CHEM 1515 Sections 20511 & 20516
Exam II
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March 10, 2021

Name _____

TA's Name _____

Section _____

INSTRUCTIONS:

1. This examination consists of a total of 10 different pages. The last two pages include a periodic table, useful mathematical equations, and a solubility table. All work should be done in this booklet.
2. PRINT your name, TA's name and your lab section number now in the space at the top of this sheet. DO NOT SEPARATE THESE PAGES.
3. Answer all questions that you can and whenever called for, show your work clearly. Your method of solving problems should pattern the approach used in lecture. You do not have to show your work for the multiple choice or short answer questions.
4. No credit will be awarded if your work is not shown in 3, 4b(ii), 4c, 5a, 5b and 5c.
5. Point values are shown next to the problem number.
6. Budget your time for each of the questions. Some problems may have a low point value yet be very challenging. If you do not recognize the solution to a question quickly, skip it, and return to the question after completing the easier problems.
7. Look through the exam before beginning; plan your work; then begin.
8. Relax and do well.

	Page 2	Page 3	Page 4	Page 5	MC	TOTAL
SCORES	_____	_____	_____	_____	_____	_____
	(23)	(17)	(28)	(11)	(24)	(103)

(9) 1. Write the chemical formula(s) of the product(s) and balance the following reactions. Identify all products phases as either (g)as, (l)iquid, (s)olid or (aq)ueous.

a) $Cu(NO_3)_{2(aq)} + NaOH_{(aq)} \rightarrow$

b) $BaCl_{2(aq)} + Na_2SO_{4(aq)} \rightarrow$

c) $C_9H_{18(l)} + O_{2(g)} \rightarrow$

(4) 2. Write the ionic and net ionic chemical equations for reaction 1a.

1a) Ionic equation:

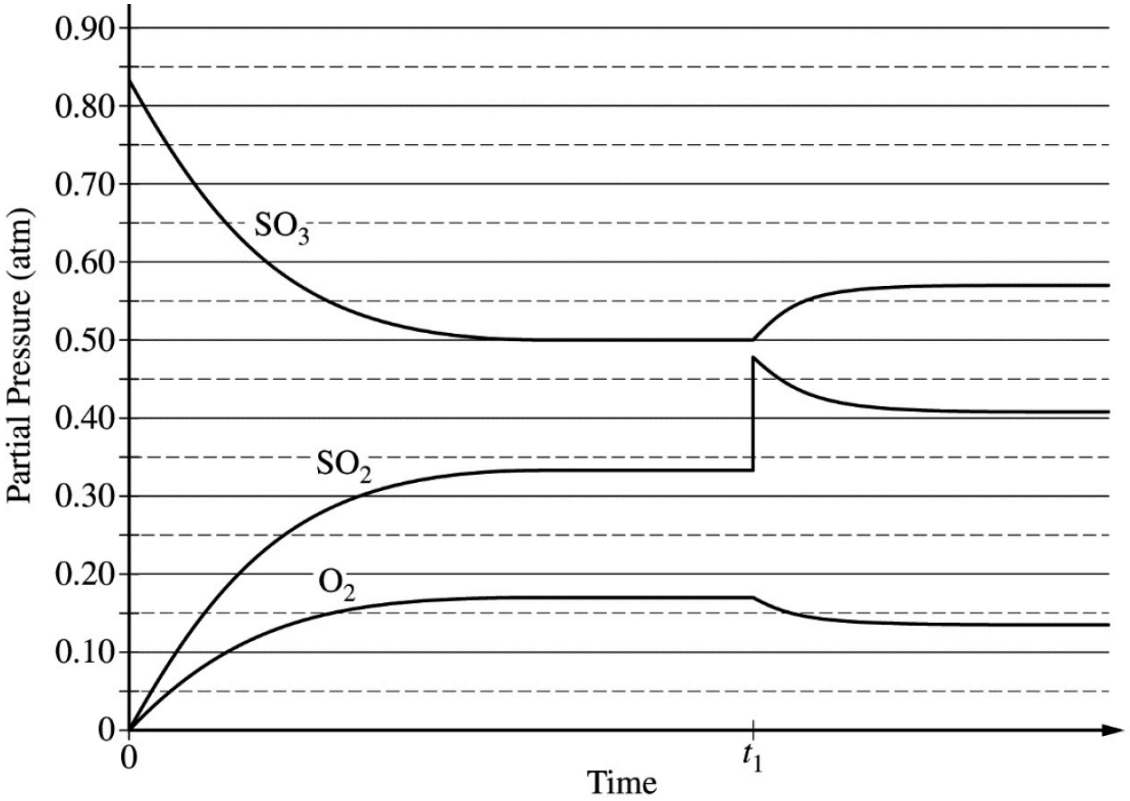
1a) Net Ionic equation:

