Chem 206 Fall 2007 section 51

GENERAL CHEMISTRY II
MIDTERM EXAMINATION

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

This test paper includes 4 pages (both sides); some potentially useful information (look at it!) is given on back of the periodic table. Check that your paper is complete before starting. You can remove the periodic table if you wish. Answer all questions in 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.	/ 15
Page 3.	/ 10
Page 4.	/ 10
Page 5.	/ 8
Page 6.	/ 8
TOTAL:	/ 50 (max. = 51)
PERCENT:	%
EARNED toward FINAL GRADE:	/ 20

 # 1. (10 marks) TRUE OR FALSE? Circle T or F to describe each of these statements.

T / F A liquid's normal boiling point is the temperature at which the liquid has a vapour pressure of 1 atmosphere.

T / F A short-lived species formed during one step of a process and consumed in a subsequent step is known as a transition state.

T / F Molarity and molality are equivalent for very dilute solutions.

T / F A solution in contact with air at atmospheric pressure will contain a lower concentration of dissolved O_2 than a solution in contact with 1 atm of pure $O_{2(g)}$.

T / F This process is more product-favoured at higher temperatures: $2\ SO_{2(g)} + O_{2(g)} \rightarrow 2\ SO_{3(g)}$.

 # 2. (5 marks) SHOW YOUR WORK. A biochemist studying the breakdown of the insecticide DDT finds that it decomposes by a first-order reaction with a half-life of 12 years. How long does it take DDT in a soil sample to decompose from 275 ppb to 15 ppb? *Recall: ppb = parts per billion, by mass.*

3. (10 marks) MULTIPLE CHOICE – Circle your answer. You do not need to show your work.

a) (1 mark – choose ONE) One statement of the first law of thermodynamics is that…

1. the amount of work done on a system is dependent on the pathway.
2. the total work done on a system must equal the heat absorbed by the system.
3. the heat flow in or out of a system is independent of the pathway.
4. the total energy flow in or out of a system is equal to the sum of the heat transferred to or from the system and the work done by or on the system.
5. in any chemical process the heat flow must equal the change in enthalpy.

b) (2 marks – choose ONE) The force primarily responsible for the solubility of $H_2S_{(g)}$ in water is…

1. hydrogen bonding.
2. induced-dipole – induced-dipole interactions.
3. dipole – dipole interactions.
4. ion – dipole interactions.
5. covalent bonding.

c) (3 marks – choose ONE) If cost per gram were <u>not</u> a concern, which of the following substances would be the most efficient per unit mass for melting ice from sidewalks and roads?

1. Glucose, $C_6H_{12}O_6$
2. LiCl
3. NaCl
4. $CaCl_2$

d) Phosgene is a toxic gas prepared by reacting carbon monoxide with chlorine: $CO_{(g)} + Cl_{2(g)} \rightarrow COCl_{2(g)}$. The data in the table were obtained in a kinetics study of this reaction.

Answer the following two questions about this reaction.

Run	Initial [CO] (mol/L)	Initial [Cl_2] (mol/L)	Initial rate (mol/L·s)
1	1.00	0.100	1.29×10^{-29}
2	0.100	0.100	1.33×10^{-30}
3	0.100	1.00	1.30×10^{-29}
4	0.100	0.0100	1.32×10^{-31}

(2 marks – choose ONE) The rate law is…

1. rate = k [CO] [Cl_2]
2. rate = k [CO]^2 [Cl_2]
3. rate = k [CO] [Cl_2]^2
4. rate = k [CO]^2 [Cl_2]^2
5. none of the above

(2 marks – choose as many as apply) The reason for choosing the rate law above was…

1. Wild guess – this type of data doesn't help us determine the rate law.
2. It matches the reaction's balanced equation.
3. When $[CO]_o$ was changed by a factor of 10, the initial rate changed by a factor of 10.
4. When $[Cl_2]_o$ was changed by a factor of 10, the initial rate changed by a factor of 10.
5. When $[CO]_o$ was decreased by a factor of 10, the initial rate decreased by a factor of 100.

 # 4. (10 marks) Ammonia is an important chemical feedstock. Consider the oxidation of ammonia to yield nitric oxide and water:

$$4\ NH_{3(l)} + 5\ O_{2(g)} \rightarrow 4\ NO_{(g)} + 6\ H_2O_{(l)}$$

a) **(6 marks)** Is the reaction spontaneous at 25°C? Explain, and show all calculations.

Thermodynamic data at 298 K		
Substance	**ΔH°_f (kJ/mol)**	**S°_f (J/mol·K)**
NH_3 (g)	-46.1	192.3
O_2(g)	0	205.1
NO(g)	90.2	210.7
H_2O(l)	-285.8	69.9

b) **(2 marks)** Would this reaction evolve heat or require an input of heat? Explain briefly.

c) **(2 marks)** Do you think it would be worth trying to find a catalyst for this reaction? Why or why not?

 # 5. (8 marks) Biochemists have discovered more than 400 mutant varieties of hemoglobin, the blood protein that carries oxygen throughout the body. A few of the mutants function normally, but many result in disease. Imagine you are a scientist studying a mutant hemoglobin associated with a fatal disease. You perform the following experiment to determine its molar mass:

- Dissolve 21.5 mg of the protein in water at 5.0°C to make 1.50 mL solution
- Measure this solution's osmotic pressure: 3.61 torr

According to this data, what is the molar mass of this mutant hemoglobin protein?

 # 6. (8 marks) A manufacturer claims that its new "diet" dessert has "fewer than 10 Calories per serving". To test the claim, a chemist at the Department of Consumer Affairs places one serving in a bomb calorimeter (heat capacity 8.151 kJ/K) and burns it in oxygen. The temperature increases by 4.937°C.
Is the manufacturer's claim correct? Include calculations to support your answer, and a brief explanation.

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 Calorie = 1 kcal = 4.184 kJ

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, $S = k\ P$)

$P = \chi\ P^o$

$\Delta T = K\ m$