CHEM 1515.001 - 006
Exam V
John V. Gelder
May 6, 2002

Name ____________________

TA's Name ____________________

Section ________

INSTRUCTIONS:

1. This examination consists of a total of 11 different pages. The last four pages include a periodic table; many useful equations and constants; a table of vapor pressures for water; a solubility table; a table of equilibrium constants for acids and bases; and a table of thermodynamic values. 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 6.

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	Page 7	TOTAL
SCORES	____	____	____	____	____	____	____
	(18)	(16)	(16)	(18)	(20)	(12)	(100)

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

a) $Zn(NO_3)_2$*(aq)* + Na_2S*(aq)* $\rightarrow$ **ZnS*(s)* + $2NO_3^-$*(aq)* + 2^+*(aq)***

b) Na_2CO_3*(s)* + HCl*(aq)* $\rightarrow$ **CO_2*(g)* + H_2O*(l)* + $2Cl^-$*(aq)* + $2Na^+$*(aq)***

c) $(CH_3)_2NH$*(aq)* + HCN*(aq)* $\rightarrow$ **$(CH_3)_2NH_2^+$*(aq)* + CN^-*(aq)***

(4) 2a. Write the ionic and net ionic chemical equation for 1a), 1b) or 1c).

Ionic equation

$2Na^+$*(aq)* + CO_3^{2-}*(g)* + $2H^+$*(aq)* + $2Cl^-$*(aq)* $\rightarrow$ CO_2*(g)* + H_2O*(l)* + $2Cl^-$*(aq)* + $2Na^+$*(aq)*

Net Ionic equation

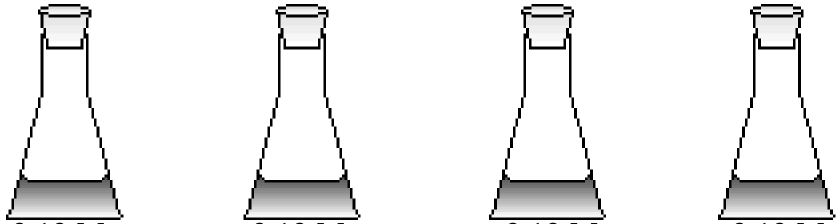
CO_3^{2-}*(g)* + $2H^+$*(aq)* $\rightarrow$ CO_2*(g)* + H_2O*(l)*

(5) 3. Account for the following observations about NH_3 and NF_3. In your answer, use appropriate principles of intermolecular forces. Your answer must include reference to both substances.

a) NH_3 has a normal boiling point of –33.4 ˚C where as NF_3 has a boiling point of –128.8 ˚C.

NH_3 is polar and can hydrogen bond. Hydrogen-bonding is a strong intermolecular attractive force and causes the boiling point of NH_3 to be high. NF_3 is polar but can not hydrogen bond. The dipole-dipole forces are not as strong an intermolecular attractive force so the boiling point of NF_3 is much lower compared to NH_3.

(16) 4.



0.10 M NaF | 0.10 M $MgCl_2$ | 0.10 M C_2H_5OH | 0.10 M CH_3COOH ($HC_2H_3O_2$)

Answer the following questions, which refer to the 100 mL samples of aqueous solutions at 25 ˚C in the stoppered flasks shown above

(a) Which solution has the lowest electrical conductivity? Explain.

The lowest electrical conductivity has the fewest ions… C_2H_5OH. All other substances above form ions in solution.

(b) Which solution has the lowest freezing point? Explain.

$MgCl_2$ has he lowest freezing point. Since $MgCl_2$ produces the most ions in solution with an I value of 3, ΔT_f will be the largest.

(c) Above which solution is the pressure of water vapor the greatest? Explain.

C_2H_5OH does not ionize, so there are the fewest particles in solution so it will have the higher vapor pressure.

(d) Which solution has the highest pH? Explain.

NaF will have the highest pH. F^- is a weak base.

(16) 5a. Define the term 'equilibrium vapor pressure'.

(b) If a sample of a liquid is injected into an evacuated container, describe what phase change occurs. (Note the amount of the liquid injected is small compared to the volume of the container.)

Since the container is evacuated when some liquid is introduced, some of the liquid will immediately vaporize until the equilibrium vapor pressure of the liquid is reached, or until all of the liquid evaporates. So if the equilibrium vapor pressure is reached, both liquid and vapor are present. Otherwise only vapor.

