Chemistry 141 Name

Dr. Cary Willard

Exam 4 A December 11, 2008

|  |  |  |
| --- | --- | --- |
|  | Points Earned | Points Possible |
| Page 1 multiple choice |  | 26 |
| Page 2 |  | 18 |
| Page 3 |  | 16 |
| Page 4 |  | 20 |
| Page 5 |  | 8 |
| Page 6 |  | 16 |
| Page 7 |  | 10 |
| Total |  | 114 |

Note: All work must be shown to receive credit. On calculation problems show answer with the correct number of significant figures using scientific notation if necessary.

 PERIODIC CHART

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  IA |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | VIIA | NOBLE GASES |
| 1**H**1.008 | IIA |  |  |  |  |  |  |  |  |  |  | IIIA | IVA | VA | VIA | 1**H**1.008 | 2**He**4.002 |
| 3**Li**6.941 | 4**Be**9.012 | Transition Metals | 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**23.00 | 12**Mg**24.30 | IIIB | IVB | VB | VIB | VIIB |  VIIIB | IB | IIB | 13**Al**27.00 | 14**Si**28.09 | 15**P**30.97 | 16**S**32.06 | 17**Cl**35.45 | 18**Ar**39.95 |
| 19**K**39.10 | 20**Ca**40.08 | 21**Sc**44.96 | 22**Ti**47.90 | 23**V**50.94 | 24**Cr**52.00 | 25**Mn**54.94 | 26**Fe**55.85 | 27**Co**58.93 | 28**Ni**58.70 | 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 |
| 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**(99) | 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 |
| 55**Cs**132.9 | 56**Ba**137.3 | 57**La**138.9 | 72**Hf**178.5 | 73**Ta**180.9 | 74**W**183.9 | 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) |
| 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**(268) | 110**??**(???) |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 58**Ce**140.1 | 59**Pr**140.9 | 60**Nd**144.2 | 61**Pm**(147) | 62**Sm**150.4 | 63**Eu**152.0 | 64**Gd**157.3 | 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 |
| 90**Th**232.0 | 91**Pa**231.0 | 92**U**238.0 | 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) | 103**Lr**(260) |

Lanthanide series

Actinide series

Chemistry Formulas and Constants

Formulas

Kinetic energy = ½ mv2

w = -PΔV

Ptotal = P1+P2+P3+…

u = (3RT/MW)½

ΔG = ΔH - TΔS

PV = nRT

Rate ∝ (MW)-½

P1=*i*X1\*Ptotal

C = q/ΔT

w=dxF

E = IR

ΔGo = -nFEo

ΔG = - RTlnK

E = mc2

Ba(Na)2 = fruit

HΨ=EΨ

Amp = C/sec

Π= *i*MRT

E = hν = hc/λ

M1V1 = M2V2

Ptotal = P1 + P2 + P3 + …

M = mol/L

m = mol/kg solvent

Xi = moli/ moltotal

ΔTb = i(kb)(m)

ΔTf = i(kf)(m)

Psoln = (Psolv)(Xsolv)



Constants

1 angstrom = 10-8 cm

F = 9.65 x 104 C

h = 6.626 x 10-34 J sec

c= 2.9979 x 108 m/sec

e = 1.602 x 10-19 C

NA = 6.022 x 1023/mol

k = 1.381 x 10-23 J/K

K = oC + 273.16

Kw = 1.0 x 10-14M2

mass electron = 9.109 x 10-31 kg

R = 0.0821 L atm/mol K= 8.314 J/K mol= 1.987 cal.mol K= 62.4 L torr/mol K

Standard Temperature and Pressure = 0oC and 1 atm

Multiple choice (26 points)

1. In liquid methanol, CH3OH which intermolecular forces are present?
	1. Dispersion, hydrogen bonding and dipole-dipole forces are present.
	2. Only dipole-dipole and ion-dipole forces are present.
	3. Only hydrogen bonding forces are present.
	4. Only dispersion and dipole-dipole forces are present.
2. Which of the following is most likely to have the highest viscosity at 25oC?
	1. C4H10
	2. HOCH2CH2OH
	3. C2H5NH2
	4. C8H18
3. The magnitude of the heats of vaporization, fusion and sublimation of a substance reflect the
	1. strength of the covalent bonds between atoms in each molecule of the substance.
	2. strength of the intermolecular forces of the substance.
	3. density of the substance.
	4. magnitudes of the boiling and melting points of the substance.
4. A supercritical fluid refers to a substance
	1. at its triple point.
	2. with a viscosity of zero.
	3. that is in the liquid crystal state.
	4. above both its critical temperature and its critical pressure.

