CHEM 1515.001
Exam II
John II. Gelder
October 17, 2001

Name ______________________

TA's Name ______________________

Lab Section _______

INSTRUCTIONS:

1. This examination consists of a total of 7 different pages. The last two pages include a periodic table, some useful mathematical equations and a solubility table. All work should be done in this booklet.
2. PRINT your name, TA's name and your lab section number now in the space at the top of this sheet. DO NOT SEPARATE THESE PAGES.
3. Answer all questions that you can and whenever called for show your work clearly. Your method of solving problems should pattern the approach used in lecture. You do not have to show your work for the multiple choice or short answer questions.
4. No credit will be awarded if your work is not shown in problems 4a, 4c, 4d, 5, 7 and 8.
5. Point values are shown next to the problem number.
6. Budget your time for each of the questions. Some problems may have a low point value yet be very challenging. If you do not recognize the solution to a question quickly, skip it, and return to the question after completing the easier problems.
7. Look through the exam before beginning; plan your work; then begin.
8. Relax and do well.

	Page 2	Page 3	Page 4	Page 5	TOTAL
SCORES	____ (32)	____ (31)	____ (18)	____ (18)	____ (100)

(9) 1. Write the chemical formula(s) of the product(s) and balance the following reactions. Identify all products phases as either (g)as, (l)iquid, (s)olid or (aq)ueous. Soluble ionic compounds should be written in the form of their component ions.

a) $H_2SO_4(aq)$ + $2KOH(aq))$ $\rightarrow$ $\mathbf{2H_2O(l) + 2K^+(aq) + SO_4^{2-}(aq)}$

b) $Na_2S(aq)$ + $Al(NO_3)_3(aq)$ $\rightarrow$ $\mathbf{Al_2S_3(s) + 6Na^+(aq) + 6NO_3^-(aq)}$

c) $2C_6H_{14}(l)$ + $19O_2(g)$ $\rightarrow$ $\mathbf{12CO_2(g) + 14H_2O(l)}$

(4) 2. Write the ionic and net ionic chemical equations for 1a).

1a)

Ionic equation:

$$\mathbf{2H^+(aq) + SO_4^{2-}(aq) + 2K^+(aq) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2K^+(aq) + SO_4^{2-}(aq)}$$

Net Ionic equation:

$$\mathbf{2H^+(aq) + 2OH^-(aq) \rightarrow 2H_2O(l)}$$

(18) 6. The half-life for the rearrangement reaction

$$CH_3NC(g) \rightarrow CH_3NC(g)$$

is 230 seconds at 250 ˚C. The reaction follows first order kinetics.

a) If the initial concentration of the reactant, methyl isonitrile, is 0.0485 M, calculate its concentration after 100 seconds.

$$\mathbf{k = \frac{0.693}{t_{1/2}} = \frac{0.693}{230\ s} = 3.01 \times 10^{-3}\ s^{-1}}$$

$$\mathbf{\ln \frac{[CH_3NC]}{[CH_3NC]_0} = -kt}$$

$$\mathbf{\ln \frac{[CH_3NC]}{[0.0485\ M]_0} = -3.01 \times 10^{-3}\ s^{-1}\ (100\ s)}$$

$$\mathbf{\ln \frac{[CH_3NC]}{[0.0485\ M]_0} = -0.301}$$

take the exp() of each side

$$\mathbf{e^{(\ln \frac{[CH_3NC]}{[0.0485\ M]_0})} = e^{-0.301}}$$

$$\mathbf{\frac{[CH_3NC]}{[0.0485\ M]_0} = 0.740}$$

$$\mathbf{[CH_3NC] = 0.0359\ M}$$

b) what fraction of methyl isonitrile remains after 400 seconds?

$$\mathbf{\ln \frac{[CH_3NC]}{[CH_3NC]_0} = -kt = -3.01 \times 10^{-3}\ s^{-1}\ (400\ s) = -1.20}$$

$$\mathbf{e^{\ln \frac{[CH_3NC]}{[CH_3NC]_0}} = e^{-1.20}}$$

$$\mathbf{\frac{[CH_3NC]}{[CH_3NC]_0} = 0.30}$$

c) At 450 ˚C the half-life of the reaction is 140 seconds. Calculate the rate constant at this temperature?

$$\mathbf{k = \frac{0.693}{t_{1/2}} = \frac{0.693}{140\ s} = 4.95 \times 10^{-3}\ s^{-1}}$$

(19) 4. A solution of magnesium chloride, $MgCl_2$, is prepared by dissolving 19.0 g of magnesium chloride in 250 mL of water.

