Concordia UNIVERSITY

COURSE	GENERAL CHEMISTRY II	NUMBER CHEM 206	SECTION /2 51
EXAMINATION	Final Examination	DATE December 19, 2005	TIME 1900-2200
INSTRUCTOR	Dr. Cerrie ROGERS		

MATERIALS ALLOWED: [x] NO [ ] YES (PLEASE SPECIFY)

CALCULATORS ALLOWED: [ ] NO [x] YES programmable calculators must be reset

Chem 206 --- GENERAL CHEMISTRY II

LAST NAME: ____________________________ FIRST NAME: ____________________________

STUDENT NUMBER: ____________________ SIGNATURE: ____________________________

Instructions: PLEASE READ THIS PAGE WHILE WAITING TO START.

- ***Make sure your exam has 13 pages, including this page, information sheet & periodic table.***
- ***Write your student ID number on all pages.***
- ***Write all answers legibly in the space provided (use the backs of pages for rough work).***
- ***Non-programmable calculators are allowed; cell phones & electronic dictionaries are not.***
- ***You are allowed to remove the periodic table and information sheet.***
- ***Read ALL questions quickly BEFORE starting the exam; do the "easy" questions first.***
- ***Suggestion: spend <15 minutes per page to have 30 minutes left to check your work.***

Mark breakdown:		
	Page 2.	/ 17
	Page 3.	/ 8
	Page 4.	/ 8
	Page 5.	/ 9
	Page 6.	/ 12
	Page 7.	/ 10
	Page 8.	/ 10
	Page 9.	/ 13
	Page 10.	/ 7
	Page 11.	/ 10
	TOTAL:	**/ 100 (MAXIMUM MARK = 104)**

 # 1. **(__/ 17 marks)** ***TRUE OR FALSE?*** Circle T or F to describe each of these statements.

1 mark each:

T / F According to the first law of thermodynamics, a system's internal energy cannot change.

T / F When a system is at equilibrium, there is no reaction occurring in either direction at the molecular level.

T / F If a mixture is cloudy, it is more correct to describe it as a colloidal dispersion than as a solution.

T / F If three reactions occur in sequence, the equilibrium constant for the overall reaction will be the same as the smallest of the three equilibrium constants.

T / F Oil and water are immiscible because the hydrogen bonds between water molecules are much stronger than the dipole–induced-dipole interactions between water and oil molecules.

T / F A catalyst increases the rate constant for a reaction by increasing the pre-exponential (also known as the frequency factor, A) for the reaction.

T / F Half-life is useful for understanding radioactive substances, because the half-life of any first-order process (such as radioactive decay) depends on the initial concentration of decaying substance.

2 marks each:

T / F A solution containing an ionic compound will have a lower vapour pressure than a solution containing the same concentration of a molecular compound.

T / F The activation energy for the reaction A → B is the same as the activation energy for the reaction B → A, regardless of the difference in thermodynamic stability of the two substances A and B.

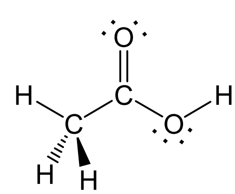
T / F If a compound with a pK_a of 9.0 is placed into a solution with a pH of 7.4, the majority of the compound's molecules will be present in their conjugate base form.

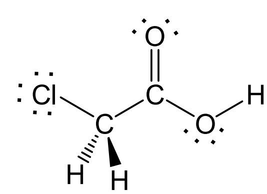
T / F For a proposed mechanism to be described as "consistent with experiment", the experimentally observed rate law for the reaction must be the same as the expected rate law for the first step in the proposed mechanism.

T / F A reaction mixture whose reaction quotient is less than the value of the reaction's equilibrium constant will be faster in the direction that leads to reactants, until equilibrium is reached.

 # 2. **(__/ 4 marks)** People often describe the reaction of an acid with a base as “neutralization”. In what ways is this accurate, and in what situations might this description be misleading?

