DAWSON COLLEGE

DEPARTMENT OF CHEMISTRY & CHEMICAL TECHNOLOGY

FINAL EXAMINATION CHEMISTRY 202-NYB-05
May 22, 2009
9:30 – 12:30

Print your Name: _____

Student Number: _____

INSTRUCTORS: ***Please circle the name of your instructor:***

J. Ali	I. Dionne	M. Haniff
D. Baril	M. Di Stefano	S. Makinen
O. Behar	N. Duxin	S. Mutic

INSTRUCTIONS:

This exam set consists of **15** questions. Please ensure that your copy of this examination is complete.

Answer all questions in the space provided.

1. Calculators may not be shared. Programmable calculators are not permitted.
2. No books or extra paper are permitted.
3. In order to obtain full credit, you must show the method used to solve all problems involving calculations and express your answers to the correct number of significant figures.
4. Your attention is drawn to the College policy on cheating.
5. A Periodic Table is provided. You may detach the Periodic Table.
6. If a mathematical equation is used to solve a problem, the equation should be clearly written.
7. Write your answer in the appropriate box when required

USEFUL DATA:

Avogadro's Number $N_A = 6.022 \times 10^{23}\ mol^{-1}$

Gas Constant $R = 0.08206\ L{\cdot}atm{\cdot}K^{-1}{\cdot}mol^{-1}$

$= 8.314\ L{\cdot}kPa{\cdot}K^{-1}{\cdot}mol^{-1}$

$= 8.314\ J{\cdot}K^{-1}{\cdot}mol^{-1}$

$1\ atm = 101.3\ kPa = 760\ mmHg = 760\ torr$

$1\ J = 1\ kg{\cdot}m^2{\cdot}s^{-2}$

$101.3\ J = 1\ L{\cdot}atm$

MARK DISTRIBUTION

1.	/ 8
2.	/ 5
3.	/ 6
4.	/ 6
5.	/ 8
6.	/ 7
7.	/ 6
8.	/ 7
9.	/ 7
10.	/ 5
11.	/ 8
12.	/ 6
13.	/ 7
14.	/ 6
15.	/ 6
Significant Figures	/ 2
TOTAL	**/100**

RED = NYB content, not part of SN2.

Question 1

The electrolyte of an automobile lead storage battery is a 3.75 M sulfuric acid (H_2SO_4) solution in water. It has a density of 1.23 g/mL. Calculate for the sulfuric acid:

a. the mass percent

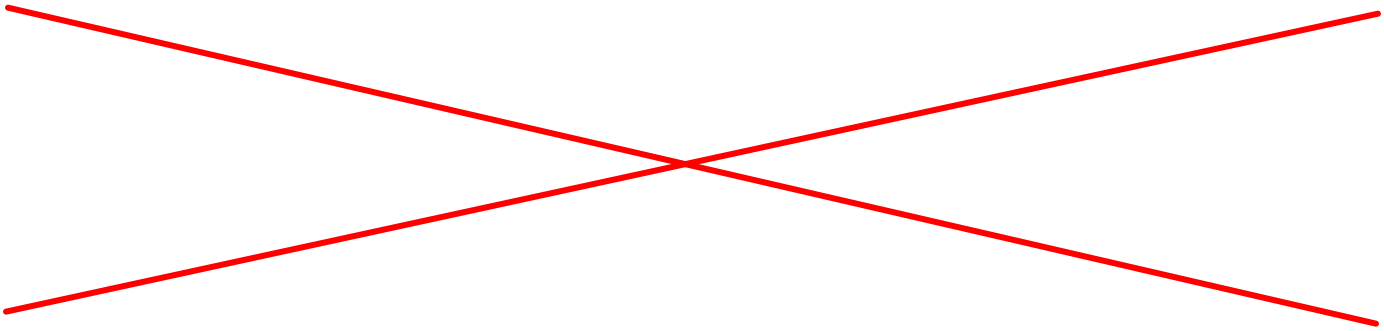
2 marks

b. the molality

2 marks

c. the mole fraction

2 marks



d. What volume of 3.75 M sulfuric acid must be used to prepare 1.5 L of a 0.10 M H_2SO_4(aq) solution?

2 marks

Answers

a. mass percent:	*b. molality:*	*c. mole fraction:*	*d. volume:*

Question 2

Knowing that a human eye has an osmotic pressure of 7.97 atm at 37.0°C, an eye-drop solution with the same osmotic pressure and temperature is prepared by adding 0.242 g of NaCl in 25.0 mL water. Calculate the van't Hoff factor for NaCl in this solution. Assume the density of the solution to be 1.00 g/mL.

5 marks

Answer

van't Hoff factor :

Question 3

At a high altitude camp in the Rockies, water boils at 95.4°C instead of 100.0°C. A visitor has requested a soft-boiled egg (usually boiled for 3.00 minutes at 100.0°C). The activation energy for the reaction in question is 453 kJ/mol.

