Concordia University CHEM 206

Fall 2008, Dr. C. Rogers, Section 51

LAST NAME:

FIRST NAME:

STUDENT ID:

Chem 206 - GENERAL CHEMISTRY II

MIDTERM EXAMINATION

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

- This test includes 4 pages (both sides). Read over the whole test quickly before starting.
- Calculators are permitted; cell phones and other electronic devices are not allowed.
- Potentially useful information (look at it…) is given on back of the periodic table.
- You can remove the periodic table if you wish.
- Answer all questions in the space provided.
- You have 70 min to complete the test.

- **GOOD LUCK!**

Mark breakdown:

Page 2.	/ 10
Page 3.	/ 8
Page 4.	/ 8
Page 5.	/ 8
Page 6.	/ 10
TOTAL:	/ 43 (max. = 44)
PERCENT:	%
EARNED toward FINAL GRADE:	/ 20

 # 1. (6 marks) TRUE OR FALSE? Circle T or F to describe each of the following statements.

T / F If the reaction $2\ N_2O_{(g)} \rightarrow 2\ N_{2(g)} + O_{2(g)}$ has a constant half-life throughout an experiment, then the reaction must be first order with respect to $[N_2O]$.

T / F At higher elevations (where the atmospheric pressure is lower), the boiling point of water is below 100°C and, therefore, cooking foods in boiling water takes less time.

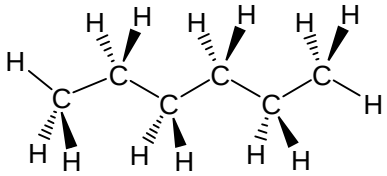
T / F A catalyst is a substance that raises the activation energy for a reaction's rate-limiting step but is not consumed, in a net sense, by the reaction.

T / F The freezing point of salt water is lower than the freezing point of fresh water.

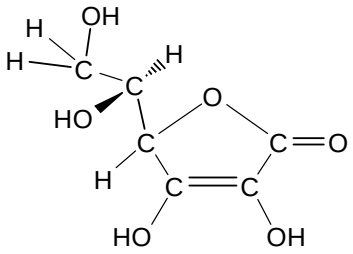
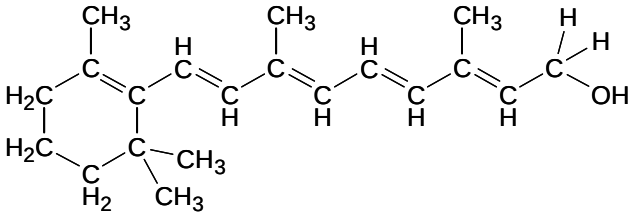
T / F If a reaction occurs by a three-step mechanism in which the slowest step is the second step, then the reaction's overall rate law should be derived from the rate law for the third step.

T / F If a solution of a gas-phase solute is warmed up, some of the gas will come out of solution.

 # 2. (4 marks) Imagine you wish to dissolve the two vitamins shown below. Based on their structures, determine which solvent (water or hexane) would be better, and for the solvent you choose, identify the strongest solute-solvent interaction. Put your answers in the table.



Hexane

Solute of interest:	**Vitamin C** 	**Vitamin A** 
Higher solubility in:	**Water** or **hexane?**	**Water** or **hexane?**
Name of strongest solute-solvent interaction:		

 # 3. (8 marks) Imagine you are stranded outside in the winter, and you eat snow to quench your thirst.

a) (6 marks) How much heat (in kJ) would your body need to supply to warm up 8.0×10^2 g of snow from an outside temperature of –12°C to normal body temperature, 37°C?

[note: $\Delta H°_{fusion}$ for solid water is 6.01 kJ/mol; other useful data is given on the formula sheet.]

b) (2 marks) If the energy required in part (a) was provided by burning fat stored in your body, what mass of fat (in pounds, **l***b*) would need to be burned? Assume that 9 Cal of energy is released per gram of fat. *[Note: if you could not answer part (a), assume 25000 kJ…which is incorrect....]*

- 1 Cal = 4.184 kJ
- 1 **l***b* = 454 g

 # 4. (8 marks) The osmotic pressure of human blood at body temperature (37°C) is 7.7 atm. If a solution containing equal concentrations of glucose ($C_6H_{12}O_6$) and sodium chloride (NaCl) is to be safely administered to a person intravenously, what must be the concentration (in molarity) of each substance?

