test. Any scratch work should be done on the back of the test pages.

Please show all work to receive partial credit.

You have 80 minutes to complete the test.

Question	Points Possible	Points Earned	TA Initial
1	10		
2	10		
3	10		
4	10		
5	10		
TOTAL	50		

#1. (10 points) Short Answer Questions

a). For the reaction 2 A ⇆ B + 3 C the value of K is 34.5 at 25°C. The value of K for the reaction 2 B + 6 C ⇆ 4 A would be _____.

b). The van't Hoff plot for a reaction has a slope of +550 K and a y-intercept of + 3.75 mol. This reaction will be:

i. Spontaneous at all T
ii. Spontaneous at low T
iii. Spontaneous at high T
iv. Non-spontaneous at all T

c). For the process A(s) → A(l), 11.2 kJ of heat must be added to melt one mole of A(s) at 78.0°C. The change in entropy for the process A(l) → A(s) would be _____.

d). In a 1.00 L flask, a small amount of hydrogen peroxide is decomposed in the following reaction: $2H_2O_2(l) \rightarrow 2H_2O(g) + O_2(g)$. If the final partial pressure of $O_2(g)$ is 0.16 atm, the *total* pressure of the gas in the flask would be _____.

e). The standard heat of formation of solid $Fe(OH)_3$ is -824 kJ/mol. Write the chemical equation for the reaction to which this value applies.

f). Under constant volume conditions, $\Delta U = \Delta H$. TRUE FALSE

g). If the molar mass of a gas is doubled, the root-mean-squared speed of the gas molecules will change by a factor of $\sqrt{2}$ 2 $\sqrt{½}$ ½

h). Write the equilibrium constant expression in pressure units, K_P, for the following reaction and name two ways in which you could encourage the formation of hydrogen gas. $C(s) + H_2O(g) \leftrightarrows CO(g) + H_2(g)$

$K_P =$

_____

_____

#2. (10 points) A 10.0 L cylinder contains 500 g of methane, CH_4 at 27.0ºC.

a) Calculate its pressure using the ideal gas law.

P = _____

b) Calculate its pressure using the van der Waals equation, where a = 2.273 (L^2•atm)/mol^2 and b = 0.0430 L/mol.

P = _____

c) What are the two key assumptions of the ideal gas law?

d) Use your answer in part (c) to explain why your answers in parts (a) and (b) are different (a hint: only one of the two assumptions applies).

#3. (10 points). For the following reaction:

$$2\ H_2\ (g) + O_2\ (g) \rightarrow H_2O\ (l) \qquad \Delta H^o = -572\ kJ$$

a) What is the quantity of work evolved at 25.0ºC?

Answer : _____

b) What is the significance of the sign of your answer in (a)? Explain briefly.

c) Calculate the change in internal energy for the reaction.

Answer: _____

#4. (10 points) Hydrogen gas can be generated by the following reaction.

$$H_2(g) + CO_2(g) \leftrightarrows CO(g) + H_2O(g)$$

a) A mixture of gases that initially contains 0.0150 M H_2 and 0.0150 M CO_2 is allowed to equilibrate at 700K, and at equilibrium the partial pressure of CO is found to be 0.212 atm. What is the value of K_c?

K_C = _____

b) What would be the value of K_P?

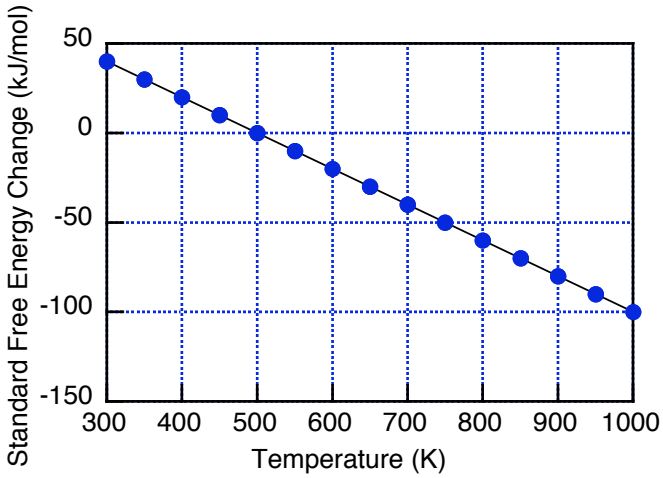
K_P = _____

c) If the equilibrated gas mixture were then transferred to a container of larger volume, what would be the resulting effect on the equilibrium? (A qualitative answer will suffice).

#5. (10 points) The standard free energy change for the reaction

$$A + B \leftrightarrows C + D$$

was measured at several temperatures. The resulting graph of standard free energy change (in kJ/mol) versus temperature is shown at right.



a) Using the data from the graph, what is ΔH^o and ΔS^o for the reaction?

ΔH^o = _____ ΔS^o = _____

b) What is the value of K at 750 K?

K = _____

c) What is the minimum/maximum temperature required for the reaction to be spontaneous? Explain your answer briefly.