(c) Is the phase change exothermic or endothermic? Explain?

Evaporation is endothermic, because to escape from the liquid phase to the vapor phase intermolecular attractive forces must be over come. Although weak these forces must be broken for particles to enter the vapor phase.

(d) In terms of the 'pressure exerted by the vapor' and the 'equilibrium vapor pressure' how do we determine what phase(s) are present in the container after adding the sample?

If the pressure due to the vapor is equal to the equilbirium vapor pressure both liquid and vapor must be present. If the pressure due to the vapor is less than the equilibrium vapor pressure only vapor is present. The pressure dur to the vapor can never exceed the equilibrium vapor pressure.

(18) 6. A commercial aqueous solution of ammonia is 28% NH_3 by mass and has a density of 0.900 g mL^{-1}.

(a) Calculate the molarity of the solution.

Assume 100 gram of solution

28 g of NH_3 and 72 grams of water. Convert the mass of NH_3 to moles, then divide the 100 gram of solution by the density to get mLs of solution. Convert mLs to liters and divide into the moles for the molarity

Answer is 14.8 M

(b) Calculate the molality of the solution.

Use the moles determined in part a and divide by the mass of water in kilograms.

Answer is 22.9 molal

(c) Describe how you would prepare 1.00 L of a 0.400 M NH_3 solution from the more concentrated solution in part a).

Using the dilution equation $M_c \cdot V_c = M_d \cdot V_d$
The volume of concentrated ammonia needed is 27.0 mL.

Add 27 mL of NH_3 to about 900 mL of water, be sure all the NH_3 is dissolved than add enough water to reach a final volume of 1000 mLs.

(10) (d) Calculate the pH of the solution prepared in part c)
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The pH of the solution is 11.43. This is a simple weak base calculation where the initial concentration of NH_3 is 0.400 M

(10) (e) Calculate the pH of the solution prepared by adding 0.250 mol of solid NH_4Cl to the solution prepared in part c).

This is a common ion/buffer solution. The pH is 9.45.

(12) 7. For the gaseous equilibrium represented below, it is observed that greater amounts of PCl_3 and Cl_2 are produced as the temperature is increased.

$$PCl_3(g) \rightleftarrows PCl_3(g) + Cl_2(g)$$

(a) What is the sign of ΔS° for the reaction? Explain.

ΔS° is positive. In the balanced equation there are more moles of gase in the products compared to the reactants. So the products are more disordered.

(b) What change, if any, will occur in ΔG° for the reaction as the temperature is increased? Explain your reasoning in terms of thermodynamic principles.

The reaction is endothermic because , ", it is observed that greater amounts of PCl_3 and Cl_2 are produced as the temperature is increased ". So if ΔH° is positive and ΔS° is positive ΔG° will be come more negative with increasing temperature. The equation $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$ means the reaction with become more spontaneous as T increases. The $T\Delta S^\circ$ term will eventually be greater than ΔH° and the reaction will be spontaneous.

(c) If the volume of the reaction mixture is decreased at constant temperature to half the original volume, what will happened to the number of moles of Cl_2 in the reaction vessel? Explain.

If the volume is decreased the pressure will increase in the container and the reaction will proceed in a direction to relive the pressure, so it will got from right to left and the amount of Cl_2 will decrease.

Q is inversely related to the volume, so as volume decreases Q increases. To re-establish equilibrium the reaction must go from R to L and amount of Cl_2 will decrease.

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 (261)	105 (262)	106 (263)												

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

$PV = nRT$ $R = 0.0821 \frac{L\cdot atm}{mol\cdot K} = 8.314 \frac{J}{mol\cdot K}$ 6.02×10^{23}

$\ln\left(\frac{vp_2}{vp_1}\right) = -\frac{\Delta H^\circ_{vap}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$ density of $H_2O = 1.00 \frac{g}{cm^3}$

$\Delta H^\circ_{rxn} = \sum n(\Delta H_f^\circ(\text{products})) - \sum m(\Delta H_f^\circ(\text{reactants}))$

$\Delta S^\circ_{rxn} = \sum n(S^\circ(\text{products})) - \sum m(S^\circ(\text{reactants}))$

