Assignment # 2  
Due Date Monday Sept. 20, 2010

1. The USA conducted numerous nuclear tests in the Marshall Islands in the 1940-1950s. The concentration of radioactive cesium ($^{137}$Cs) in the island air in 1946 was determined to be 120,000 Bq/L (Bq=Bequerel a measure of radioactivity). The half life of $^{137}$Cs is known to be 30 years. The acceptable levels of cesium for human exposure is $1.3 \times 10^{-7}$ Bq/L. How long (in years) will it take for the $^{137}$Cs levels in the Marshall Islands to reach acceptable levels?

$$30 = \ln 2/k \quad \text{or} \quad k = 0.0231 \text{ yr}^{-1}$$

$$\ln \frac{1.3 \times 10^{-7}}{120,000} = -0.0231 \text{ yr}^{-1} \times t \quad \text{or} \quad t = 1,192.683 \text{ years}$$

2. The pesticide, parathion, undergoes photolytic degradation (destruction by absorption of energy from the sun's rays) in natural waters. This is a first order process with a rate constant of $8 \times 10^{-7} \text{s}^{-1}$.

a) What is the half-life in days for parathion based on this degradation process?

$$\text{Half life} = \frac{0.693}{k} = \frac{0.693}{8 \times 10^{-7} \text{s}^{-1}} = 866,250 \text{ seconds} = 866250/60*60*24 = 10.02 \text{ days}$$

b) How long in days will it take for 90% of the parathion to degrade?

$$\ln \frac{100-90}{100} = -8 \times 10^{-7} \text{s}^{-1} \times t \quad \text{or} \quad t = 287,823 \text{ seconds} = 33.3 \text{ days}$$

3. What is the reaction rate in min$^{-1}$ for a first order reaction if 99.999% of bacteria need to be removed by disinfection in 10 minutes?

$$\ln \frac{100-99.999}{100} = -k \times 10 \quad \text{or} \quad k = 1.15 \text{ min}^{-1}$$
4. Derive an expression for a second order reaction for removal of a pollutant C in time t with a reaction rate of k. Show how you would plot the data to determine the reaction rate and indicate the reaction rate units.

\[ \frac{dc}{dt} = -kC^2 \]

or \[ \int_{c_0}^{c} C^{-2} \, dC = -k \int_{0}^{t} dt \]

or \[ \frac{1}{c} = \frac{1}{c_0} - kt \]

Plot 1/C on Y axis versus time on x axis to get line.
Slope = k

Reaction rate units = Volume/Mass*Time