$$CO_{(g)} + H_2O_{(g)} \rightleftarrows CO_{2(g)} + H_{2(g)} \quad K_c = 2.0 \text{ at } 25\ ^\circ C$$

(10) 3. Calculate the concentration of all species at equilibrium when a 1.00 L container initially has 1.50 mol of $CO_{(g)}$ and 1.50 mol of $H_2O_{(g)}$. Assume no $CO_{2(g)}$ or $H_{2(g)}$ are present initially.

$$2\ SO_{3(g)} \rightleftarrows 2\ SO_{2(g)} + O_{2(g)}$$

(23) 4. A rigid container is filled with $SO_{3(g)}$ until the pressure of $SO_{3(g)}$ in the container is 0.83 atm at 298 K. The $SO_{3(g)}$ decomposes as the partial pressures of $SO_{3(g)}$, $SO_{2(g)}$, and $O_{2(g)}$ in the container are monitored over time, as shown in the graph below. A change is made to the system at time, t_1



(a) Answer the following questions based on the graph.

(i) Draw an X on the time axis to show when the system first reached equilibrium. (3)

(ii) Describe the change that was made to the system at time t_1. (3)

(iii) After the change was made at t_1, the partial pressure of $SO_{3(g)}$ increased while the partial pressure of $O_{2(g)}$ decreased. Explain this observation. (4)

(b) Use the information above to answer the following.

(i) Write the expression for the equilibrium constant, K_p, for the reaction. (3)

(ii) Determine the value of K_p for the reaction. (4)

(c) Is the decomposition of $SO_{3(g)}$ to $SO_{2(g)}$ and $O_{2(g)}$ thermodynamically favored? Yes or No. Support your claim with a calculation of ΔG°. (6)

(27) 5. Sodium bicarbonate, $NaHCO_3$, is soluble in water. An aqueous solution is 6.00% by weight sodium bicarbonate and has a density of 1.043 g mL^{-1} . Calculate

a) The molality of sodium bicarbonate in the solution; (7)

b) the molarity of sodium bicarbonate in the solution; (7)

c) The experimental freezing point of the sodium bicarbonate solution is –2.73 ˚C. Calculate the experimental 'i' value for sodium bicarbonate in this solution and indicate the formula(s), and charges where appropriate, for all of the particles in this solution. (NOTE: You do not have to include water as one of the particles.) (8)

d) What do you think an ideal 'i' value would be for an aqueous solution of sodium bicarbonate? Provide an explanation for the difference in the experimental and ideal 'i' values. (5)

e) Using equipment selected from below, describe how you would prepare 100.00 mL of 0.75 M $NaHCO_3$ beginning with solid sodium bicarbonate and distilled water? (6)

Analytical balance 50 mL beaker 50 mL graduate cylinder 250.00 mL volumetric flask
Evaporating dish 25 mL pipet 100.00 mL volumetric flask Eyedropper

Multiple Choice: (24 points)

Print the letter (A, B, C, D) which corresponds to the answer selected.

6. _____ 7. _____ 8. _____ 9. _____

10. _____ 11. _____

ONLY THE ANSWERS IN THE AREA ABOVE WILL BE GRADED. Select the most correct answer for each question. Each question is worth 4 points.