$\Delta G^\circ_{rxn} = \sum n(\Delta G_f^\circ(\text{products})) - \sum m(\Delta G_f^\circ(\text{reactants}))$

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

$pH = -\log[H^+]$ $pH + pOH = 14$ $pOH = -\log[OH^-]$ $K_w = 1.00 \times 10^{-14}$

$\Delta G^\circ = -RT\ln K$ $K_p = K_c(RT)^{\Delta n}$

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

1 pm = 10^{-12} m

$P_{solution} = \chi_{solvent}P^{\circ}_{solvent}$

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

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

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

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

Name	Formula	K_{a1}	K_{a2}	K_{a3}
Acetic	$HC_2H_3O_2$	1.8×10^{-5}		
Ascorbic	$HC_6H_7O_6$	8.0×10^{-3}		
Arsenic	H_3AsO_4	5.6×10^{-3}	1.0×10^{-7}	3.0×10^{-12}
Arsenous	H_3AsO_3	6.0×10^{-10}		
Benzoic	$HC_7H_5O_2$	6.5×10^{-5}		
Boric	H_3BO_3	5.8×10^{-10}		
Butyric acid	$HC_4H_7O_2$	1.5×10^{-5}		
Carbonic	H_2CO_3	4.3×10^{-7}	5.6×10^{-11}	
Cyanic	HCNO	3.5×10^{-4}		
Citric	$H_3C_6H_5O_7$	7.4×10^{-4}	1.7×10^{-5}	4.0×10^{-7}
Formic	$HCHO_2$	1.8×10^{-4}		
Hydroazoic	HN_3	1.9×10^{-5}		
Hydrocyanic	HCN	4.9×10^{-10}		
Hydrofluoric	HF	7.2×10^{-4}		
Hydrogen chromate ion	$HCrO_4^-$	3.0×10^{-7}		
Hydrogen peroxide	H_2O_2	2.4×10^{-12}		
Hydrogen selenate ion	$HSeO_4^-$	2.2×10^{-2}		
Hydrogen sulfate ion	HSO_4^-	1.2×10^{-2}		
Hydrogen sulfide	H_2S	5.7×10^{-8}	1.3×10^{-13}	
Hypobromous	HBrO	2.0×10^{-9}		
Hypochlorous	HClO	3.0×10^{-8}		
Hypoiodus	HIO	2.0×10^{-11}		
Iodic	HIO_3	1.7×10^{-1}		
Lactic	$HC_3H_5O_3$	1.4×10^{-4}		
Malonic	$H_2C_3H_2O_4$	1.5×10^{-3}	2.0×10^{-6}	
Oxalic	$H_2C_2O_4$	5.9×10^{-2}	6.4×10^{-5}	
Nitrous	HNO_2	4.5×10^{-4}		
Phenol	HC_6H_5O	1.3×10^{-10}		
Phosphoric	H_3PO_4	7.5×10^{-3}	6.2×10^{-8}	4.2×10^{-13}
Paraperiodic	H_5IO_6	2.8×10^{-2}	5.3×10^{-9}	
Propionic	$HC_3H_5O_2$	1.3×10^{-5}		
Pyrophosphoric	H_4P_2O	3.0×10^{-2}	4.4×10^{-3}	
Selenous	H_2SeO_3	2.3×10^{-3}	5.3×10^{-9}	
Sulfuric	H_2SO_4	strong acid	1.2×10^{-2}	
Sulfurous	H_2SO_3	1.7×10^{-2}	6.4×10^{-8}	
Tartaric	$H_2C_4H_4O_6$	1.0×10^{-3}	4.6×10^{-5}	

E.2 DISSOCIATION CONSTANTS FOR BASES AT 25˚C

Name	Formula	K_b	Name	Formula	K_b
Ammonia	NH_3	1.8×10^{-5}	Hydroxylamine	$HONH_2$	1.1×10^{-8}
Aniline	$C_6H_5NH_2$	4.3×10^{-10}	Methylamine	CH_3NH_2	4.4×10^{-4}
Dimethylamine	$(CH_3)_2NH$	5.4×10^{-4}	Pyridine	C_5H_5N	1.7×10^{-9}
Ethylamine	$C_2H_5NH_2$	6.4×10^{-4}	Trimethylamine	$(CH_3)_3N$	6.4×10^{-5}
Hydrazine	H_2NNH_2	1.3×10^{-6}			