 # 3. **(__/ 12 marks)** Consider these two carboxylic acids:





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a) **(4 marks)** Based on the structures of the two acids, which do you expect to be stronger? Explain.

3. continued…

b) **(4 marks)** Using the thermodynamic data in the table, calculate ΔG^o_{rxn} for the reaction of each of these acids with water at 25°C. Would these reactions become more or less product-favoured at higher temperatures? Why?

Thermodynamic data for the reaction of the acids with water, in aqueous solution at 25°C

Acid	ΔH^o_{rxn} (kJ/mol)	ΔS^o_{rxn} (J/mol·K)
CH_3COOH	-0.57	-92.6
$ClCH_2COOH$	-4.70	-70.8

c) **(4 marks)** Using the thermodynamic data provided, calculate the acid dissociation constant, K_a, for each of the acids at 25°C. Which acid is stronger according to these K_a's? Explain briefly.

 # 4. **(__/ 9 marks)** A forensic chemist is given a white solid that is suspected of being pure cocaine ($C_{17}H_{21}NO_4$, molar mass 303.35 g/mol). She dissolves 1.22 ± 0.01 g of the solid in 15.60 ± 0.01 g of benzene, and finds that the freezing point is lowered by 1.32 ± 0.04 °C. [The K_f of benzene is 5.12 °C·kg/mol.]

a) **(5 marks)** Use the experimental data to calculate the molar mass of the white solid.

b) **(4 marks)** Assuming that the percent uncertainty in the calculated molar mass is the same as the percent uncertainty in the temperature change, calculate the uncertainty in the molar mass. Could the chemist accurately state that the substance is cocaine? For example, is the uncertainty small enough to distinguish cocaine from codeine ($C_{18}H_{21}NO_3$, molar mass 299.36 g/mol)?

 # 5. **(__/ 12 marks)** Chlorine dioxide (ClO_2) is a gas used as a disinfectant in municipal water-treatment plants. It dissolves in basic solution to produce the strong oxidizing agents ClO_3^- and ClO_2^-.

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

a) **(5 marks)** Using the kinetic data given in the table, determine the rate law for this reaction and the average value of its rate constant at 298 K.

Kinetic data for reaction at 298 K

Run #	$[ClO_2]_0$ (mol/L)	$[OH^-]_0$ (mol/L)	Initial rate (mol/L·s)
1	0.060	0.030	0.0248
2	0.020	0.030	0.00827
3	0.020	0.090	0.0247

b) **(2 marks)** Does the balanced chemical equation correctly represent the mechanism of this reaction? Did you need to analyze kinetic data to make this conclusion? Why or why not?

c) **(2 marks)** What can you deduce about the nature of the rate-limiting step of this reaction?

d) **(3 marks)** If this reaction was performed at 298 K using an initial ClO_2 concentration of 0.035 M in a solution with pH 12.75, what would be the initial reaction rate?

 # 6. **(__/ 10 marks)** Imagine you are sitting in a hot sauna. The stove (heater) in the sauna has a layer of rocks on top of it, so that you can pour water onto them to create steam, which makes the sauna feel hotter.

a) **(5 marks)** Imagine you poured 215 mL of 45°C water onto the hot rocks, and it all evaporated to form steam. How much heat needed to be absorbed from the hot rocks?
[ΔH°_{vap} of $H_2O(l)$ at 100°C = 40.68 kJ/mol; other data on information sheet.]

b) **(5 marks)** If 3.25% of the steam from part (a) condensed onto 1.50 m^2 of your skin (about half your body's surface area), by how many degrees would the temperature of your skin rise?
Assume that:
- the heat was transferred quantitatively into the outer 1.0 mm of skin.
- the density and heat capacity of skin are the same as water, since human cells are ~90% water.

