Concordia University CHEM 206

Fall 2009, 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.	/ 12
Page 3.	/ 9
Page 4.	/ 7
Page 5.	/ 8
Page 6.	/ 8
TOTAL:	/ 43 (max. = 44)
PERCENT:	%
EARNED toward FINAL GRADE:	/ 15

 # 1. (6 marks) CIRCLE THE CORRECT WORDS (in capitals) to make the following statements true.

a) Consider the reaction: $A \rightarrow B + C$. If $[A]_o$ is doubled and the reaction's rate quadruples, the reaction is described as being (FIRST ORDER / SECOND ORDER) with respect to reactant A.

b) When a process does not involve work, the first law of thermodynamics requires that the heat flow according to the system is equal in (SIGN / MAGNITUDE) to the heat flow according to the surroundings.

c) By comparing their Henry's law constants, k, we can see that helium gas ($k = 3.7 \times 10^{-4}$ M/atm) is (LESS SOLUBLE / MORE SOLUBLE) water at 30°C than nitrogen gas ($k = 6.0 \times 10^{-4}$ M/atm).

d) When a temperature decrease causes a solution to contract in volume, its concentration expressed in (MOLALITY / MOLARITY) can increase significantly.

e) When a car's air bag is activated during an accident, a chemical reaction occurs that rapidly produces gas. Defining this reaction as the system: work is done (BY THE SYSTEM / ON THE SYSTEM).

f) A 1.0 **m** aqueous solution of $CaCl_2$ will have a (LOWER / HIGHER) freezing point than a 1.0 **m** aqueous solution of KCl.

 # 2. (6 marks) Phosphorus trichloride (PCl_3) is more volatile than arsenic trichloride ($AsCl_3$) at 25°C.
Note: for this question, point-form explanations are acceptable.

a) Both PCl_3 and $AsCl_3$ are trigonal pyramidal molecules, and As and P have nearly identical electronegativities. So, what causes $AsCl_3$ to have stronger intermolecular forces? Explain briefly.

b) Define *vapour pressure*. Which substance has the higher vapour pressure at 25°C? Explain briefly.

c) Define *normal boiling point*. Which substance has the higher boiling point? Explain your choice.

 # 3. (9 marks) The reaction used by Joseph Priestley to prepare (and discover!) elemental oxygen was:

$$2\ HgO(s) \rightarrow 2\ Hg(l) + O_2(g)$$

Thermodynamic data at 298 K		
Substance	**ΔH_f^o (kJ/mol)**	**S_f^o (J/mol·K)**
$HgO(s)$	-90.83	70.29
$Hg(l)$	0	76.02
$O_2(g)$	0	205.07

a) **(6 marks)** Is this reaction thermodynamically favourable at 298 K? Include full calculations and brief comments about the meaning of each quantity you calculate.

b) **(1 mark)** Is the reaction driven by enthalpy, by entropy, or by neither?

c) **(2 marks)** Did Mr. Priestley need to heat up or cool down his reaction mixture in order to obtain a high yield of oxygen gas? Explain. *Assume the values of ΔH_{rxn} & ΔS_{rxn} are unaffected by temperature changes.*

 # 4. (7 marks) Sucrose ($C_{12}H_{22}O_{11}$), commonly known as table sugar, breaks down in dilute acid solution into two simpler sugars, glucose and fructose (each with formula $C_6H_{12}O_6$):

$$C_{12}H_{22}O_{11}(aq) + H_2O(\mathbf{l}) \rightarrow 2\ C_6H_{12}O_6(aq)$$

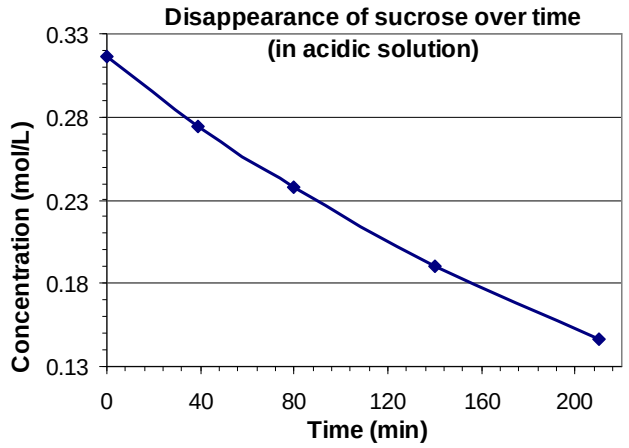
The data in the first graph were collected for the disappearance of sucrose in 0.50 M aqueous HCl at 23°C. To analyze the reaction kinetics, the other two graphs were plotted and fitted to linear trends (see equations).