a) calculate the weight percent of magnesium nitrate in the solution;

$$\mathbf{\frac{19.0\ g\ MgCl_2}{250\ g\ H_2O + 19.0\ g\ MgCl_2} \times 100 = 7.06\ \%}$$

b) the solution described above has a density of 1.05 g mL^{-1}. Calculate the molarity of the magnesium chloride in the solution;

$$\mathbf{269\ g\ solution \left(\frac{1\ mL\ solution}{1.05\ g\ solution}\right) = 256\ mL\ solution}$$

$$\mathbf{19.0\ g\ MgCl_2 \left(\frac{1\ mol\ MgCl_2}{95.2\ g\ MgCl_2}\right) = 0.200\ mol\ MgCl_2}$$

$$\mathbf{\frac{0.200\ mol\ MgCl_2}{0.256\ L\ solution} = 0.780\ M}$$

c) calculate the ideal freezing point of the solution;

$$\mathbf{\frac{0.200\ mol\ MgCl_2}{0.250\ kG\ solvent} = 0.800\ molal}$$

$$\mathbf{\Delta T_f = \mathit{i} k_f m}$$
$$\mathbf{= 3\ (1.86 \frac{^\circ C}{m})\ (0.800\ molal)}$$
$$\mathbf{= 4.46\ ^\circ C}$$
$$\mathbf{T_f = -4.46\ ^\circ C}$$

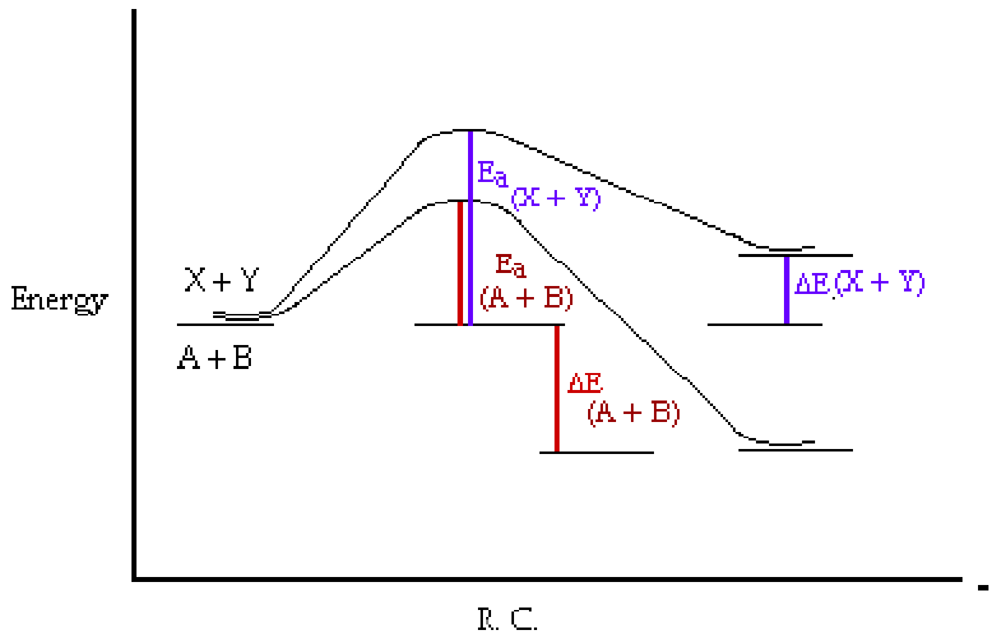
d) would you expect the experimental freezing point to be more negative, less negative than the ideal freezing point? Briefly explain the basis of your prediction.

Experimental freezing point would be less negative due to ion-pairing. At high concentrations of solute, the solvent can not hydrate the solute ions effectively. Some ions pair to reduce the apparent number of particles and the freezing point is not as low as predicted ideally.

(31) 5.

$$A(g) + B(g) \rightarrow AB(g)$$
$$X(g) + Y(g) \rightarrow XY(g);$$

Two reactions are represent above. The potential energy diagram for the first reaction is shown below. The energy of the reactants for the second reaction is the same as the energy of the reactant for the first equation. The reaction between X and Y is endothermic and the activation energy for the reaction between X and Y is lower than that of the reaction between A and B.



a) Complete the potential energy diagram for the reaction between X and Y in the diagram above.

b) How is the rate of the reaction between A and B affected as the temperature is increased by 20 ˚C? Explain the basis of your prediction.