The phase diagram of a substance is shown at the right.

1. The approximate normal boiling point of this substance is
	1. 180 K.
	2. 300 K.
	3. 190 K.
	4. 430 K.
2. What is the physical phase of the substance at T = 400 K and P = 2.0 atm?
	1. gas
	2. supercritical fluid
	3. solid
	4. liquid
3. The rubbing alcohol sold in drug stores often is composed of 70% isopropyl alcohol and 30% water. In this solution
	1. isopropyl alcohol is the solvent.
	2. water is the solvent.
	3. both water and isopropyl alcohol are solvents.
	4. neither water nor isopropyl alcohol is a solvent.
4. How will the osmotic pressure of an aqueous solution change as evaporation occurs?
	1. The osmotic pressure will decrease.
	2. The osmotic pressure will not change.
	3. The osmotic pressure will increase.
	4. The osmotic pressure will increase or decrease until it equals the vapor pressure of water.
5. Drawing (1) shows a nonequilibrium system comprised of pure water separated from an aqueous solution by a semipermeable membrane. Shaded spheres represent solute particles and unshaded spheres represent water molecules. Which drawing (2)-(5) represents this system after equilibrium is reached?
	1. drawing (2)
	2. drawing (3)
	3. drawing (4)
	4. drawing (5)
6. A reaction reaches dynamic equilibrium at a given temperature when
	1. the amount of products exceeds the amount of reactants.
	2. the relative amounts of reactants and products are constant and ratefwd = raterev.
	3. opposing reactions cease and the system is static.
	4. kfwd equals k rev
7. A crude type of disappearing ink is based on the following endothermic equilibrium:

[Co(H2O)6]CL2 (*aq*) ↔ [CoCl2(H2O)4] (*aq*) + 2 H2O (*g*)

(colorless) (blue)

If the reactant solution is used to write on a piece of paper and the paper is allowed to partially dry, what can be done to bring out the colored handwriting?

* 1. add water
	2. put the paper in the oven
	3. put the paper in the freezer
	4. decrease the volume
1. Which statement is **true** for a reaction with *Kc* equal to 2.43 x 10-12?
	1. The reaction proceeds nearly all the way to completion.
	2. There are appreciable concentrations of both reactants and products.
	3. The reaction proceeds hardly at all towards completion.
	4. Increasing the temperature will not change the value of *Kc*.
2. Which statement about the equilibrium constant is **true**? The value of *Kc*
	1. changes as temperature changes.
	2. changes as reactant concentration changes.
	3. never changes.
	4. changes as product concentration changes.

Problems (70 points)

1. (5 points) For many years drinking water has been cooled in hot climates by evaporating it from the surfaces of canvas bags or porous clay pots. Explain why this technique is effective.

The vaporization of water is an endothermic process. When water evaporates it takes heat from the remaining water thus cooling the water.

1. (5 points) The freezing point of a solution prepared by dissolving 1.00 mol of hydrogen fluoride, HF, in 500 g water is -3.8oC, but the freezing point of a solution prepared by dissolving 1.00 mol of hydrogen chloride, HCl, in 500g water is -7.4oC. Explain.

The freezing point depression is dependent on the number of particles in the solution. The HCl freezes at a lower temperature because it dissociates to a greater extent than the HF meaning that there are more particles in solution for the same molarity.

1. (8 points) The equilibrium constant for the reaction N2O4(g) <==> 2 NO2(g) is 0.3852 mol/L at 200o C. What is the value of Kc at 200oC for:
	1. 2 NO2(g) <==> N2O4(g)

$$K\_{C\_{reverse}}=\frac{1}{K\_{C\_{forward}}}=\frac{1}{0.3852 M}=2.596 M^{-1}$$

* 1. NO2(g) <==> 1/2 N2O4(g)

$$K\_{C}=\sqrt{\frac{1}{K\_{C\_{forward}}}}=\sqrt{\frac{1}{0.3852 M}}=\sqrt{2.596 M^{-1}}=1.611 M^{-^{1}/\_{2}}$$

1. (16 points) The steroid hormone estradiol contains only C, H, and O. Combustion analysis of a 3.40 mg sample yields 9.90 mg CO2 and 2.70 mg H2O. On dissolving 9.41 mg of estradiol in 0.500 g f camphor, the melting point of camphor is depressed by 2.10oC. What is the molecular mass of esradiol, and what is a probably formula? Kf camphor = 37.7oC/m
	1. What is the empirical formula of the compound?