6. NaOH, an ionic solid, dissolves in water with an enthalpy of solution that is exothermic. Which of the following best describes the solution process for this system?

(A) the lattice energy for the ionic solid is more positive than the absolute value of the hydration energy, and the change in entropy is positive.

(B) the enthalpy of the solution process is negative and the entropy change of the solution process is negative.

(C) the enthalpy of the solution process is negative and the entropy change of the solution process is positive.

(D) more heat is required to separate both the solute and the solvent particles, compared to the heat released when the solute-solvent attractions are formed, and the entropy of the solution process is positive.

PERIODIC TABLE OF THE ELEMENTS

1												13	14	15	16	17	18
1 H 1.008	2											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	2 He 4.00
3 Li 6.94	4 Be 9.01											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	10 Ne 20.18
11 Na 22.99	12 Mg 24.30	3	4	5	6	7	8	9	10	11	12	31 Ga 69.72	32 Ge 72.63	33 As 74.92	34 Se 78.97	35 Br 79.90	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 65.38	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.95	43 Tc (97)	44 Ru 101.1	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
55 Cs 132.91	56 Ba 137.33	57 *La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.2	77 Ir 192.2	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	113 Uut (285)	114 Fl (289)	115 Uup (288)	116 Lv (293)	117 Uus (294)	118 Uuo (294)
87 Fr (223)	88 Ra (226)	89 †Ac (227)	104 Rf (267)	105 Db (270)	106 Sg (271)	107 Bh (270)	108 Hs (277)	109 Mt (276)	110 Ds (281)	111 Rg (282)	112 Cn (285)						

	58	59	60	61	62	63	64	65	66	67	68	69	70	71
*Lanthanoid Series	Ce 140.12	Pr 140.91	Nd 144.24	Pm (145)	Sm 150.4	Eu 151.97	Gd 157.25	Tb 158.93	Dy 162.50	Ho 164.93	Er 167.26	Tm 168.93	Yb 173.05	Lu 174.97
	90	91	92	93	94	95	96	97	98	99	100	101	102	103
†Actinoid Series	Th 232.04	Pa 231.04	U 238.03	Np (237)	Pu (244)	Am (243)	Cm (247)	Bk (247)	Cf (251)	Es (252)	Fm (257)	Md (258)	No (259)	Lr (262)

Useful Information

$PV = nRT$ $\qquad R = 0.0821 \frac{L \cdot atm}{mol \cdot K} = 8.314 \frac{J}{mol \cdot K}$

$$\ln\left(\frac{K_2}{K_1}\right) = -\frac{\Delta H^\circ_{rxn}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$P_{solution} = \chi_{solvent} P^\circ_{solvent}$ $\qquad$ density of $H_2O = 1.00 \frac{g}{cm^3}$

$\Delta T = ikm$ $\qquad k_f(H_2O) = 1.86 \frac{^\circ C}{m}$ $\qquad k_b(H_2O) = 0.512 \frac{^\circ C}{m}$

$\Delta G^\circ_{rxn} = -RT \ln K$

Solubility Table

Ion	Solubility	Exceptions
NO_3^-	soluble	none
ClO_4^-	soluble	none
Cl^-	soluble	except Ag^+, Hg_2^{2+}, *Pb^{2+}
I^-	soluble	except Ag^+, Hg_2^{2+}, Pb^{2+}
SO_4^{2-}	soluble	except Ca^{2+}, Ba^{2+}, Sr^{2+}, Hg^{2+}, Pb^{2+}, Ag^+
CO_3^{2-}	insoluble	except Group IA and NH_4^+
PO_4^{3-}	insoluble	except Group IA and NH_4^+
^-OH	insoluble	except Group IA, *Ca^{2+}, Ba^{2+}, Sr^{2+}
S^{2-}	insoluble	except Group IA, IIA and NH_4^+
Na^+	soluble	none
NH_4^+	soluble	none
K^+	soluble	none

*slightly soluble