The rate of the reaction will increase with increasing temperature. At a higher temperature a greater fraction of particles have an energy that exceeds the activation energy.

c) Write the general rate law for the reaction between X and Y. write an expression for the rate of the reaction in terms of one of the reactants.

rate = k[X]^m[y]^n

$$\text{rate} = -\frac{\Delta[X]}{\Delta t} \text{ or } -\frac{\Delta[Y]}{\Delta t}$$

5. (CONTINUED)

d) Briefly describe an experiment(s) that can be conducted to determine the order of the reaction for both X and Y.

Measure the initial rate of different initial concentrations of reactants, according to the table below;

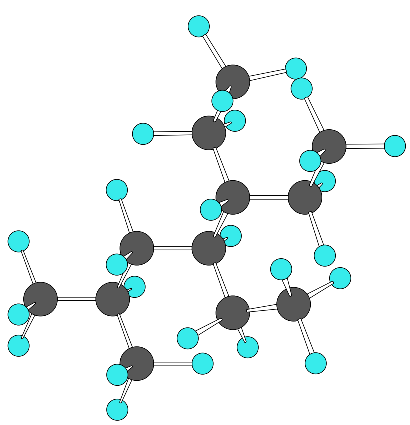
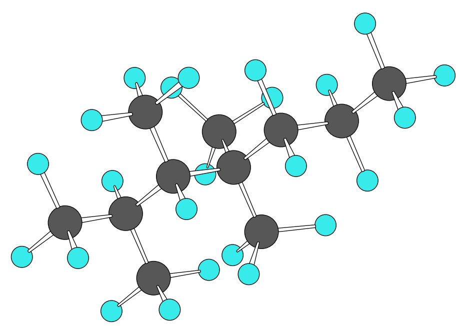
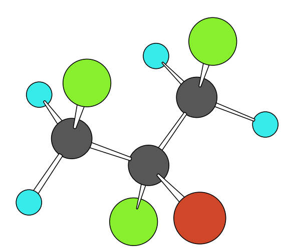
Experiment	[X]	[Y]	Initial Rate (M time^{-1})
1	**0.100 M**	**0.100 M**	**x**
2	**0.200 M**	**0.100 M**	**2x**
3	**0.100 M**	**0.200 M**	**2x**

By taking ratios of concentration of X and the ratio of the initial rates for experiments 1 and 2 the order of the reaction with respect to X can be determined. The order of the reaction with respect to Y can be determined by taking the ratio of the concentration of Y and the initial rates for experiments 2 and 3.

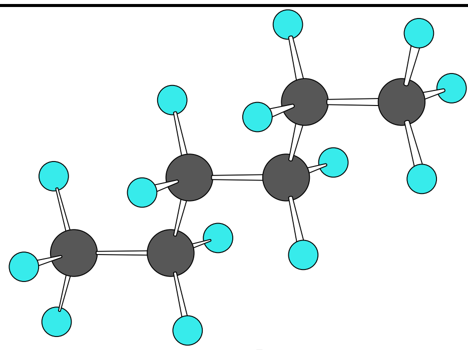
e) From the information given, which reaction initially proceeds at the faster rate under the same conditions of concentration and temperature. Justify your answer

The reaction A + B will proceed at the faster rate. This reaction has the lower activation energy. The lower the activation energy the greater the fraction of particles with energy (in a collision) that exceeds the activation energy with an increase in temperature.

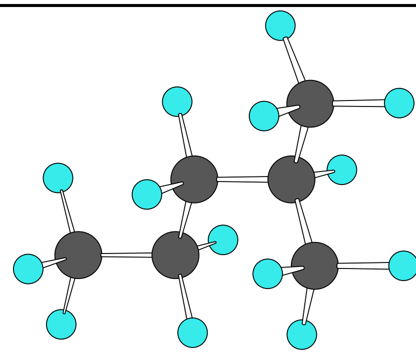
(6) 6. Give the name or draw the Lewis structure for each of the following compounds.

 **2-methyl-4,5-diethylheptane**	2,3,4,4-tetramethylheptane 	1,2,3-trichloro-2-bromopropane 

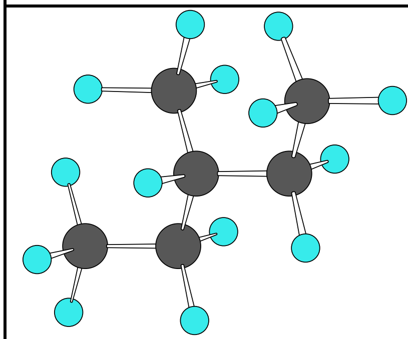
(12) 7. Draw and name all of the structural isomers for C_6H_{14}.



