# Chem 206 Winter 2007 section 52

# GENERAL CHEMISTRY II
# **MIDTERM EXAMINATION**

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

This test paper includes 7 pages; the last pages include 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: _____

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Mark breakdown:

| | |
|---|---|
| Page 2. | / 12 |
| Page 3. | / 11 |
| Page 4. | / 10 |
| Page 5. | / 10 |
| TOTAL: | / 42 (with 43 points possible) |
| PERCENT: | % |
| EARNED toward FINAL GRADE: | / 20 |

**# 1. (12 marks) TRUE OR FALSE?** Circle T or F to describe each of these statements. You do not need to explain anything.

**T / F** For the purpose of melting the ice on your front steps at home, calcium chloride ($CaCl_2$) would be a better choice of salt than sodium chloride (NaCl).

**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.

**T / F** The rate-limiting (or rate-determining) step in a reaction's mechanism is the elementary step with the largest rate constant.

**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 not permitted to lose energy by performing work.

**T / F** If a solution contains equal moles of two volatile components, the vapour above this solution will contain equal moles of the two components.

**T / F** If a reaction's products are more thermodynamically stable than its reactants, then a sample containing only these reactants will react at a very high rate to form products.

**# 2. (6 marks)** The solubility of $H_2S(g)$ in water at STP (1atm, 0°C) is 0.195 M. What mass of $H_2S$ would be dissolved in a 1.5 L solution at 0°C if the air above the solution contains 0.0055 % (by mole) $H_2S$ at a total pressure of 765 mm Hg?

**# 3. (5 marks)** Explain <u>on a molecular level</u> why it is essential that fluids used in intravenous injections have approximately the same osmotic pressure as blood. Include relevant diagrams.

**# 4. (10 marks)** Think about the gas-phase decomposition of nitrogen dioxide: $2\ NO_{2(g)} \rightarrow 2\ NO_{(g)} + O_{2(g)}$.

a) **(4 marks)** Determine the rate law (including the numerical value of the rate constant, and its units) for this reaction. Explain your reasoning.

| **Kinetics data (at 600 K) for: $2\ NO_{2(g)} \rightarrow 2\ NO_{(g)} + O_{2(g)}$** | | |
|---|---|---|
| ***Expt.*** | ***$[NO_2]_o$ (M)*** | ***Initial rate (M/s)*** |
| **1** | 0.0010 | $5.4 \times 10^{-7}$ |
| **2** | 0.0020 | $2.2 \times 10^{-6}$ |

b) **(2 marks)** Does your result from part (a) give you any insight into the mechanism of the reaction? Explain.

c) **(4 marks)** If 0.0050 mol of $NO_2$ is placed into a 1.0 L flask and allowed to decompose at 600 K, how many seconds does it take for the $NO_2$ concentration to drop to 0.0010 M? *If you could not do part (a), use a rate constant of "5.0" to solve this problem.*

**# 5. (10 marks)** Ethanol is made industrially by the hydration of ethylene: $CH_2{=}CH_2(g) + H_2O(\ell) \rightarrow CH_3CH_2OH(\ell)$

a) **(7 marks)** Is this reaction product-favoured at 25°C? Include brief explanatory comments at each step of your calculation.

| Thermodynamic data at 298 K | | |
|---|---|---|
| **Substance** | **$\Delta H^\circ_f$ (kJ/mol)** | **$S^\circ_f$ (J/mol·K)** |
| $CH_2{=}CH_2(g)$ | 52.3 | 219.5 |
| $H_2O(\ell)$ | -285.8 | 69.9 |
| $CH_3CH_2OH(\ell)$ | -277.7 | 161 |

b) **(3 marks)** Why does this reaction become non-spontaneous at high temperatures? Explain in words. Do not include calculations.

## 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, $S = k\,P$)

$P = \chi\,P^o$

$\Delta T = K\,m$

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

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

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