$$9.90 mg CO\_{2}×\frac{1 mmol CO\_{2}}{44.01 mg CO\_{2} }×\frac{1 mmol C}{1 mmol CO\_{2}}=0.225 mmol C\rightarrow 2.70 mg C$$

$$2.70 mg H\_{2}O×\frac{1 mmol H\_{2}O}{18.02 mg H\_{2}O}×\frac{2 mmol H}{1 mmol H\_{2}O}=0.300 mmol H\rightarrow 0.302 mg H$$

$$3.40 mg estradiol-\left(2.70 mg C+0.302 mg H\right)=0.40 mg O×\frac{1 mmol O}{16.00 mg O}=0.025 mmol O$$

$$C\_{\frac{0.225}{0.025}}H\_{\frac{0.300}{0.025}}O\_{\frac{0.025}{0.025}}\rightarrow \rightarrow C\_{9.}H\_{12}O\_{1}$$

* 1. What is the molality of the compound?

$$∆T\_{f}=mK\_{f} $$

$$m=\frac{∆T\_{f}}{K\_{f}}=\frac{2.10℃}{37.7{℃}/{m}}=0.0557 m$$

* 1. What is the molar mass of the compound?

$$MM=\frac{g estradiol}{mol}$$

$$=\frac{0.00941 g estradiol}{0.500 g camphor}×\frac{1000 g camphor}{1 kg camphor}×\frac{1 kg camphor}{0.0557 mol estradiol}$$

$$=338 g/mol$$

* 1. What is the molecular formula of the compound?

Molar mass of C9H12O = 136.2

388/136=2.8 molecular formula C18H24O2 or C27H36O3

1. (20 points) Citric acid, H3C6H5O7, occurs in plants. Lemons contain 5% to 8% citric acid by mass. The acid is added to beverages and candy. An aqueous solution is 0.7594 M citric acid and the density of the solution is 1.071 g/mL. Answer the following questions for this solution. (If you are unable to complete the concentration conversions for parts a-c, make up a number for parts d-e so that you can show me that you know how to do those questions.) Remember to use the correct number of significant figures!!!
	1. Calculate the mass percent citric acid in the solution.

$$\% H\_{3}C\_{6}H\_{5}O\_{7}=\left(\frac{g H\_{3}C\_{6}H\_{5}O\_{7}}{g soln}\right)×100$$

$$=\left(\frac{0.7594 mol H\_{3}C\_{6}H\_{5}O\_{7}}{1000 mL solution}×\frac{192.1 g H\_{3}C\_{6}H\_{5}O\_{7}}{1 mol H\_{3}C\_{6}H\_{5}O\_{7}}×\frac{1 mL soln}{1.071 g soln}\right)×100$$

$$=13.62\% H\_{3}C\_{6}H\_{5}O\_{7}$$

* 1. Calculate the molality of the solution.

$$ m H\_{3}C\_{6}H\_{5}O\_{7}=\frac{mol H\_{3}C\_{6}H\_{5}O\_{7}}{1 kg H\_{2}O}$$

$$=\frac{13.62 g H\_{3}C\_{6}H\_{5}O\_{7}}{86.38 g H\_{2}O}×\frac{1 mol H\_{3}C\_{6}H\_{5}O\_{7}}{192.1 g H\_{3}C\_{6}H\_{5}O\_{7}}×\frac{1000 g H\_{2}O}{1 kg H\_{2}O}$$

$$=0.8207 m H\_{3}C\_{6}H\_{5}O\_{7}$$

* 1. Calculate the mole fraction of citric acid in the solution

$$mol H\_{3}C\_{6}H\_{5}O\_{7}=13.62 g H\_{3}C\_{6}H\_{5}O\_{7}×\frac{1 mol H\_{3}C\_{6}H\_{5}O\_{7}}{192.1 g H\_{3}C\_{6}H\_{5}O\_{7}}=0.0709 mol H\_{3}C\_{6}H\_{5}O\_{7}$$

$$mol H\_{2}O=86.38 g H\_{2}O×\frac{1 mol H\_{2}O}{18.02 g H\_{2}O}=4.79 mol H\_{2}O$$

$$X\_{H\_{3}C\_{6}H\_{5}O\_{7}}=\frac{mol H\_{3}C\_{6}H\_{5}O\_{7}}{total mols }=\frac{0.0709 mol H\_{3}C\_{6}H\_{5}O\_{7} }{\left(4.79+0.0709\right)mol}=\frac{0.0709 mol H\_{3}C\_{6}H\_{5}O\_{7}}{4.86 mol}$$

$$=0.0146$$

* 1. Calculate the osmotic pressure (in atm) of the solution at 35oC.