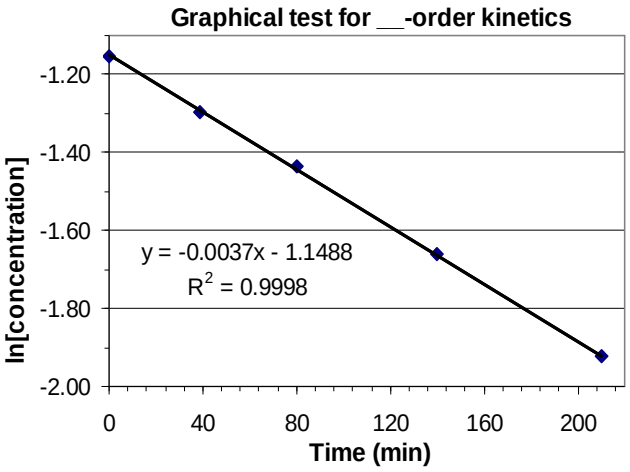
a) **(1 mark)** What is the order of the reaction with respect to sucrose? How did you decide?

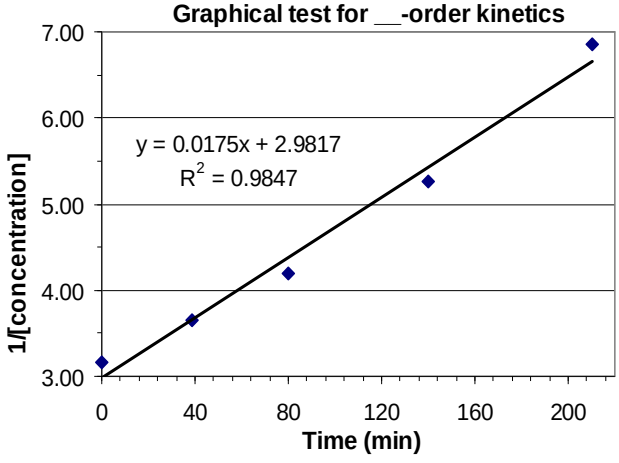
b) **(1 mark)** What is the value of the rate constant?

c) **(5 marks)** How long will it take for 75% of the sucrose in a 0.075 M acidic sucrose solution to be broken down into glucose and fructose? *If you could not solve parts a-b, use the following assumptions (possibly wrong…): 1st order, $k = 5\ s^{-1}$.*

Check the numbers!







 # 5. (8 marks) Imagine you are working in a lab that studies the active ingredients in herbal medicines. You take 53.0 mg of an electrolyte (previously determined to have **i** = 2) isolated from throat lozenges and dissolve it in enough water to make 10.0 mL of solution. The osmotic pressure of the resulting solution at 25°C was 1034 mm Hg. **What is the molar mass of this compound?**

Provide full calculations and brief explanatory comments.

 # 6. (8 marks) Chlorofluorocarbons (CFCs, tradename *freon*) have long been used as heat transfer fluids in air conditioners, but they will be banned as of 2010 because they are known to damage the ozone layer. However, if your air conditioner is more than 10 years old, it may contain the chlorofluorocarbon CCl_2F_2.

Data for CCl_2F_2: boiling point b.p. = -29.8°C

heat of vaporization $\Delta H°_{vap}$ = +20.11 kJ/mol

molal heat capacity C_m = 117.2 J/mol·K for CCl_2F_2(g) & 72.3 J/mol·K for CCl_2F_2(**l**).

How much heat is absorbed when 20.0 g of CCl_2F_2 is warmed from -35°C to +35°C?

Provide full calculations with brief explanatory comments at each step.

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**