 # 7. (__/ 10 Marks) An artificial fruit beverage contains 12.0 g of tartaric acid, $H_2C_4H_4O_6$, and 21.0 g of its salt, potassium hydrogen tartrate ($KHC_4H_4O_6$), per liter. Tartaric acid is a diprotic acid, but in this situation only the first ionization step is important ($K_{a1} = 1.0 \times 10^{-3}$).

a) **(4 marks)** Would this beverage behave as a buffer? Why or why not?

b) **(6 marks)** A person's stomach usually contains about 75 mL of stomach acid, which is essentially hydrochloric acid with a pH of approximately 2.00. If you drink a glass (250 mL) of the beverage described above, what will be the pH of the final mixture in your stomach?

 # 8. (__/ 13 marks) At high temperatures, a dynamic equilibrium exists between carbon monoxide, carbon dioxide and solid carbon:

$$C(s) + CO_2(g) \rightleftharpoons 2CO(g) \qquad \Delta H° = -172.5 \text{ kJ}$$

At 850°C, the equilibrium constant K_c is 0.153.

a) **(3 marks)** What is the value of K_p?

b) **(6 marks)** If solid carbon plus 1.75 atm of CO_2 are placed in a 1.00 L container, what would be the pressures of CO_2 and CO when equilibrium has been established at 850°C?

c) **(2 marks)** How will the equilibrium pressure of CO change if the temperature is increased? Why?

d) **(2 marks)** How will the equilibrium pressure of CO change if some argon is added? Why?

 # 9. (__/ 7 marks) Sodium fluoride is added to many municipal water supplies to reduce tooth decay. Would a 0.00512 M solution of NaF feel much different than pure water? That is, would it have a neutral pH?

To support your answer, show a full calculation of the pH of this solution. [The K_a of HF is 6.8×10^{-4} at 25°C.]

 # 10. (__/ 10 marks) A saturated solution of an unidentified ionic salt with the formula MX_3 exhibits an osmotic pressure of 74.4 mm Hg at 25°C.

a) **(3 marks)** What is the total concentration of dissolved ions in this solution?

b) **(1 mark)** Write a chemical equation that summarizes the processes occurring in this saturated solution.

c) **(6 marks)** Assuming that MX_3 is fully dissociated (*i.e.,* no ion-pairing) in this saturated solution, what is the value of its K_{sp}?

-- **HAPPY HOLIDAYS** --

POTENTIALLY USEFUL INFORMATION

Constants:

$R = 8.314\ J \cdot mol^{-1}K^{-1} = 0.08206\ L \cdot atm \cdot mol^{-1}K^{-1}$

1 atm = 760 mm Hg = 760 torr = 101.325 kPa

1 mL = 1 cm^3

1 L = 1 dm^3

Data:

Properties of liquid water:

bp (at 1 atm) = 100.00°C

$C_{H_2O(l)} = 4.184\ J \cdot g^{-1}K^{-1}$

$d_{H_2O(l)} = 1.00\ g \cdot mL^{-1}$

$K_{f\ H_2O} = 1.86\ °C \cdot kg \cdot mol^{-1}$

$K_{b\ H_2O} = 0.52\ °C \cdot kg \cdot mol^{-1}$

$K_w = 10^{-14}$

Properties of solid water:

mp (at 1 atm) = 0.00°C

$C_{H_2O(s)} = 2.06\ J \cdot g^{-1}K^{-1}$

$d_{H_2O(s)} = 0.917\ g \cdot mL^{-1}$

Formulae:

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

$\Delta G = \Delta G^o + RT \ln Q$

$\Delta G^o = -RT \ln K_{eq}$

$PV = nRT$

$C = k P$ (or, $S = k P$)

$P = \chi P^o$

$\Delta T = K m$

$\pi V = nRT$

$k = A e^{(-Ea/RT)}$

$[A]_t = -kt + [A]_o$

$\ln[A]_t = -kt + \ln[A]_o$

$1/[A]_t = kt + 1/[A]_o$

$x = \frac{-b \pm \sqrt{(b^2-4ac)}}{2a}$

$pH = -\log[H_3O^+]$

$pH = pK_a + \log \frac{[A^-]}{[HA]}$