Chem 206 Fall 2006 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 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 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.	/ 10
Page 6.	/ 11
TOTAL:	/ 50 (max. = 51)
PERCENT:	%
EARNED toward FINAL GRADE:	/ 20

 # 1. **(__/ 5 marks) TRUE OR FALSE?** Circle T or F to describe each of these statements.

T / F During a chemical reaction that leads to an explosion, the system performs work on the surroundings.

T / F Hess's law can be used to calculate changes in thermodynamic functions that vary depending on the mechanism or path of the process.

T / F When an attractive interaction is broken, energy is released by the system.

T / F When describing a milky liquid prepared during an experiment, it is best to use the term "solution".

T / F If a single-cell organism that normally lives in the sea is placed into fresh water, the electrolyte imbalance will cause the organism to swell (expand) and die.

 # 2. **(__/ 5 marks)** Hydrogen gas reduces NO to N_2:

$$H_2(g) + 2NO(g) \rightarrow 2H_2O(g) + N_2(g)$$

The initial reaction rates for four mixtures of H_2 and NO were measured at 900°C (results shown in the table). Determine the rate law and the rate constant for the reaction at 900°C. Show your work.

Expt.	**$[H_2]_o$ (M)**	**$[NO]_o$ (M)**	**Initial rate (M/s)**
1	0.212	0.136	0.0248
2	0.212	0.272	0.0991
3	0.424	0.544	0.793
4	0.848	0.544	1.59

 # 3. **(__/ 10 marks)** A simple humidity sensor consists of a cardboard square that is blue in dry weather and red in humid weather. The colour change is due to the formation of a hydrated compound, which forms because water molecules bind to the cobalt ion via coordinate covalent bonds:

$$CoCl_2(s) + 6\ H_2O(g) \rightleftharpoons [Co(H_2O)_6]Cl_2(s) \qquad \textit{note: same as } CoCl_2\bullet 6H_2O(s)$$

a) **(4 marks)** Consider the reaction shown above. Briefly explain what causes this reaction to be:

i. Exothermic (ΔH°_{rxn} = -352 kJ·mol^{-1} at 25°C)

ii. Entropically unfavourable (ΔS° = -899 J·mol^{-1}·K^{-1} at 25°C)

b) **(6 marks)** Calculate the standard Gibbs free energy change for this reaction on a hot summer day when the temperature is 35°C. Is the reaction product-favoured at this temperature? Explain.

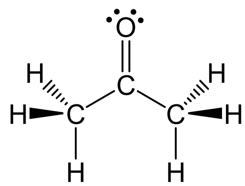
 # 4. **(__/ 10 marks)** Compare the following three aqueous solutions by completing the table below. Show calculations necessary to support your explanations, but **do not** calculate the solutions' actual melting point, osmotic pressure and vapour pressure values.

- 0.075 M zinc (II) nitrate, $Zn(NO_3)_2$
- 0.120 M glycerin, $C_3H_8O_3$
- 0.050 M lithium bromide, LiBr

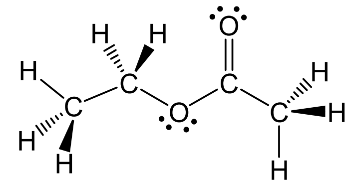
PROPERTY	**Highest melting point**	**Highest osmotic pressure**	**Highest vapour pressure**
CHOICE OF SOLUTION			
RELEVANT FORMULA			
BRIEF EXPLANATION			

 # 5. (__/ 10 marks) Acetone, C_3H_6O, and ethyl acetate, $C_4H_8O_2$, are volatile liquids often used as solvents.

acetone



ethyl acetate



a) **(4 marks)** Name <u>and describe</u> two intermolecular forces that would exist <u>between</u> acetone and ethyl acetate molecules in a mixture of the two substances. Clearly indicate which parts of each molecule would be involved for each interaction type.

b) **(6 marks)** Imagine you are using a mixture of 25.0 g acetone and 25.0 g ethyl acetate as a cleaning fluid. If this mixture behaves ideally, what would be the vapour pressure above the solution at 30°C? The pure liquids' vapour pressures at 30°C are: $P^{o}_{acetone}$ 285 mm Hg; $P^{o}_{ethyl\ acetate}$ 118 mm Hg.

 # 6. **(__/ 11 marks)** When 1.50 g of magnesium metal is allowed to react with 200. mL of 1.00 M aq. HCl in a coffee-cup calorimeter with heat capacity of 776 J/°C, the temperature rises from 25.0°C to 42.9°C:

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

a) **(8 marks)** Using the experimental data, calculate the enthalpy change (in kJ/mol Mg) for the reaction. [Assume that the density and specific heat capacity of the initial and final solutions are the same as water.]

b) **(2 marks)** Using the thermodynamic data given in the table, calculate the expected value for the standard enthalpy change for the reaction at 298 K.

Thermodynamic data for 298 K
(data from Silberberg's Chemistry)

Substance	ΔH^o_f ($kJ \cdot mol^{-1}$)	S^o_f ($J \cdot mol^{-1} \cdot K^{-1}$)
Mg(s)	0	32.69
HCl(aq)	-167.2	56.5
Mg^{2+}(aq)	-461.96	118
Cl^-(aq)	-167.46	55.10
H_2(g)	0	130.6

c) **(1 mark)** Comment on the accuracy of the experimental data (support with a calculation). Suggest one source of error in a calorimetry experiment that might have led to this difference.

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

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

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

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

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

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

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, $S = k P$)

$P = \chi P^o$

$\Delta T = K\, m$