

Integrated Rate Laws: $\ln [A] = -kt + \ln[A]_0$

$$1/[A] = kt + 1/[A]_0$$

First-order Half-life: $k = 0.693/t_{1/2}$

$$k = Ae^{-(E_a/RT)} \quad \ln [k_1/k_2] = E_a/R [1/T_2 - 1/T_1] \quad R = 8.314 \text{ J/mol-K}$$

1. The first-order decay of radon has a half-life of 3.823 days. How many grams of radon remain after 8.50 days if the sample initially weighs 250.0 grams? Show your work. (10 pts)

$$\ln [A] = -kt + \ln [A]_0 \quad k = \frac{0.693}{3.823 \text{ days}} = 1.813 \times 10^{-1} \text{ d}^{-1}$$

$$\ln [A] = -(1.813 \times 10^{-1} \text{ d}^{-1})(8.50 \text{ d}) + \ln [250.0]$$
$$= -1.541 + 5.5216 = 3.980$$

$$[A] = e^{3.980} = 53.5 \text{ grams}$$

2. How does the presence of a catalyst affect the activation energy of a reaction? (Circle your choice.) (8 pts)

- a) A catalyst increases the activation energy of a reaction.
- b) A catalyst decreases the activation energy of a reaction.
- c) A catalyst does not affect the activation energy of a reaction.
- d) It depends on whether you are talking about the forward or the reverse reaction.

3. The first-order rearrangement of CH_3NC is measured to have a rate constant of $3.61 \times 10^{-15} \text{ s}^{-1}$ at 298 K and a rate constant of $8.66 \times 10^{-7} \text{ s}^{-1}$ at 425 K. Determine the activation energy for this reaction. Show your work. (8 pts)

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

$$\ln \frac{3.61 \times 10^{-15} \text{ s}^{-1}}{8.66 \times 10^{-7} \text{ s}^{-1}} = \frac{E_a}{8.314 \text{ J/mol}\cdot\text{K}} \left[\frac{1}{425 \text{ K}} - \frac{1}{298 \text{ K}} \right]$$

$$\ln(4.17 \times 10^{-9}) = \frac{E_a}{8.314 \text{ J/mol}\cdot\text{K}} \left[2.35 \times 10^{-3} - 3.36 \times 10^{-3} \right]$$

$$-19.30 \qquad \qquad \qquad -1.006 \times 10^{-3} \text{ K}^{-1}$$

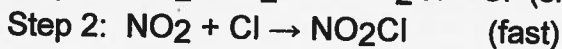
$$\cancel{(-19.30)} \cancel{(-1.006 \times 10^{-3} \text{ K}^{-1})} = E_a$$

$$\frac{-19.30 (8.314 \text{ J/mol}\cdot\text{K})}{-1.006 \times 10^{-3} \text{ K}^{-1}} = 1.60 \times 10^5 \frac{\text{J}}{\text{mol}} = 160. \frac{\text{kJ}}{\text{mol}}$$

4. Given the following proposed mechanism, predict the rate law for the overall reaction. (8 pts)



Mechanism



- a) Rate = $k[\text{NO}_2][\text{Cl}_2]$
- b) Rate = $k[\text{NO}_2]^2[\text{Cl}_2]$
- c) Rate = $k[\text{NO}_2][\text{Cl}]$
- d) Rate = $k[\text{NO}_2\text{Cl}][\text{Cl}]$
- e) Rate = $k[\text{NO}_2\text{Cl}]^2$

5. In the reaction mechanism provided in question 4, Cl is: (circle your choice) (6 pts)

- a) a catalyst
- b) a reaction intermediate
- c) a reaction inhibitor
- d) a reaction product
- e) a reaction accelerator