Homework Set 2 – Chemistry 633 – Spring 2012

Put answers on the blank lines where provided. Attach enough work to show that you understand what you are doing and how you arrived at the answer. A few lines and/or calculations or spreadsheet may be sufficient. Where asked for, attach graphs and/or sections of a spread sheet. Attach work with a new problem starting on a new page using one side of the paper only. Present neat and organized work.

1. The half-life of a radioisotope is found to be 4.55 minutes. Radioactive decay follows is a first order process. What percentage of isotope remains after 10 minutes and after 2.00 hours?

% remaining after 10 min ______________________________

% remaining after 2 hours ______________________________

2. For the reaction A + B → C, the rate constant at 215 ^oC is 5.0 x 10^{-3} sec^{-1} and at 452^o C it is 1.2 x $10^{-1}$$sec^{-1}$.

a) What is the activation energy in kJ/mol? ____

b) What is the rate constant at 100 ^oC. ______________________________________

3. Given the following experimental data, find the rate law and the rate constant for the reaction:

$NO (g) + NO_2 (g) + O_2 (g) \rightarrow N_2O_5 (g)$

Run	$[NO]_o$, M	$[NO_2[_o$, M	$[O_2]_o$, M	Initial Rate, Ms^{-1}
1	0.10 M	0.10 M	0.10 M	2.1 x 10^{-2}
2	0.20 M	0.10 M	0.10 M	4.2 x 10^{-2}
3	0.20 M	0.30 M	0.20 M	1.26 x 10^{-1}
4	0.10 M	0.10 M	0.20 M	2.1 x 10^{-2}

Rate Equation ____________________________________

Rate Constant with units _________________________

4. Oxygen gas O_2 has an effective collision diameter of 0.30 nm. Calculate the number of binary (between two oxygen molecules) collisions per cm^3 per second in a container of oxygen gas at 25 C (298 K) at a pressure of 1.0 atm (~10^5 N m^{-2}).

Collisions per cubic centimeter per second ____________

5. A chip of wood from an Egyptian tomb showed ^{14}C radioactivity at a rate of 7.3 counts per minute per gram. The half-life of the radioactive isotope mass number 14 of carbon is 5730 years. A piece of wood taken from a currently living tree showed radiation from 14C at a rate of 12.6 counts per minute per gram of wood. How old is the wood taken from this tomb?

Age in years = _____________________

6.

In a sequence of experiments on the unimolecular thermal decomposition of methyltertbutylether (MTBE) to methanol plus isobutene on microsecond time scales, my former graduate students Zhen Liu and Vi-Dat Tu obtained the following data. The scatter in the data is inherent in the technique used, and should not be taken to indicate that the students did a bad job of making the measurements:

T (°C)	674	693	784	822	841	935	940	949	950	965	1001	1004
k (s^{-1})	1.74	2.19	13.9	17.8	32.8	1188	594	1449	1276	1598	2157	502

Determine the activation energy and pre-exponential factor for this reaction from the data. Does this reaction obey the Arrhenius equation? Predict the rate coefficient at 1500 °C. How much does the predicted rate coefficient at 1500 °C change if the activation energy is increased or decreased by 5%?

Attach an appropriate graph generated by Excel (or its equivalent like QuatroPro or MathCad)

Activation Energy (specify units) __________________

Pre-exponential term (specify units) ________________

What is rate constant k at 1500 ^{o}C (with units) ______________

What is k at 1500 ^{o}C if activation energy is increased by 5% _______________

7. The following time vs concentration of reactant data was taken for the reaction A → B. What is the reaction order and rate constant (with units) for this reaction? Include three well drawn (Excel or QuatroPro, or ?) and properly printed graphs, (1) conc vs. time, (2) ln conc vs time and (3) reciprocal concentration vs. time.

time (sec)	0.00	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200.00
conc (M)	2.000	1.516	1.149	0.871	0.660	0.500	0.379	0.287	0.218	0.165	0.125

reaction order=_____________ rate constant with units = ___________________

8. Daniels and Johnston {JACS 43,53,(1921)} measured the rate of decomposition of N_2O_5 at several temperatures. What is the activation energy and the Arrhenius pre-exponential value for this process (in proper units)? $\mathbf{N_2O_5 = 2NO_2 + \frac{1}{2} O_2}$ Attach appropriate graphs supporting your answer.

Temp (K)	273	298	308	318	328	338
rate const (1/s)	7.87E-07	3.46E-05	1.35E-04	4.98E-04	1.50E-03	4.87E-03

Activation energy (with units) ________

Pre-exponential term (with units)__________