Chem 206 Winter 2007 section 01

GENERAL CHEMISTRY II
MIDTERM EXAMINATION

INSTRUCTIONS: ***PLEASE READ THIS PAGE WHILE WAITING TO START YOUR EXAM.***

This test paper includes 8 pages; the last page includes potentially useful data and formulae, and a periodic table. Check that your paper is complete before starting. You can remove the periodic table if you wish. Answer all questions inside the space provided. Calculators are permitted; cell phones and electronic dictionaries are not allowed. You have 75 min to complete the test. *I suggest you scan the whole test quickly before starting & do the 'easy' stuff first.*
GOOD LUCK! *Suggestion: spend 1 min / mark ⇨ 25 min left to finish uncertain problems & check.*

LAST NAME: _____ FIRST NAME: _____

STUDENT NUMBER: _____

Mark breakdown:

Page 2.	/ 10
Page 3.	/ 10
Page 4.	/ 10
Page 5.	/ 11
Page 6.	/ 10
TOTAL:	/ 50 (with 51 points possible)
PERCENT:	%
EARNED toward FINAL GRADE:	/ 20

 # 1. (__/ 10 marks) TRUE OR FALSE? Circle T or F to describe each of these statements. You do not need to explain anything.

T / F For a first order process, the time required for the reactant concentration to decrease by a factor of two depends on the reaction's rate constant but not on the initial reactant concentration.

T / F If a reaction is performed in a bomb calorimeter, the measured heat flow is not necessarily equal to the enthalpy change for the reaction, because the system is permitted to lose extra energy by performing work.

T / F The concentration of dissolved O_2 will be lower in a solution in contact with 1.0 atm of a gas mixture containing 20 mol % $O_2(g)$ than in a solution in contact with 0.20 atm of pure $O_2(g)$.

T / F London dispersion forces are weak attractive forces that arise between molecules because of mutual polarization of electron clouds, which gives rise to transient dipoles.

T / F If one knows the enthalpy change for a process and the corresponding entropy change for the surroundings, one can calculate the direction in which the process will be spontaneous.

 # 2. (__/ 10 marks) Consider the combustion of ethanol: $CH_3CH_2OH(g) + 3\ O_2(g) \rightarrow 2\ CO_2(g) + 3\ H_2O(g)$

a) **(7 marks)** Is the reaction product-favoured at 25°C? Explain, and show all calculations.

Thermodynamic data at 298 K		
Substance	**ΔH°_f (kJ/mol)**	**S°_f (J/mol·K)**
$CH_3CH_2OH(g)$	-235.3	282.7
$O_2(g)$	0	205.1
$CO_2(g)$	-393.5	213.7
$H_2O(g)$	-241.8	188.8

b) **(3 marks)** Would this reaction be more favourable or less favourable at –15°C? Explain in words; calculations will not be graded.

 # 3. (__/ 10 marks) Think about mixing water and salt, as you might do to prepare an extra-cold ice bath for making home-made ice cream.

a) **(8 marks)** What mass of NaCl must be dissolved in 575 mL of water to create a mixture that melts at –12.5°C? Use a van't Hoff factor of 1.87 for NaCl; properties of water are given on the formula page.

b) **(2 marks)** Would this solution have a higher or a lower vapour pressure than pure water? Explain very briefly (one sentence).

 # 4. (__/ 11 marks) Ammonia (NH_3) is used as a refrigerant.

a) **(3 marks)** Name and briefly explain the nature of the strongest intermolecular force that exists between molecules in pure ammonia. Provide structural drawings to clearly indicate the various ways the molecules can interact in this fashion.

b) **(2 marks)** At its boiling point (-33°C), the enthalpy of vaporization of ammonia is 23.3 kJ/mol. How much heat, "q_{NH_3}", is required to vaporize 355 g of ammonia at -33°C?

c) **(6 marks)** A standard refrigerator contains about 515 g of air (C_s = 1.0035 J/g·°C). Imagine your refrigerator was left open; it is now closed, filled with 22°C air and the walls/shelves are at 7°C. If the process from part (b) occurs within the cooling system, what is the minimum temperature the inside of the refrigerator (air + walls/shelves) could reach? Assume the refrigerator is perfectly insulated and the walls/shelves have a heat capacity of 235 kJ/°C. *[If you could not do part (b), use 275 kJ for q_{NH_3}.]*

 # 5. (__/ 9 marks) The following three-step mechanism has been proposed for the reaction of chlorine with chloroform. The numerical value (*i.e.,* without units) of the rate constant for each step is provided.

STEP 1: $Cl_{2(g)} \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} 2Cl_{(g)}$ $k_1 = 4.8\text{x}10^3$ and $k_{-1} = 3.6\text{x}10^3$

STEP 2: $Cl_{(g)} + CHCl_{3(g)} \xrightarrow{k_2} HCl_{(g)} + CCl_{3(g)}$ $k_2 = 1.3\text{x}10^{-2}$

STEP 3: $CCl_{3(g)} + Cl_{(g)} \xrightarrow{k_3} CCl_{4(g)}$ $k_3 = 2.7\text{x}10^2$

a) **(2 marks)** Which step is rate limiting? Briefly explain your choice.

b) **(4 marks)** Based on this proposed mechanism, what do you predict the reaction's overall rate law to be, and why?

c) **(3 marks)** Using the data in the table, determine the observed rate law for the reaction. Is the proposed mechanism consistent with experiment? Why or why not?

Kinetics data (fabricated for exam purposes) **for $Cl_2 + CHCl_3 \rightarrow HCl + CCl_4$**

Expt.	$[Cl_2]_o$ (M)	$[CHCl_3]_o$ (M)	Initial rate (M/s)
1	0.136	0.212	0.0248
2	0.272	0.212	0.0991
3	0.544	0.424	0.793
4	0.544	0.848	1.59

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

Data:

Properties of liquid water:

b.p. (at 1 atm) = 100.00°C

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

$\Delta H^o_{vap} = 40.7\ kJ \cdot mol^{-1}$

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

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

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

$P^o_{(298\ K)} = 23.8$ mm Hg

Properties of solid water:

m.p. (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:

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

$PV = nRT$

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

$P = \chi\ P^o$

$\Delta T = K\ m$

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

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

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

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