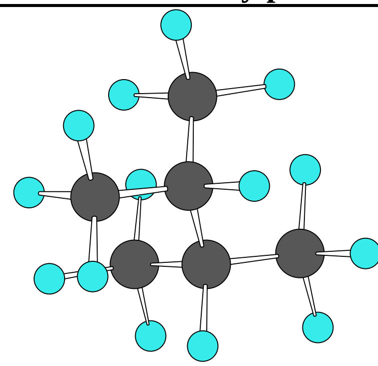
***n*-hexane**



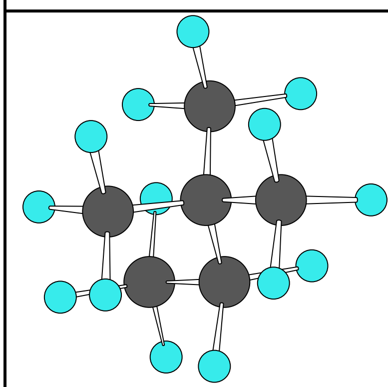
2-methylpentane



3-methylpentane



2,3-dimethylbutane



2,2-dimethylbutane

(6) 7. The rate law for the reaction;

$$NO_2(g) + CO(g) \rightarrow NO(g) + CO_2(g)$$

is rate = $k[NO_2]^2$. Suggest a mechanism for the reaction.

Step 1 : $\mathbf{NO_2(g) + NO_2(g) \rightarrow NO(g) + NO_3(g)}$ **(slow)**

Step 2 : $\mathbf{NO_3(g) + CO(g) \rightarrow NO_2(g) + CO_2(g)}$ **(fast)**

$$\mathbf{NO_2(g) + CO(g) \rightarrow NO(g) + CO_2(g)}$$

Periodic Table of the Elements

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII	VIII	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1 **H** 1.008																	2 **He** 4.00
2	3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
3	11 **Na** 22.99	12 **Mg** 24.30											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
4	19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	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** 65.38	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
5	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** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
6	55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** 226.0	89 **Ac** 227.0	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)									

Lanthanides	58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.2	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
Actinides	90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** 237.0	94 **Pu** (244)	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)

Useful Information

$\Delta T = ikm$ $\qquad k_f(H_2O) = 1.86\ \frac{^\circ C}{m}$ $\qquad k_b(H_2O) = 0.512\ \frac{^\circ C}{m}$

$R = 0.0821\ \frac{L\cdot atm}{mol\cdot K} = 8.314\ \frac{J}{mol\cdot K}$

$P_{solution} = \chi_{solvent}\, P^\circ_{solvent}$

density of $H_2O = 1.00\ \frac{g}{cm^3}$ $\qquad 6.023 \times 10^{23}$

$$\ln\left(\frac{k_1}{k_2}\right) = \frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$\ln\left(\frac{[A]_t}{[A]_o}\right) = -kt \qquad \frac{1}{[A]_t} - \frac{1}{[A]_o} = kt$$

6.023×10^{23}

Solubility Table

Ion	Solubility	Exceptions
NO_3^-	soluble	none
ClO_4^-	soluble	none
Cl^-	soluble	except Ag^+, Hg_2^{2+}, *Pb^{2+}
I^-	soluble	except Ag^+, Hg_2^{2+}, Pb^{2+}
SO_4^{2-}	soluble	except Ca^{2+}, Ba^{2+}, Sr^{2+}, Hg^{2+}, Pb^{2+}, Ag^+
CO_3^{2-}	insoluble	except Group IA and NH_4^+
PO_4^{3-}	insoluble	except Group IA and NH_4^+
^-OH	insoluble	except Group IA, *Ca^{2+}, Ba^{2+}, Sr^{2+}
S^{2-}	insoluble	except Group IA, IIA and NH_4^+
Na^+	soluble	none
NH_4^+	soluble	none
K^+	soluble	none

*slightly soluble

(14) 5. Molecules of butadiene, C_4H_6, are known to "dimerize" according to the equation

$$2C_4H_6(g) \rightarrow C_8H_{12}(g)$$

This dimerization reaction is second order and the rate constant has a value of 0.0140 $M^{-1} \cdot s^{-1}$ at 500 ˚C.

a) Calculate the concentration of C_4H_6 after 45.0 seconds if the initial concentration of C_4H_6 is 0.0250 M.

b) Calculate the half-life for the reaction when the initial concentration of C_4H_6 is 0.0250 M.