6 marks

egg protein (l) ⟶ egg protein (s)

How long will it take to cook his egg at 95.4°C?

Answer

time :

Question 4

The following data were obtained for the reaction:

$$2ClO_2(aq) + 2OH^-(aq) \longrightarrow ClO_3^-(aq) + ClO_2^-(aq) + H_2O(l)$$

Where Rate = $-\frac{\Delta[ClO_2]}{2\Delta t}$

Experiment no.	$[ClO_2]_o$ ($mol \cdot L^{-1}$)	$[OH^-]_o$ ($mol \cdot L^{-1}$)	Initial rate ($mol \cdot L^{-1} \cdot s^{-1}$)
1	0.0500	0.100	5.75×10^{-2}
2	0.100	0.100	2.30×10^{-1}
3	0.200	0.0250	2.30×10^{-1}

a. Determine the rate law *3 marks*

b. Calculate the value of the rate constant (with units). *2 marks*

c. What is the overall order of this reaction? *1 mark*

Answers

a. rate law :	*b. rate constant :*	*c. overall order :*

Question 5

Consider the following chemical reaction at 10°C with $[NOBr]_o$ = 0.080 M:

$$2NOBr(g) \longrightarrow 2NO(g) + Br_2(g) \qquad \text{Rate} = 0.80\ M^{-1}s^{-1}[NOBr]^2$$

a. Calculate the time required for 85% of the initial NOBr to react. *3 marks*

Answer

time :

b. What is the half-life of this reaction? *2 marks*

Answer

b. half-life :

c. Indicate whether the following statements are true of false for the chemical reaction described above. *3 marks*

	True	False
i. The rate of the reaction doubles if the concentration of NOBr is doubled	☐	☐
ii. The rate of the reaction decreases as time goes on	☐	☐
iii. If $[NOBr]_o$ = 0.080 mol/L, then after 100 s all the reactant is consumed	☐	☐
iv. The half-life of the reaction is 5.0 s when $[NOBr]_o$ = 0.040 mol/L	☐	☐
v. The plot of [NOBr] vs. time is a straight line	☐	☐
vi. Changing the temperature will affect the order of the reaction	☐	☐

Question 6

Consider the following reaction

$$H_2S(g) + I_2(s) \rightleftharpoons 2HI(g) + S(s) \qquad K_p = 1.34 \times 10^{-5} \text{ at } 60°C$$

A 5.00 L reactor contains the following initial mixture at 60°C

- 2.00 g solid iodine (I_2)
- 1.07 g sulfur powder
- 10.1 kPa of hydrogen sulfide (H_2S)

a. What will be the pressure of HI at equilibrium? *3 marks*

b. What is the *K* value for this equilibrium at 60°C? *2 marks*

c. What will be the value of K_p for the following reaction at the same temperature? *2 marks*

$$4HI(g) + 2S(s) \rightleftharpoons 2H_2S(g) + 2I_2(s)$$

Answers

a. HI pressure :	*b. K :*	*c. K_p :*

Question 7

a. Indicate whether the following statements are true of false *3 marks*

	True	False
i. The solubility of a gas in water decreases with increasing temperature	☐	☐
ii. The presence of a non-volatile solute in a solvent lowers the vapor pressure of the solution	☐	☐
iii. Henry's law states that the amount of a gas dissolved in a solution is directly proportional to the pressure of the gas above the solution	☐	☐
iv. A liquid-liquid solution that obeys Raoult's law is called an "ideal solution"	☐	☐
v. Colligative properties are based on the number of particles in solution, whatever the "size" of the particle.	☐	☐
vi. The addition of an ionic compound to any solvent will cause a boiling point depression.	☐	☐

b. The gas Arsine, AsH_3 decomposes as follows:

$$2AsH_3(g) \rightleftharpoons 2As(s) + 3H_2(g) \qquad \Delta H = +122.8 \text{ kJ}$$

For each of the following cases, in which direction will the position of the equilibrium be shifted if: *3 marks*

(to the reactant = left, to the products = right, no effect = no change)

	left	no change	right
i. As(s) is added	☐	☐	☐
ii. the pressure is increased by adding argon gas	☐	☐	☐
iii. the volume of the reaction container is decreased	☐	☐	☐
iv. the temperature is decreased	☐	☐	☐
v. hydrogen is removed	☐	☐	☐
vi. a catalyst is added	☐	☐	☐

Question 8

The percent dissociation of chlorous acid $HClO_2$ in water is 8.0% when its concentration is 1.58 M.

a. What is the pH of this solution? *2 marks*

b. What is the K_a of this acid? *2 marks*

c. What will be the percent dissociation if the concentration increases to 4.5 M? *3 marks*

Answers

a. pH :	*b. K_a :*	*c. percent dissociation :*

Question 9

a. Order the following from the strongest to the weakest base *1.5 marks*

i. H_2O
ii. CH_3NH_2
iii. ClO_4^-

_____ _____ _____
strongest base *weakest base*

b. Arrange the following aqueous solutions in order from most acidic to most basic. *1.5 marks*

i. $0.1M\ KF$
ii. $0.1M\ KNO_3$
iii. $0.1M\ NH_4Cl$

_____ _____ _____
most acidic *most basic*

c. What will be the pH of an aqueous solution made up of 0.514 g potassium cyanide KCN in 125 mL water. *4 marks*
K_a $HCN = 6.2 \times 10^{-10}$.

