

Time: 2 hrs & 15min.

Chemistry 102
Final Examination

June 29, 1998

Family Name : _____

First Name: _____

ID No. : _____

Section : _____

DATA

SCORE

Gas constant (R) = 0.08205 L. atm. mol.⁻¹ K⁻¹
= 8.314 J. mol.⁻¹ K⁻¹

Part A: /32

One atmosphere = 760 mm Hg

Part B: /12

T(Kelvin) = (273.2 + °Celsius)

Part C: /56

K_w = 1.00 × 10⁻¹⁴

_____ Total: /100

K_f for H₂O = 1.86°C/m

PART A (32 points)

The following are **EIGHT** problems. Each is **FOUR** points worth. Write the calculated numerical answer to the proper number of significant figures in the provided space. Indicate units whenever applicable.

- The osmotic pressure of a benzene solution containing 2.47g of an organic polymer in 202 ml. of the solution is 8.63 mmHg at 21°C.

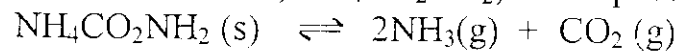
The molar mass of the polymer is: _____

- Calculate K_p at 1273°C for the reaction
$$2\text{CO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{CO}_2(\text{g})$$

if $K_c = 2.24 \times 10^{22}$ at the same temperature:

Answer: _____

- Ammonium carbamate, $\text{NH}_4\text{CO}_2\text{NH}_2$, decomposes as follows:



Starting with only the solid, it is found that at 40°C the total gas pressure is 0.363 atm .

Calculate K_p for the reaction:

Answer: _____

- Estimate the molar heat of vaporization, $\Delta\bar{H}_{\text{vap}}$, of a liquid whose vapor pressure doubles when the temperature is raised from 85°C to 95°C . Assume that $\Delta\bar{H}_{\text{vap}}$ is independent of temperature:

Answer: _____

- The molar heat of fusion $\Delta\bar{H}_{fus}$ of benzene is 10.9 kJ mol^{-1} . Calculate the entropy change ($\Delta\bar{S}_{fus}$) for the transition $\text{C}_6\text{H}_6(\text{s}) \rightarrow \text{C}_6\text{H}_6(\text{l})$.

At 1 atm. pressure, benzene melts at 5.5°C .

Answer: _____

- ΔG° for the reaction $2\text{H}_2\text{O}(\text{l}) \rightleftharpoons 2\text{H}_2(\text{g}) + \text{O}_2(\text{g})$ is 474.4 kJ . Calculate the equilibrium constant K_p for the reaction at 25°C :

Answer: _____

- Calculate the pH of a buffer solution prepared by mixing 50.0ml of 0.100 M acetic acid (CH_3COOH) solution with 50.0 ml of 0.100 M sodium acetate (CH_3COONa) solution at 25°C . K_a of acetic acid is 1.85×10^{-5} at 25°C :

Answer: _____

- The solubility product constant of $\text{Ca}(\text{OH})_2$ is 8.0×10^{-6} . Calculate its molar solubility in a 0.1 M solution of NaOH.

Answer: _____

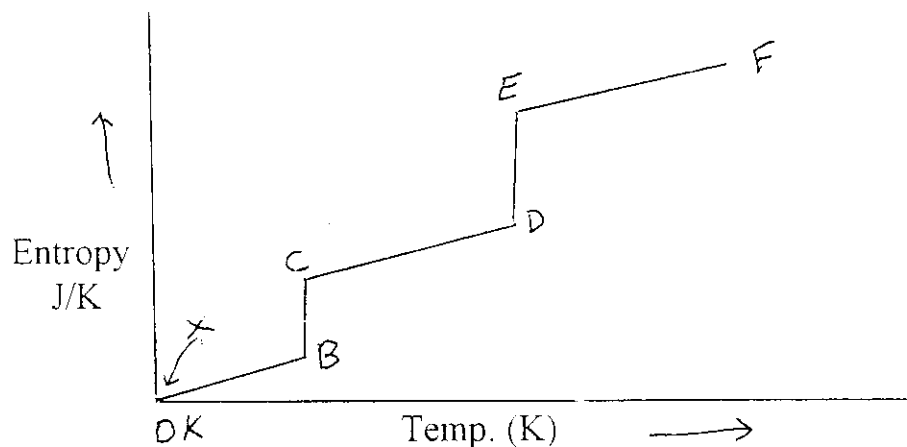
PART B (12 points)

The following are **FOUR** multiple-choice type questions. Each is **THREE** points worth. Circle the letter preceding the correct answer.