Gas Laws

$PV = nRT$

$P_T = P_1 + P_2 + P_3 + \ldots$

$d = m/V = P(MW) / RT$

$KE = (1/2)mv_{av}^2$

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\frac{RateA}{RateB} = \sqrt{\frac{M_b}{M_a}}$$

$$\left(P + \frac{n^2a}{V^2}\right)(V - nb) = nRT$$

Equilibrium

$K_P = K_C(RT)^{\Delta n}$

Acid/Base

$pOH = -\log[OH^-]$

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

$pH + pOH = 14$

$K_a \times K_b = K_W$

$pH = pK_a + \log [A^-]/[HA]$

$$pH = \frac{pK_{a1} + pK_{a2}}{2}$$

Kinetics

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

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

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

$k = Ae^{(-Ea/RT)}$

$\ln(k_2/k_1) = (-Ea/R)(1/T_2 - 1/T_1)$

Thermodynamics

$\Delta U = Q + W$

$W_{system} = -P\Delta V = -\Delta nRT$

$\Delta H = \Delta U + P\Delta V$

$Q_P = \Delta U + P\Delta V$

$C_P = C_V + R$

$Q = mc\Delta T$

$\Delta H_{rxn}^\circ = \sum n\Delta H_f^\circ(pdts) - \sum n\Delta H_f^\circ(rxts)$

$q_{rev} = -w_{max} = nRT \ln(V_2/V_1)$

$\Delta S = q_{rev}/T$

$\Delta S\ (T_1\text{-}T_2) = nC_P \ln(T_2/T_1)$

$\Delta S\ (T_1\text{-}T_2) = nC_V \ln(T_2/T_1)$

$$\Delta S^0_{ext} = \frac{q_{ext}}{T} = \frac{-\Delta H_{sys}}{T}$$

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

$\Delta G = \Delta G^\circ + RT \ln(Q)$

$\Delta G^\circ = -RT \ln(K)$

$\ln(K_2/K_1) = (-\Delta H^\circ/R)(1/T_2 - 1/T_1)$

The atom

$E = h\nu$

$c = \nu\lambda$

$E = -B/n2$

Data For Water

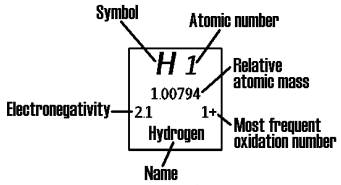
Density $\rho = 1.00$ g/mL (25°C)
$C = 2.13$ J g^{-1} K^{-1} (solid)
$C = 4.18$ J g^{-1} K^{-1} (liquid) $\Delta H°_{fus} = 6.02$ kJ mol^{-1}
$C_p = 2.01$ J g^{-1} K^{-1} (gas) $\Delta H°_{vap} = 40.7$ kJ mol^{-1}

Constants and Conversion Factors

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

Avogadro's Number	*N*	6.022×10^{23} mol^{-1}
Boltzmann's constant	*k*	1.30866×10^{-23} $J \cdot K^{-1}$
Faraday's constant	*F*	96 485 $C \cdot mol^{-1}$
Gas constant	*R*	8.31451 $J \cdot K^{-1} \cdot mol^{-1}$
	R	0.08206 $atm \cdot L \cdot K^{-1} \cdot mol^{-1}$
	R	8.31451 m^3 $Pa \cdot K^{-1} \cdot mol^{-1}$
Planck's constant	*h*	6.62608×10^{-34} $J \cdot s$
Speed of light	*c*	2.99792458×10^{8} $m \cdot s^{-1}$