Thermodynamic Values (25 ˚C)

Substance and State	ΔH^o_f $\left(\frac{kJ}{mol}\right)$	ΔG^o_f $\left(\frac{kJ}{mol}\right)$	S^o $\left(\frac{J}{K\cdot mol}\right)$
Carbon			
C(*s*) (graphite)	0	0	6
C(*s*) (diamond)	2	3	2
CO(*g*)	-110.5	-137	198
$CO_2(g)$	-393.5	-394	214
$CH_4(g)$	?	-51	186
$CH_3OH(g)$	-201	-163	240
$CH_3OH(l)$	-239	-166	127
$CH_3Cl(g)$	-80.8	-57.4	234
$CHCl_3(g)$	-100.8		
$CHCl_3(l)$	-131.8		
$H_2CO(g)$	-116	-110	219
HCOOH(*g*)	-363	-351	249
HCN(*g*)	135.1	125	202
$C_2H_2(g)$	227	209	201
$C_2H_4(g)$	52	68	219
$CH_3CHO(g)$	-166	-129	250
$C_2H_5OH(l)$	-278	-175	161
$C_2H_6(g)$	-84.7	-32.9	229.5
$C_3H_6(g)$	20.9	62.7	266.9
$C_3H_8(g)$	-104	-24	270
Bromine			
$Br_2(l)$	0	0	152.
BrCl(*g*)	14.64	-0.96	240
Chlorine			
$Cl_2(g)$	0	0	223
$Cl_2(aq)$	-23	7	121
$Cl^-(aq)$	-167	-131	57
HCl(*g*)	-92	-95	187
Fluorine			
$F_2(g)$	0	0	203
$F^-(aq)$	-333	-279	-14
HF(*g*)	-271	-273	174
Hydrogen			
$H_2(g)$	0	0	131
H(*g*)217	203	115	
$H^+(aq)$	0	0	0
$OH^-(aq)$	-230	-157	-11
$H_2O(l)$			
$H_2O(g)$	-242	-229	189
Magnesium			
Mg(s)	0	0	33
Mg(aq)	-492	-456	-118
MgO(s)	-601	-569	26.9

Substance and State	ΔH^o_f $\left(\frac{kJ}{mol}\right)$	ΔG^o_f $\left(\frac{kJ}{mol}\right)$	S^o $\left(\frac{J}{K\cdot mol}\right)$
Oxygen			
$O_2(g)$	0	0	205
O(*g*)249	232	161	
$O_3(g)$	143	163	239
Nitrogen			
$N_2(g)$	0	0	192
$NCl_3(g)$	230	271	-137
$NF_3(g)$	-125	-83.6	-139
$NH_3(g)$	?	-17	193
$NH_3(aq)$	?	-27	111
$NH_2CONH_2(aq)$	?	?	174
NO(*g*)	90	87	211
$NO_2(g)$	32	52	240
$N_2O(g)$	82	104	220
$N_2O_4(g)$	10	98	304
$N_2O_5(g)$	-42	134	178
$HNO_3(aq)$	-207	-111	146
$HNO_3(l)$	-174	-81	156
$NH_4Cl(s)$	-314	-201	95
$NH_4ClO_4(s)$	-295	-89	186
Silver			
Ag(*s*)	0	0	42.6
$Ag^+(aq)$	105.6	77.1	72.7
$Ag(S_2O_3)^{3-}(aq)$	-1285.7	--	--
AgBr(s)	-100.4	-96.9	107.1
AgCl(s)	-127.1	-109.8	96.2
Sulfur			
S(rhombic)	0	0	31.8
$SO_2(g)$	-296.8	-300.2	248.8
$SO_3(g)$	-395.7	-371.1	256.3
$H_2S(g)$	-20.17	-33.0	205.6
Titanium			
$TiCl_4(g)$	-763	-727	355
$TiO_2(s)$	-945	-890	50
Aluminum			
$AlCl_3(s)$	-526	-505	184
Barium			
$BaCl_2(aq)$	-872	-823	123
$Ba(OH)_2\cdot 8H_2O(s)$	-3342	-2793	427
Iodine			
$I_2(s)$	0	0	116.7
HI(*g*)	25.94	1.30	206.3