Chemistry 1142
Fall 2008
Exam 2

Name:_____

Take a deep breath, and relax! First, answer the questions you know how to do and then work on the more difficult problems. Don't forget to show all your work, so I can give you as much credit as possible.

Good Luck!

Andy

"This is a lovely old song that tells of a young woman who leaves her cottage, and goes off to work. She arrives at her destination, and places some solid NH_4HS in a flask containing 0.50 atm of ammonia, and attempts to determine the pressures of ammonia and hydrogen sulfide when equilibrium is reached."
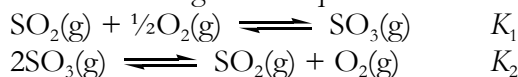
Multiple Choice. (3 pts. each.)

Q1.   Which is the correct equilibrium constant expression for the following reaction?

$$Fe_2O_3(s) + 3H_2(g) \rightleftharpoons 2Fe(s) + 3H_2O(g)$$
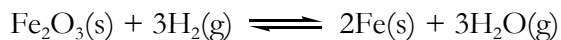
A. $K_c = [Fe_2O_3] [H_2]^3 / [Fe]^2[H_2O]^3$ B. $K_c = [H_2]/ [H_2O]$
C. $K_c = [H_2O]^3 / [H_2]^3$ D. $K_c = [Fe]^2[H_2O]^3 / [Fe_2O_3] [H_2]^3$
E. $K_c = [Fe] [H_2O] / [Fe_2O_3] [H_2]$

Q2. Consider the two gaseous equilibria
$$SO_2(g) + \tfrac{1}{2}O_2(g) \rightleftharpoons SO_3(g) \qquad K_1$$
$$2SO_3(g) \rightleftharpoons SO_2(g) + O_2(g) \qquad K_2$$
The values of the equilibrium constants K_1 and K_2 are related by

A. $K_2 = K_1^2$ B. $K_2 = \sqrt{K_1}$ C. $K_2 = -\tfrac{1}{2} K_1$
D. $K_2 = 1/K_1$ E. $K_2 = 1/(K_1^2)$

Q3. Which of the following is a true statement about chemical equilibria in general?

A. At equilibrium the total concentration of products equals the total concentration of reactants,
    that is, [products] = [reactants].
B. Equilibrium is the result of the cessation of all chemical change.
C. There is only one set of equilibrium concentrations that equals the K_c value.
D. At equilibrium, the rate constant of the forward reaction is equal to the rate constant for the
    reverse reaction.
E. At equilibrium, the rate of the forward reaction is equal to as the rate of the reverse reaction.

Q4. Phosgene, $COCl_2$, a poisonous gas, decomposes according to the equation

$$COCl_2(g) \rightleftharpoons CO(g) + Cl_2(g).$$ Calculate K_p for this reaction if K_c = 0.083 at 900°C.
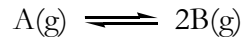
A. 0.125   B. 8.0   C. 6.1   D. 0.16   E. 0.083

Q5. For the following reaction at equilibrium, which one of the changes below would cause the
    equilibrium to shift to the *left*?

$$2NOBr(g) \rightleftharpoons 2NO(g) + Br_2(g), \Delta H°_{rxn} = +30 \text{ kJ/mol}$$
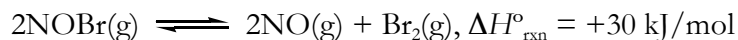
A. Increase the container volume.   B. Remove some NO.   C. Remove some Br_2.
D. Add more NOBr.   E. Decrease the temperature.

Q6. Consider the following reaction at equilibrium: (15 pts.)

$$A(g) \rightleftharpoons 2B(g)$$

From the following data, calculate the equilibrium constant, K_c at each temperature. (Show work!)

Is the reaction endothermic or exothermic? (No credit without a correct explaination.)

Temperature (°C)	[A] / M	[B] / M	K_c
200	0.0125	0.843	
300	0.171	0.764	
400	0.250	0.724	

Q7. 4.2 mol of oxygen and 4.0 mol of NO are introduced to an evacuated 0.50 L reaction vessel. At a specific temperature, the equilibrium $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$ is reached when [NO] = 1.6 M. Calculate K_c for the reaction at this temperature? (15 pts.)

Q8.   A first-order chemical reaction has a rate-constant of 0.0542 s^{-1} at a temperature of −12 °C, and a rate-constant of 1.06 s^{-1} at a temperature of 21 °C. Assuming that the pre-exponential factor is the same at both temperatures, calculate the activation energy of this reaction. (15 pts.)

Q9.   Kinetic data for the following reaction was determined experimentally (20 Pts.)

$$2A_2(g) + B_2(g) \longrightarrow 2A_2B(g)$$
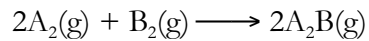
Experiment Number	Initial Conc [A₂], M	Initial Conc [B₂], M	Initial Rate of Reaction, M·s⁻¹
1	0.10	0.60	3.10×10^{-4}
2	0.10	0.30	7.75×10^{-5}
3	0.20	0.60	6.20×10^{-4}

a) What is the rate law for the reaction?

b) Calculate the rate constant for the reaction. Be sure to include units.

Q10. The chemical reaction, $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$ has an equilibrium constant of 7120 at 250 °C. If a flask containing only HCl at a concentration of 0.541 M at a temperature of 250 °C is allowed to reach equilibrium, then calculate the concentrations of H_2, Cl_2, and HCl. (20 pts.)

BONUS Questions:

1. Write formulas for the following compounds:

a) sodium phosphate

b) copper(I) carbonate

c) heptasulfur nonafluoride

d) sulfuric acid

2. What graphs could you plot to determine whether a reaction has a rate law that is either first order or second order in a reactant, A.

Useful Information

$$k = Ae^{-E_a/RT} \qquad\qquad \ln k = (-E_a/R)(1/T) + \ln A$$

$$\ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

•1-order: $\ln[A]_t = -kt + \ln[A]_0 \qquad \ln\left(\frac{[A]_t}{[A]_0}\right) = -kt \qquad\qquad t_{1/2} = 0.693 \,/\, k$

•2-order: $1/[A]_t = kt + 1/[A]_0 \qquad t_{1/2} = 1\,/\,([A]_0 \cdot k)$

$R = 8.3145\ \text{J/mol·K} = 0.08206\ (\text{L·atm})/(\text{mol·K})$
$N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$

Periodic Table of the Elements

IA	IIA											IIIA	IVA	VA	VIA	VIIA	VIIIA
1 H 1.01																	2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											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 74.92160	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 [98]	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	71 Lu 174.97	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.20	83 Bi 208.98	84 Po [210]	85 At [210]	86 Rn [222]
87 Fr [223]	88 Ra** [226]	103 Lr [262]	104 Rf [261]	105 Db [262]	106 Sg [266]	107 Bh [264]	108 Hs [265]	109 Mt [268]	110 [269]	111 [272]	112 [277]	113	114 [285]	115	116 [289]	117	118 [293]

*	57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm [145]	62 Sm 150.36	63 Eu 151.96	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
**	89 Ac [227]	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np [237]	94 Pu [244]	95 Am [243]	96 Cm [247]	97 Bk [247]	98 Cf [251]	99 Es [252]	100 Fm [257]	101 Md [258]	102 No [259]