Mokeur's Periodic table of the elements



	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIII	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	H 1 1.00794 2.1 1+ Hydrogen																	He 2 4.002602 - - Helium
2	Li 3 6.941 1.0 1+ Lithium	Be 4 9.012182 1.5 2+ Beryllium											B 5 10.811 2.0 3+ Boron	C 6 12.011 2.5 4+,4- Carbon	N 7 14.00674 3.0 3+,3- Nitrogen	O 8 15.9994 3.5 2- Oxygen	F 9 18.9984032 4.0 1- Fluorine	Ne 10 20.1797 - - Neon
3	Na 11 22.989768 0.9 1+ Sodium	Mg 12 24.3050 1.2 2+ Magnesium											Al 13 26.981539 1.5 3+ Aluminum	Si 14 28.0855 1.8 4+ Silicon	P 15 30.973762 2.1 5+ Phosphorus	S 16 32.066 1.8 4+ Sulfur	Cl 17 35.4527 3.0 1- Chlorine	Ar 18 39.948 - - Argon
4	K 19 39.0983 0.8 1+ Potassium	Ca 20 40.078 1.0 2+ Calcium	Sc 21 44.955910 1.3 3+ Scandium	Ti 22 47.88 1.5 4+ Titanium	V 23 50.9415 1.6 5+ Vanadium	Cr 24 51.9961 1.6 3+ Chromium	Mn 25 54.93805 1.5 2+ Manganese	Fe 26 55.847 1.8 3+ Iron	Co 27 58.9332 1.8 2+ Cobalt	Ni 28 58.6934 1.8 2+ Nickel	Cu 29 63.546 1.9 2+ Copper	Zn 30 65.39 1.6 2+ Zinc	Ga 31 69.723 1.6 3+ Gallium	Ge 32 72.61 1.6 4+ Germanium	As 33 74.92159 2.0 3+,3- Arsenic	Se 34 78.96 2.4 4+ Selenium	Br 35 79.904 2.8 1- Bromine	Kr 36 83.80 - - Krypton
5	Rb 37 85.4678 0.8 1+ Rubidium	Sr 38 87.62 1.0 2+ Strontium	Y 39 88.90585 1.3 3+ Yttrium	Zr 40 91.224 1.4 4+ Zirconium	Nb 41 92.90638 1.6 5+ Niobium	Mo 42 95.94 1.8 6+ Molybdenum	Tc 43 98.9063 1.9 7+ Technetium	Ru 44 101.57 2.2 3+,4+ Ruthenium	Rh 45 102.9055 2.2 3+ Rhodium	Pd 46 106.42 2.2 2+ Palladium	Ag 47 107.8682 1.9 1+ Silver	Cd 48 112.411 1.7 2+ Cadmium	In 49 114.82 1.7 3+ Indium	Sn 50 118.71 1.8 4+ Tin	Sb 51 121.757 1.9 3+,3- Antimony	Te 52 127.60 2.1 4+ Tellurium	I 53 126.90447 2.5 1- Iodine	Xe 54 131.29 - - Xenon
6	Cs 55 132.90543 0.7 1+ Cesium	Ba 56 137.327 0.9 2+ Barium	La 57 138.9055 1.1 3+ Lanthanum	Hf 72 178.49 1.3 4+ Hafnium	Ta 73 180.9479 1.5 5+ Tantalum	W 74 183.85 1.7 6+ Tungsten	Re 75 186.207 1.9 7+ Rhenium	Os 76 190.2 2.2 4+ Osmium	Ir 77 192.22 2.2 4+ Iridium	Pt 78 195.08 2.2 4+ Platinum	Au 79 196.96654 2.4 3+ Gold	Hg 80 200.59 1.9 2+ Mercury	Tl 81 204.3833 1.8 1+ Thallium	Pb 82 207.2 1.8 2+ Lead	Bi 83 208.98037 1.9 3+ Bismuth	Po 84 208.9824 2.0 2+ Polonium	At 85 209.9871 2.2 1- Astatine	Rn 86 222.0176 - - Radon
7	Fr 87 223.0197 0.7 1+ Francium	Ra 88 226.0254 0.9 2+ Radium	Ac 89 227.0278 1.1 3+ Actinium	Rf 104 261.11 - - Rutherfordium	Db 105 262.11 - - Dubnium	Sg 106 263.12 - - Seaborgium	Bh 107 262.12 - - Bohrium	Hs 108 264 - - Hassium	Mt 109 266.1378 - - Meitnerium	Uun 110 269 - - Ununnilium	Uuu 111 272 - - Unununium	Uu 112 277 - - Ununbium		Uuq 114 289 - - Ununquadium		Uuh 116 289 - - Ununhexium		Uuo 118 293 - - Ununoctium

6	Ce 58 140.115 1.1 3+ Cerium	Pr 59 140.90765 1.1 3+ Praseodymium	Nd 60 144.24 1.1 3+ Neodymium	Pm 61 144.9127 1.1 3+ Promethium	Sm 62 150.36 1.2 3+ Samarium	Eu 63 151.965 1.2 3+ Europium	Gd 64 157.25 1.2 3+ Gadolinium	Tb 65 168.92534 1.2 3+ Terbium	Dy 66 162.50 1.2 3+ Dysposium	Ho 67 164.93032 1.2 3+ Holmium	Er 68 167.26 1.2 3+ Erbium	Tm 69 168.93421 1.2 3+ Thulium	Yb 70 173.04 1.1 3+ Ytterbium	Lu 71 174.967 1.2 3+ Lutetium
7	Th 90 232.0381 1.3 4+ Thorium	Pa 91 231.03588 1.5 5+ Protactinium	U 92 238.0289 1.4 6+ Uranium	Np 93 237.082 1.3 5+ Neptunium	Pu 94 244.0642 1.3 4+ Plutonium	Am 95 243.0614 1.3 3+ Americium	Cm 96 247 1.3 3+ Curium	Bk 97 247.0703 1.3 3+ Berkelium	Cf 98 251.0796 1.3 3+ Californium	Es 99 252.03 1.3 - Einsteinium	Fm 100 257.0951 1.3 - Fermium	Md 101 258.01 1.3 - Mendelevium	No 102 259.1009 1.3 - Nobelium	Lr 103 260.1053 - - Lawrencium