CHEM 1515.001
Exam V
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May 8, 2001

Name ____________________________

TA's Name ____________________________

Lab Section ________

INSTRUCTIONS:

1. This examination consists of a total of 9 different pages. The last three pages include a periodic table, some 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 problems 4, 5d, 6b, 6c, 6d and 7.

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	Page 6	TOTAL
SCORES	____ (26)	____ (26)	____ (15)	____ (22)	____ (12)	____ (100)

(12) 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. Soluble ionic compounds should be written in the form of their component ions.

a) H_5SO_4*(aq)* + $Ba(OH)_2$*(aq)* $\rightarrow$

b) $Fe(NO_3)_3$*(aq)* + KSCN*(aq)* $\rightarrow$

c) C_5H_{10}*(g)* + O_2*(g)* $\rightarrow$

d) Al*(s)* + KOH*(aq)* + H_2O*(l)* $\rightarrow$

(8) 2. Write the ionic and net ionic chemical equations for 1a) and 1b.

1a)
Ionic equation:

Net Ionic equation:

1b)
Ionic equation:

Net Ionic equation:

(6) 3. Define the term equilibrium vapor pressure.

(9) 4. A 0.900 g sample of pure water is injected into a 3.50 L evacuated vessel at 70.0 ˚C. Indicate the phase(s) present and the pressure exerted by water in the vapor phase.

Short Answer:

5a. Explain why alcohols like CH_3OH and C_2H_5OH are very soluble in water but an alcohol like $C_8H_{17}OH$ is insoluble in water. (9)

b) Acetone, $(CH_3)_2CO$ is very soluble in water. Draw several acetone molecules and several water molecules and clearly indicate how molecules interact. In your sketch label the most important intermolecular attractive force between acetone and water molecules. (8)

Short Answer:

5. Continued

c) Perovskite is composed of titanium, oxygen and calcium. A unit cell of perovskite is simple cubic in titanium ions and contains a calcium ion in the center of the unit cell and crystallizes and oxide ions located in the center of every edge (in the edge-centered octahedral holes). What is the formula for perovskite? (5)

d) Diamond crystallizes in a face-centered cubic unit cell of carbon atoms with additional carbon atoms in half of the tetrahedral holes. How many carbon atoms in a unit cell of diamond? If the density of diamond is 3.51 g cm^{-3}, what is the volume of the unit cell and its edge length? (10)

(22) 6. $$2H_2S(g) \rightleftarrows 2H_2(g) + S_2(g)$$

When heated, hydrogen sulfide gas decomposes according to the equation above. A 3.40 g sample of $2H_2S(g)$ is introduced into an evacuated rigid 1.25 L container. The sealed container is heated to 483 K, and 3.72×10^{-2} mol of $S_2(g)$ is present at equilibrium.

a) Write the equilibrium expression, K_c, for the decomposition reaction represented above. (4)

b) Calculate the equilibrium concentrations, in mol L^{-1}, of H_2S and H_2. (8)

c) Calculate the value of the equilibrium constant, K_c, for the decomposition reaction at 483 K. (4)

d) After the above reaction attains equilibrium at 483 K, the volume of the container is doubled to 2.50 L. Which direction will the reaction proceed to re-establish equilibrium? Explain your answer. (6)

(12) 7. The decomposition of dimethyl ether at ordinary pressures is first order with a half-life of 25.0 min at 500 ˚C.

$$CH_3OCH_3(g) \rightarrow CH_4(g) + CO_2(g) + H_2(g)$$

Calculate

a) Beginning with 8.00 g of dimethyl ether, determine the mass remaining after 145 minutes.

b) What fraction of the original dimethyl ether remains after 3.50 minutes?

b) the pH of the solution after adding 0.0100 mol of HCl to the solution.

Periodic Table of the Elements

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII	VIII	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1 **H** 1.008																	2 **He** 4.00
2	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
3	11 **Na** 22.99	12 **Mg** 24.30											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
4	19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	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	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
5	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** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
6	55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** 226.0	89 **Ac** 227.0	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)									

Lanthanides	58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.2	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
Actinides	90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** 237.0	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)	103 **Lr** (260)

Useful Information

$PV = nRT$

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

$\ln\left(\frac{vp_2}{vp_1}\right) = -\frac{\Delta H^\circ_{vap}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$

density of $H_2O = 1.00 \frac{g}{cm^3}$

$q = \text{mass} \cdot \text{Specific heat} \cdot \Delta T$

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

$P_{solution} = \chi_{solvent} P^\circ_{solvent}$

edge length (l) = 2r $\quad$ edge length (l) = $2\sqrt{2}\cdot r$ $\quad$ edge length (l) = $\frac{4r}{\sqrt{3}}$

$x_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ for $ax^2 + bx + c = 0$ $\quad 6.023 \times 10^{23}$

$\ln\left(\frac{k_1}{k_2}\right) = \frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$ $\quad \ln\left(\frac{K_1}{K_2}\right) = \frac{\Delta H^\circ_{rxn}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$

$\ln\left(\frac{[A]_t}{[A]_o}\right) = -kt$ $\quad \frac{1}{[A]_t} - \frac{1}{[A]_o} = kt$

$K_p = K_c(RT)^{\Delta n}$

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

Temperature (°C)	Vapor Pressure(mmHg)	Temperature (°C)	Vapor Pressure(mmHg)
-5	3.2	50	92.5
0	4.6	55	118.0
5	6.52	60	149.4
10	9.20	65	187.5
15	12.8	70	233.7
20	17.5	75	289.1
25	23.8	80	355.1
30	31.8	85	433.6
35	42.1	90	525.8
40	55.3	95	633.9
45	71.9	100	760

Simple Ionic Structures Grouped According to Anion Packing

Structure Name	Anion Packing	Coordination Number	Sites Occupied by Cations	Examples
Rock Salt	ccp	6:6 MO	all octahedral	NaCl, LiF, KBr, CdO, FeO
Zinc Blende	ccp	4:4 MO	$\frac{1}{2}$ tetrahedral	ZnS, BeO, SiC
Antifluorite	ccp	4:8 M_2O	all tetrahedral	Li_2O, sulfides
Rutile	distorted ccp	6:3 MO_2	$\frac{1}{2}$ octahedral	TiO_2, GeO_2, MnO_2, OsO_2
Perovskite	ccp	12:6:6 ABO_3	$\frac{1}{4}$ octahedral(B)	$CaTiO_3$, $SrSnO_3$
Spinel	ccp	4:6:4 AB_2O_4	$\frac{1}{8}$ tetrahedral(A) $\frac{1}{2}$ octahedral(B)	$MgAl_2O_4$, $FeAlO_4$
Cesium Chloride	simple cubic	8:8 MO	all cubic	CsCl, CsBr, CsI
Florite	simple cubic	8:4 MO_2	$\frac{1}{2}$ cubic	CaF_2, UO_2, ThO_2

Lattice Types and Radius Ratios of Cations and Anions

Radius Ratio (Cation/Anion)	Lattice Type	Coordination Number of Cation	Anion
A. 1:1 Stoichiometry of Salt (MX)			
0.225 – 0.414	Zinc Blende	4	4
0.414 – 0.732	Rock salt (NaCl)	6	6
0.732 – 1.000	Cesium chloride	8	8
B. 1:2 Stoichiometry of Salt (MX_2)			
0.225 – 0.414	Beta-quartz	4	2
0.414 – 0.732	Rutile (TiO_2)	6	3
0.732 – 1.000	Fluorite (CaF_2)	8	4