Chemistry 150 Name:

Exercise 7: Rates, rate laws and mechanisms

1. In the reaction $2\ NO + Cl_2 \rightarrow 2\ NOCl$, the reactants and the products are gases at the temperature of the reaction. The following rate data were measured for the three experiments:

Initial P_{NO}	Initial P_{Cl}	Initial rate
0.50 atm	0.50 atm	5.1×10^{-3} atm/sec
1.00	1.00	4.0×10^{-2}
0.50	1.00	1.0×10^{-2}

a. From these data, write the rate equation for this gas reaction. What order is the reaction in NO, in Cl_2, and overall?

b. Calculate the specific rate constant for this reaction.

2. Assume that a reaction proceeds with some given rate constant, k, and an activation energy of 176 kJ/mol (fairly typical for gas reactions) at 25°C. Using the Arrhenius equation, calculate the temperature at which the rate constant will be double what it was at 25°C (that is, at what T will the rate constant be 2k)?

3. One of the problems in decommissioning obsolete nuclear reactors is the lingering radioactivity in structural materials induced by neutron bombardment during the life of the reactor. This problem of radioisotope formation during operation was largely overlooked by the nuclear industry until the late 1970's. Specifically, concern centered around the radioisotope niobium-94, whose half life is 20,300 years. In the late 1970's, niobium-94 contaminated materials were placed in storage units with a predicted lifetime of 500 years. How much of the original niobium-94 will remain when the storage units break down? (To be fair to the nuclear industry, it designed these units to hold the more intensely radioactive but much shorter half lived cobalt-60). Hint: recall that all radioactive decays follow a first-order rate law.

4. For the reaction 2 NH_3 (g) → N_2 (g) + 3 H_2 (g), the following information is known about the activation energies:

Catalyst	None	W (tungsten)	Os (osmium)
Activation energy (kJ/mol)	335	163	197

a. If you want this reaction to go fast, should you use a catalyst? If so, which one, and why?

b. How many times faster is the reaction when tungsten catalyst is used compared to no catalyst? Assume T = 298K.

c. As the temperature increases, will the catalyst be equally effective, or will it lose or gain effectiveness? Show this in a semi-quantitative way.

d. The rate law for this reaction is: $rate = k\frac{[NH_3]}{[H_2]}$. Give a reason why this reaction rate is inverse in H_2.