$$π=MRT=\left(0.7594\frac{mol}{L}\right)\left(0.0821 \frac{L atm}{mol K}\right)\left(308 K\right)=19.2 atm$$

* 1. Calculate the vapor pressure of the solution at 70oC. The vapor pressure of pure water at 70oC is 233.7 torr.

$$X\_{H\_{2}O}=1-X\_{H\_{3}C\_{6}H\_{5}O\_{7}}=1-0.0146=0.9854$$

$$P\_{solution}=\left(X\_{H\_{2}O}\right)\left(P\_{H\_{2}O}\right)=\left(0.9854\right)\left(233.7 torr\right)=230.3 torr$$

1. (8 points) Write out the Kp expression for the reaction

2 N2(g) + CO2(g) ⬄ 2 N2O(g) + C(s)

$$K\_{P}=\frac{\left(P\_{N\_{2}O}\right)^{2}}{\left(P\_{N\_{2}}\right)^{2}\left(P\_{CO\_{2}}\right)}$$

In which direction will the reaction proceed if the pressure in increased?

The reaction will shift to the right if the pressure is increased (shift to make more product).

1. (16 points) A 2.00 mole sample of nitrogen dioxide was placed in an 8.00 L vessel. At 400oC, the nitrogen dioxide was 10.00% decomposed according to the equation 2 NO2(g) ⬄ 2 NO(g) + O2(g)
	1. Write out the Kc expression.

$$K\_{c}=\frac{\left[O\_{2}\right]\left[NO\right]^{2}}{\left[NO\_{2}\right]^{2}}$$

* 1. Calculate the final concentrations of all species using an IΔE diagram. (remember to find [ ]!)

(Hint: Think about what 10% decomposed means, what % remains?)

2 NO2(g) ⬄ 2 NO(g) + O2(g)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 2 NO2 | ⬄ | 2 NO | + | O2 |
| I | 0.250 M |  | 0 M |  | 0 M |
| D | -2x |  | +2x |  | +x |
| E | 0.250-2x= 90% or 0.225 M |  | 2x=.0250M |  | x=.0125 M |

x =0.0125 M

* 1. Calculate the value of the equilibrium constant Kc at 300oC.

$$K\_{c}=\frac{\left[O\_{2}\right]\left[NO\right]^{2}}{\left[NO\_{2}\right]^{2}}=\frac{\left(0.0125M\right)\left(0.0250M\right)^{2}}{\left(0.225M\right)^{2}}=1.543×10^{-4}M$$

* 1. Calculate the value of the equilibrium constant Kp at 300oC.

$$K\_{P}=\left(1.543×10^{-4}\frac{mol}{L}\right)\left(0.0821 \frac{L atm}{mol K}\right)\left(573 K\right)=7.26×10^{-2}atm$$

or

$$K\_{P}=\left(1.543×10^{-4}\frac{mol}{L}\right)\left(62.4 \frac{L torr}{mol K}\right)\left(573 K\right)=5.52 torr$$

1. (10 points) Initially a mixture contains 0.632 mole each of N2 and O2 in an 1.00L vessel. Find the composition of the mixture when equilibrium is reached at 3900oC. The reaction is

N2(g) + O2(g) ⬄2NO(g) Kc = 0.0123 at 3900oC.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |
|  | N2 | + | O2 | ⬄ | 2NO |
| I | 0.632 M |  | 0.632 M |  | 0 M |
|  | -x |  | -x |  | +2x |
| E | 0.632 – x  |  | 0.632 – x  |  | 2x |
|  | 0.632-.035=0.597M |  | 0.632-.035=0.597M |  | 2(.035)=0.070M |

$$K\_{C}=\frac{\left[NO\right]^{2}}{\left[N\_{2}\right]\left[O\_{2}\right]}=0.0123=\frac{\left(2x\right)^{2}}{\left(0.632-x\right)\left(0.632-x\right)}$$

$$0.0123=\frac{\left(2x\right)^{2}}{\left(0.632-x\right)\left(0.632-x\right)}$$

$$\sqrt{0.0123}=\sqrt{\frac{\left(2x\right)^{2}}{\left(0.632-x\right)\left(0.632-x\right)}}$$

$$0.0111=\frac{\left(2x\right)^{}}{\left(0.632-x\right)}$$

$$0.0111\left(0.632-x\right)=0.0701-0.0111x=2x$$

$$0.0701=2.011x$$

$$x=0.0349$$

[O2]=[N2]=0.597 M

[NO]=0.070M

[O2] = M

[N2] = M

[NO] = M