Chemistry 141 Name

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Exam 4 A May 21,22, 2008

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| --- | --- | --- |
|  | Points Earned | Points Possible |
| Page 1 multiple choice |  | 30 |
| Page 2 |  | 20 |
| Page 3 |  | 15 |
| Page 4 |  | 15 |
| Page 5 |  | 17 |
| Page 6 |  | 8 |
| Total |  | 100 |

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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|  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**??**(???) |  |  |  |  |  |  |  |  |

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| 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 (30 points)

1. When a narrow diameter glass tube is inserted into a body of water, water rises in the tube and its surface inside is concave upwards. Which statement, concerning the strength of the intermolecular forces between glass and water molecules compared to those between water molecules, is accurate?
	1. The forces of attraction between the glass and water are the same as those in water.
	2. The forces of attraction between the glass and water are weaker than those in water.
	3. Intermolecular forces are irrelevant to this situation.
	4. The forces of attraction between the glass and water are stronger than those in water.
2. Molecules of a liquid can pass into the vapor phase only if the
	1. vapor pressure of the liquid is high.
	2. molecules have sufficient kinetic energy to overcome the intermolecular forces in the liquid.
	3. temperature of the liquid is near its boiling point.
	4. liquid has little surface tension.



1. Which drawing best represents hydrogen bonding?

* 1. Drawing (1)
	2. Drawing (2)
	3. Drawing (3)
	4. Drawing (4)
1. Which is expected to have the largest dispersion forces?
	1. C10H22
	2. CH4
	3. CS2
	4. O2
2. 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.
3. If figure (1) represents the vapor pressure of water at 25oC in a 1 liter container, which figure represents the vapor pressure of water at 25oC in a 2 liter container?
	1. Figure (2)
	2. Figure (3)
	3. Figure (4)
	4. None of the above
4. Arrange the following compounds in order of their expected **increasing** solubility in water: KCl, CH3CH2-O-CH2CH3, CH3CH2CH2CH2-OH, CH3CH2CH2CH2CH3.
	1. CH3CH2CH2CH2CH3 < CH3CH2-O-CH2CH3 < KCl < CH3CH2CH2CH2-OH
	2. KCl < CH3CH2-O-CH2CH3 < CH3CH2CH2CH2-OH < CH3CH2CH2CH2CH3
	3. CH3CH2CH2CH2CH3 < CH3CH2-O-CH2CH3 < CH3CH2CH2CH2-OH < KCl
	4. CH3CH2CH2CH2CH3 < KCl < CH3CH2-O-CH2CH3 < CH3CH2CH2CH2-OH
5. In which case should CO2(*g*) be more soluble in water?
	1. The total pressure is 1 atm and the partial pressure of CO2 is 0.03 atm.
	2. The total pressure is 3 atm and the partial pressure of CO2 is 2 atm.
	3. The total pressure is 1 atm and the partial pressure of CO2 is 0.5 atm.
	4. The total pressure is 5 atm and the partial pressure of CO2 is 1 atm.
6. Write the equilibrium equation for the reverse reaction 2 CH4(g) + 3 O2(g) ↔ 2 CO(g) + 4 H2O(g)
	1. $K\_{p^{'}}=\frac{\left[P\_{CO}\right]^{2}\left[P\_{H\_{2}O}\right]^{4}}{\left[P\_{CH\_{4}}\right]^{2}\left[P\_{O\_{2}}\right]^{3}}$
	2. $K\_{p^{'}}=\frac{\left[P\_{CH\_{4}}\right]^{2}\left[P\_{O\_{2}}\right]^{3}^{}}{\left[P\_{CO}\right]^{2}\left[P\_{H\_{2}O}\right]^{4}}$
	3. $K\_{p^{'}}=\frac{2 \left[P\_{CO}\right]^{}+ 4 \left[P\_{H\_{2}O}\right]^{}}{2 \left[P\_{CH\_{4}}\right]^{}+ 3 \left[P\_{O\_{2}}\right]^{}}$
	4. $K\_{p^{'}}=\frac{2 \left[P\_{CH\_{4}}\right]^{}+ 3 \left[P\_{O\_{2}}\right]^{}^{}}{2 \left[P\_{CO}\right]^{}+ 4 \left[P\_{H\_{2}O}\right]^{}}$
7. A catalyst increases the rate of a chemical reaction by providing a lower-energy mechanism for the reaction. When this occurs, which one of the following is **not** affected?
	1. rate of the forward reaction
	2. rate of the reverse reaction
	3. equilibrium constant
	4.  all are affected
8. 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)
9. The dissolution of calcium hydroxide is exothermic. Ca(OH)2(*s*) ↔ Ca2+(*aq*) + 2 OH-(*aq*) What happens when the solution of Ca(OH)2 is heated?
	1. The amount of Ca(OH)2(*s*) remains unchanged.
	2. The amount of Ca(OH)2(*s*) decreases.
	3. The Ca(OH)2(*s*) completely dissolves.
	4. The amount of Ca(OH)2(*s*) increases.
10. Iron oxide ores are reduced to iron metal by exothermic reaction with carbon monoxide:

FeO(s) + CO(g) ↔CO2(g). Which of the following changes in condition will cause the equilibrium to shift to the right?

* 1. add CO2
	2. add FeO
	3. add CO
	4. raise the temperature
1. Which change in the system will drive equilibrium to the left in the reaction below?

N2O5(*g*) ↔ NO2(*g*) + NO3(*g*)

* 1. decrease the amount of NO3
	2. increase the amount of N2O5
	3. increase the volume
	4. increase the pressure
1. 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.

As the water evaporates from the surface of these containers it must absorb energy because the heat of vaporization is positive. It absorbs this energy from the water in the containers, thus cooling it.

1. (5 points) Two pans of water are on different burners of a stove. One pan of water is boiling vigorously, while the other is boiling gently. What can be said about the temperature of the water in the two pans?

Both pans of water will be at the same temperature. The transition from the liquid to the gas state occurs at the boiling temperature. It is not important whether or not it is boiling gently or vigorously! This only demonstrates the amount of heat being put into the water and how quickly the sample will vaporize.

1. (10 points) Argon has a normal boiling point of 87.2 K and a melting point (at 1 atm) of 84.1K. Its critical temperature is 150.8 K and the critical pressure is 48.3 atm. It has a triple point at 83.7K and 0.68 atm. Sketch the phase diagram for argon. Be sure to identify the gas, liquid, solid and supercritical fluid regions. Label the normal boiling and freezing point and the critical point. The beginning of a graph has been drawn for you. Be sure to properly label all axes! The graph will not be to scale.

Pressure

Temperature

Based on your phase diagram, which is more dense the liquid or the solid form of argon?

The solid phase of argon is more dense.

1. (5 points) Ethylene glycol (HOCH2CH2OH), the major substance in antifreeze, has a normal boiling point of 199oC. By comparison, ethyl alcohol(CH3CH2OH) boils at 78oC at atmospheric pressure. Ethylene glycol dimethyl ether (CH3OCH2CH2OCH3) has a normal boiling point of 83oC, and ethyl methyl ether (CH3CH2OCH3) has a normal boiling point of 11oC. Explain why replacement of a hydrogen on the oxygen by CH3 generally results in a lower boiling point.

When the hydrogen on the alcohol is replaced by a methyl group the molecule is no longer to form hydrogen bonds with other molecules like it so the intermolecular forces are reduced and the boiling points are reduced.

1. (10 points) The carbohydrate digitoxose contains 48.64% carbon and 8.16% hydrogen with the remainder oxygen. The addition of 18.0 g of this compound to 100.0 g of water gives a solution that has a freezing point of −2.20oC. Kf water = 1.86oC/m
	1. What is the empirical formula of the compound?

$$48.68 g C×\frac{1 mol C}{12.01 g C}=4.05 mol C \frac{4.05}{2.69}=1.51$$

$$8.16 g H×\frac{1 mol H}{1.008 g H}=8.09 mol H \frac{8.09}{2.69}=3.01$$

$$43.16 g O×\frac{1 mol O}{16.00 g O}=2.69 mol O \frac{2.69}{2.69}=1.00$$

Empirical formula C3H6O2

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

$$∆T\_{f}=imK\_{f}$$

$$m=^{∆T\_{f}}/\_{K\_{f}}=\frac{2.20℃}{1.86℃/m}=1.18 m$$

$$Molar mass=\frac{grams}{moles}=\frac{18.0 g digitoxose}{100 g water}×\frac{1000 g water}{1 kg water}×\frac{1 kg water}{1.18 mol digitoxose}=152 g/mol$$

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

Molar mass of C3H6O2 is 74 g/mol

Need 2 units so molecular formula is C6H12O4

1. (15 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 0.7590 m citric acid and the density of the solution is 1.061 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.