- In the electrolysis of an aqueous solution of CuSO_4 :

- a. The reduction occurs at the anode.
- b. Copper is deposited at the anode.
- c. Oxygen is produced at the anode.
- d. Hydrogen is produced at the anode.

- The following diagram represents absolute entropy at various temperatures for substance A. Which statement is correct ?



- a. Line X-B represents melting of solid A.
- b. Line CD represents melting of solid A.
- c. Line DE represents evaporation of liquid A.
- d. Point X is in accordance with the second law of thermodynamics.

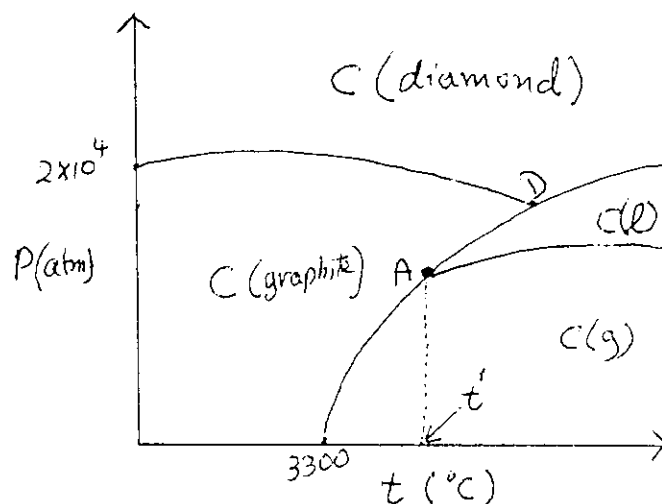
- The equilibrium constant K_p for the reaction:



is 1.05 at 250°C . The reaction starts with a mixture of PCl_5 , PCl_3 , and Cl_2 at pressures 0.177 atm, 0.223 atm and 0.111 atm respectively, at 250°C . When equilibrium is established, the total number of moles of gaseous components will be:

- Larger than the initial number of moles in the mixture.
- Smaller than the initial number of moles in the mixture.
- Equal to the initial number of moles in the mixture.

- Consider the phase diagram of carbon. Which of the following statements is incorrect ?



- At 25°C and 1 atm pressure, $\Delta G^\circ = -2.87 \text{ kJ}$ for the transformation $\text{C}(\text{diamond}) \longrightarrow \text{C}(\text{graphite})$ therefore, diamond spontaneously converts to graphite.
- At point A, the equilibrium system $\text{C}(\text{graph}) \rightleftharpoons \text{C}(\text{l}) \rightleftharpoons \text{C}(\text{g})$ holds.
- "A" is the triple point for carbon.
- Liquid C can exist at all temperatures above t' .
- The points on curve AD are potential boiling points for C(graph).
- (d) and (e).

PART C (56 points)

Each of the following questions is composed of more than one part. In each part write the correct answer in the provided space or circle the correct answer. Points for each question are indicated.