 # 5. (8 marks) Some reactions are so rapid that they are "diffusion-controlled"; that is, the reactants react as quickly as they can collide. An example is the neutralization of H_3O^+ by OH^-, which has a second-order rate constant of 1.3×10^{11} $M^{-1}s^{-1}$ at 25°C.

$$H_3O^+(aq) + OH^-(aq) \rightarrow H_2O(\mathbf{l})$$

a) **(7 marks)** If equal volumes of 0.0020 M HCl (source of H_3O^+) and 2.0 M NaOH are mixed instantaneously, how much time is required for 99.999% of the acid to be neutralized?

NOTE (Oct.27/09): the original version of this question was flawed, and the solutions have not yet been fully corrected.

b) **(1 mark)** Under normal laboratory conditions, which do you the rate of the acid-base neutralization is limited by: (1) the rate of the reaction itself, or (2) the speed of mixing?

 # 6. (10 marks) Yeast can produce ethanol (C_2H_5OH) by the fermentation of glucose ($C_6H_{12}O_6$), which is the basis for the production of most alcoholic beverages:

$$C_6H_{12}O_6(aq) \rightarrow 2\ C_2H_5OH(\mathbf{l}) + 2\ CO_2(g)$$

Thermodynamic data at 25 °C		
Substance	**ΔH_f^o (kJ/mol)**	**S_f^o (J/mol·K)**
$C_6H_{12}O_6(aq)$	-1260.0	289
$C_2H_5OH(\mathbf{l})$	-277.0	160.7
$CO_2(g)$	-393.51	213.74

a) **(7 marks)** Is this reaction product-favoured at 25°C? Show calculations, and explain your answer briefly.

b) **(3 marks)** At higher temperatures, will this reaction reach its ultimate yield of ethanol more quickly or more slowly? Explain (hint: a diagram might help here).

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

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

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

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

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

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

$P^o_{(298\ K)} = 23.8$ 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, $S = k\ P$)

$P = \chi\ P^o$

$\Delta T = K\ m$

$\pi V = nRT$

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

$[A]_t = -k\ t + [A]_o$

$\ln[A]_t = -k\ t + \ln[A]_o$

$1/[A]_t = k\ t + 1/[A]_o$

Periodic Table of the Elements

1												13	14	15	16	17	18
1 **H** 1.008	2																2 **He** 4.00
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31	3	4	5	6	7	8	9	10	11	12	13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.61	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (97.91)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	**La-Lu**	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.2	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** 208.98	85 **At** 209.99	86 **Rn** 222.02
87 **Fr** 223	88 **Ra** 226.03	**Ac-Lr**	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)									

57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.35	63 **Eu** 151.97	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97
89 **Ac** 227.03	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (245)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

Electronegativity Values of the Elements

H 2.1																**He**
Li 1.0	**Be** 1.5											**B** 2.0	**C** 2.5	**N** 3.0	**O** 3.5	**F** 4.0	**Ne**
Na 0.9	**Mg** 1.2											**Al** 1.5	**Si** 1.8	**P** 2.1	**S** 2.5	**Cl** 3.0	**Ar**
K 0.8	**Ca** 1.0	**Sc** 1.3	**Ti** 1.5	**V** 1.6	**Cr** 1.6	**Mn** 1.5	**Fe** 1.8	**Co** 1.9	**Ni** 1.9	**Cu** 1.9	**Zn** 1.6	**Ga** 1.6	**Ge** 1.8	**As** 2.0	**Se** 2.4	**Br** 2.8	**Kr**
Rb 0.8	**Sr** 1.0	**Y** 1.2	**Zr** 1.4	**Nb** 1.6	**Mo** 1.8	**Tc** 1.9	**Ru** 2.2	**Rh** 2.2	**Pd** 2.2	**Ag** 1.9	**Cd** 1.7	**In** 1.7	**Sn** 1.8	**Sb** 1.9	**Te** 2.1	**I** 2.5	**Xe**
Cs 0.7	**Ba** 0.9	**La-Lu**	**Hf** 1.3	**Ta** 1.5	**W** 1.7	**Re** 1.9	**Os** 2.2	**Ir** 2.2	**Pt** 2.2	**Au** 2.4	**Hg** 1.9	**Tl** 1.8	**Pb** 1.9	**Bi** 1.9	**Po** 2.0	**At** 2.2	**Rn**