$$\left(\frac{0.7590 mol HCit}{1 kg H2O}×\frac{1 kg H2O}{1000 g H2O}×\frac{192.14 g HCit}{1 mol HCit}\right)=\frac{0.1458g HCit}{g H2O}$$

$$\%\_{HCit}=\left(\frac{g HCit}{total grams}\right)×100=\left(\frac{0.1458 g HCit}{0.1458+1.000}\right)×100=12.72\% HCit$$

* 1. Calculate the molarity of the solution.

$$\left(\frac{0.7590 mol HCit}{1 kg H2O}×\frac{1 kg H2O}{1000 g H2O}×\frac{87.28 g H2O}{100 g solution}×\frac{1.061 g soln}{1 mL soln}×\frac{1000mL}{1 L soln}\right)$$

$$=0.7029MHCit$$

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

$$\left(\frac{0.7590 mol HCit}{1 kg H2O}×\frac{1 kg H2O}{1000 g H2O}×\frac{18.01 g H2O}{1 mol H2O}\right)=\frac{0.01367 mol HCit}{mol H2O}$$

$$X\_{HCit}=\frac{mol HCit}{total moles}=\frac{0.01367 mol HCit}{0.01367+1.000}=0.01348$$

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

$$π=MRT=\left(\frac{0.7029 mol HCit}{1 L}\right)\left(\frac{0.0821 L atm}{mol K}\right)\left(308 K\right)=17.77 atm$$

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

$$X\_{H2O}=1-x\_{HCit}=1-0.01348=0.98652$$

$$P\_{solution}=\left(P\_{H2O}\right)\left(X\_{H2O}\right)=\left(0.9865\right)\left(233.7 torr\right)=230.5 torr$$

1. (12 points) A 3.00 mole sample of nitrogen dioxide was placed in an 80.0 L vessel. At 300oC, the nitrogen dioxide was 6.0% decomposed according to the equation 2 NO2(g) ⬄ 2 NO(g) + O2(g)
	1. Write out the Kc expression.

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

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

2 NO2(g) ⬄ 2 NO(g) + O2(g)

|  |  |  |  |
| --- | --- | --- | --- |
| I | 0.0375 M | 0M | 0M |
| Δ | -2x | +2x | +x |
| E | (0.0375-2x)M | 2x | x |
|  | = 0.03525 M(94%)x=0.00112M | 2x= 2(0.00112M)= 0.00224 M | x=0.00112M |

Initial concentration NO2 $\frac{3.00 mol NO\_{2}}{80.0 L}=0.0375M$

Final concentration NO2 6% decomposed so 94% or 0.03525 remains

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

$$K\_{c}=\frac{\left[NO\right]^{2}\left[O\_{2}\right]}{\left[NO\_{2}\right]^{2}}=\frac{\left[0.00224 M\right]^{2}\left[0.00112 M\right]}{\left[0.0353 M\right]^{2}}=4.51 x 10^{-6}M$$

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

$$K\_{p}=\left(4.51 x 10^{-6}\frac{mol}{L}\right)\left(0.0821 \frac{L atm}{mol K} \right)\left(573 K\right)=2.12 x 10^{-4} atm$$

or

$$K\_{p}=\left(4.51 x 10^{-6}\frac{mol}{L}\right)\left(62.4 \frac{L torr}{mol K} \right)\left(573 K\right)=1.61 torr$$

1. (5 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 proceed in the forward direction to minimize the number of moles of gas.

1. (8 points) Initially a mixture contains 0.895 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.

|  |  |  |  |
| --- | --- | --- | --- |
| I | 0.895 M | 0.895 M | 1. M
 |
| Δ | -x | -x | +2x |
| E | (0.895-x)M | (0.895-x)M | 2x |
|  | =0.895-0.0471=0.847M | =0.895-0.0471=0.847M | =2(0.0471M)=0.0942M |

Initial concentrations of reactants

$$\left[N\_{2}\right]=\left[O\_{2}\right]=\frac{0.895 mol}{1.00 L}=0.895 M$$

$$K\_{c}=0.0123=\frac{\left[NO\right]^{2}}{\left[N\_{2}\right]\left[O\_{2}\right]}$$

$$0.0123= \frac{\left(2x\right)^{2}}{\left(0.895-x\right)\left(0.895-x\right)}$$

$$\sqrt{0.0123}= \sqrt{\frac{\left(2x\right)^{2}}{\left(0.895-x\right)\left(0.895-x\right)}}$$

$$0.111= \frac{\left(2x\right)^{}}{\left(0.895-x\right)}$$

$$\left(0.111\right)\left(0.895-x\right)=0.0993-0.111x=2x$$

$$0.0993=2.111x$$

$$x=0.0471 M$$