Answer

pH :

Question 10

Calculate the mass of KNO_2 that must be added to 500. mL of 0.20 M nitrous acid (HNO_2, K_a = 4.6x10^{-4}) to get a solution of pH = 4.00. Assume no change of the volume of the solution with the addition of KNO_2. *5 marks*

Answer

Mass of KNO_2 :

Question 11

A 20.0 mL sample of 0.10 M formic acid ($HCOOH$) was titrated with 5.0×10^{-2} M $Ba(OH)_2$.

K_a for $HCOOH$ is 1.8×10^{-4}.

a. Calculate the pH of the solution upon the addition of 15.0 mL of $Ba(OH)_2$ to the sample. *3 marks*

Answer

a. pH :

Question 11 (cont.)

b. What volume of $Ba(OH)_2$ is needed to reach the equivalence point? *2 marks*

c. Calculate the pH of the solution at the equivalence point. *3 marks*

Answers

b. volume at equivalence point :	*c. pH at equivalence point :*

Question 12

Solid NaI is slowly added to a solution that contains both $Pb(NO_3)_2$ (0.100 *M*) and $AgNO_3$ (2.0×10^{-4} *M*). *6 marks*

a. Which begins to precipitate first: the lead iodide or the silver iodide? Show your work

b. The concentration of the first cation species to precipitate, either the lead or the silver, decreases as the precipitate forms. What is the concentration in solution of the first species when the second begins to precipitate? Assume no change of volume of the solution with the addition of NaI.

Note: K_{sp} $PbI_2 = 1.4 \times 10^{-8}$, K_{sp} $AgI = 1.5 \times 10^{-16}$

Answers

a. :	*b. :*

Question 13

a. Predict the sign of ΔS of the system for each of the following processes *3 marks*

		$\Delta S < 0$	$\Delta S > 0$
i.	A liquid that boils	☐	☐
ii.	Sugar that crystallized out from a supersaturated sugar solution	☐	☐
iii.	Iron rusts (formation of Fe_2O_3 from pure Fe and O_2)	☐	☐
iv.	$A\text{-}B(g) + C\text{-}D(s) \longrightarrow A\text{-}B\text{-}C(g) + D(s)$	☐	☐
v.	$N_2O_4(g) \longrightarrow 2NO_2(g)$	☐	☐
vi.	$NaCl(s) \xrightarrow{H_2O} Na^+(aq) + Cl^-(aq)$ ΔH_{sol} = +4.0 kJ/mol	☐	☐

b. For mercury (Hg), the enthalpy of vaporization is 58.51 kJ/mol and the entropy of vaporization is 92.92 J/K.mol. What is the normal boiling point of mercury? *4 marks*

Answer

b. T_b :

Question 14

Consider the following reaction

$$N_2O_4(g) \longrightarrow 2NO_2(g)$$

Will the reaction be spontaneous at each of the following temperatures? Show your work.
(assume that $\Delta H°$ and $\Delta S°$ do not change very much within the given temperature range) *6 marks*

a. 25.0°C
b. 60.0°C

Answers

a. spontaneous at 25°C? :	*b. spontaneous at 60°C? :*

Useful data	$N_2O_4(g)$	$NO_2(g)$
$\Delta H°_f$ in kJ/mol	+9.67	+33.8
$S°$ in J/(mol·K)	+304	+240.5

Question 15

Complete the "experiment 2" laboratory data sheet and find the molar mass of the unknown no 3. *6 marks*

The solid unknown added is a non-ionic compound, completely soluble in cyclohexane.

Experiment 2

COLLIGATIVE PROPERTIES
DATA SHEET

k_f cyclohexane = 20.2°C.kg.mol^{-1} T_f cyclohexane = 6.55°C

Data for the Unknown Solute/Cyclohexane Solution

Unknown Number: *3*

Mass of empty test tube, stopper, beaker	g	*185.2235*
Mass of test tube, stopper, beaker, & cyclohexane	g	*204.5736*
Mass of test tube, stopper, beaker, & unknown solute/cyclohexane solution	g	*204.9847*
Mass of cyclohexane	g	
Mass of unknown solute	g	
Freezing Temperature of unknown solute/cyclohexane solution	°C	*4.27*
Molar mass of unknown solute	g·mol^{-1}	

Sample calculation.