- (3 points) Of the following:

(I) $\text{HOCH}_2\text{CH}_2\text{CH}_2\text{OH}$, (II) $\text{H}_3\text{COCH}_2\text{CH}_2\text{OH}$, (III) $\text{CH}_3\text{OCH}_2\text{OCH}_3$

a. The one that has the highest boiling point is: _____

b. The one that has the lowest vapor pressure is: _____

c. The one that has the highest viscosity is: _____

- (6 points) A solution is made by dissolving 25.0 g of $\text{Ba}(\text{OH})_2$ in enough water to make a total of 600 ml of solution:

a. The molarity of the solution is: _____

b. If the density of the solution is 1.07 g/ml, the molality of the solution is:

c. The freezing point of the solution is: _____

- (4 points) Specify whether each of the following species is paramagnetic or diamagnetic:

K (atoms) : _____

Li_2 (molecules): _____

O_2 (molecules): _____

- (12 points) Give the chemical name and the formula of the following:

	Name	Formula
1. A stable compound of any alkali metal:	_____	_____
2. An amphoteric oxide of aluminum:	_____	_____
3. A compound of carbon where the oxidation number is -4	_____	_____
4. A strong base of a Group II A metal	_____	_____
5. The strongest acid in H ₂ O	_____	_____
6. The ion in which oxygen has an oxidation number of -1	_____	_____
7. An oxide of nitrogen in which nitrogen has an oxidation number of -1	_____	_____
8. A compound of chlorine used as a source of O ₂ (g) in the laboratory	_____	_____

- (2 points) The compounds Br₂ and ICl have the same number of electrons, yet Br₂ melts at -7.2°C whereas ICl melts at 27.2°C. the difference between the melting points is mainly due to:

_____ forces.

- (8 points) Given the following K_a values for the indicated acids:

	<u>K_a</u>
HNO_2	4.5×10^{-4}
HCOOH	1.7×10^{-4}
$\text{CH}_3\text{CO}_2\text{H}$	1.8×10^{-5}
HCN	4.9×10^{-10}

a. K_b for the base NO_2^- is: _____

b. Choose the acid and the base or salt that when react together will have the largest equilibrium constant.

acid: _____

base: _____

c. The pH of a 0.1 M solution of HCN is: _____

d. The salt of the acid that produces an aqueous solution of the lowest pH is:

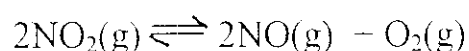
(8 points) Given the standard thermodynamic data:

	ΔG_f° (kJ/mol)	ΔH_f° (kJ/mol)	S° J/k. mol
NO(g)	+86.7	90.4	210.6
NO ₂ (g)	+51.8	33.85	240.5
N ₂ (g)	0.0	0.0	191.5
O ₂ (g)	<u>0.0</u>	<u>0.0</u>	205.0

For each of the following questions circle the correct answer where applicable OR fill-in the blank:

T F A. NO is more stable than NO₂.

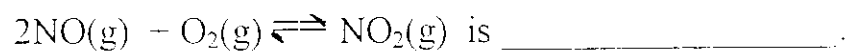
B. When 1 mole of each of NO, N₂, O₂, NO₂ is placed in a 1 liter container, then for the reaction:



T F a. At equilibrium there will be more NO than NO₂

b. ΔG for the reaction at the moment when the substances are mixed is: _____.

c. The equilibrium constant for the reaction:



C. For the reaction: $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}$ ΔS at Zero Kelvin is:

_____.

- (6 points) $K_c = 150$ for the reaction $\text{CO(g)} + \text{Cl}_2\text{(g)} \rightleftharpoons \text{COCl}_2\text{(g)}$ at a certain temperature. If 15.0 moles of $\text{COCl}_2\text{(g)}$ are introduced into a 5.00 liter container, it decomposes until equilibrium is reached.

a. ΔS° for the forward reaction as written is (circle one):

positive, negative, zero.

b. For the decomposition at a higher temperature the concentration of CO(g) is expected to (circle one):

increase, decrease, remain unchanged.

c. $\frac{k_p}{K_c}$ is (circle one):

more than one, less than one, equal to one.

- (7 points) Consider the following list of elements:

C, B, Si, P, O, K, S

a. The element that would form n-type semi conductor with Si is: _____

b. The element that would form p-type semiconductor with Si is: _____

c. The element with the largest atomic size is: _____

d. The element that is easiest to oxidize is: _____

e. The element that forms the strongest basic hydride is: _____

f. The element that forms the strongest acidic hydride is:

g. The carbide that is as hard as diamond is: _____