

$$\text{rate} = k \quad \text{rate} = k[A] \quad \text{rate} = k[A]^2 \quad [A]_t = -kt + [A]_0 \quad \ln[A]_t = -kt + \ln[A]_0 \quad R = 8.314 \text{ J}/(\text{mol}\cdot\text{K})$$

$$1/[A]_t = kt + 1/[A]_0 \quad t_{1/2} = [A]_0/2k \quad t_{1/2} = 0.693/k \quad t_{1/2} = 1/k[A]_0 \quad \ln \frac{k_1}{k_2} = \frac{E_a}{R} \left(\frac{1}{T_2} - \frac{1}{T_1} \right) \quad e=mc^2$$

1.(2 Pts) What is the overall order of the reaction is 2nd

$\text{CO}(\text{g}) + \text{NO}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + \text{NO}(\text{g})$ if it proceeds via the following rate expression?

$$\frac{\Delta[\text{CO}_2]}{\Delta t} = k[\text{CO}][\text{NO}_2]$$

2.(6 Pts) Calculate the activation energy, E_a for $\text{N}_2\text{O}_5(\text{g}) \rightarrow 2 \text{NO}_2(\text{g}) + 1/2 \text{O}_2(\text{g})$

given k (at 25°C) = $3.46 \times 10^{-5} \text{ s}^{-1}$ and k (at 35°C) = $1.48 \times 10^{-4} \text{ s}^{-1}$.

$$\ln \frac{3.46 \times 10^{-5}}{1.48 \times 10^{-4}} = \frac{E_a}{8.314} \left(\frac{1}{308} - \frac{1}{298} \right)$$

$$E_a = 111 \frac{\text{kJ}}{\text{mol}}$$

3.(6 Pts) For a given reaction, the activation energy is 19.0 kJ/mol . If the reaction rate constant is $8.30 \times 10^{-3} \text{ M}^{-1}\text{s}^{-1}$ at 298 K , what is the reaction rate constant at 348 K ?

$$\ln \frac{k_2}{8.30 \times 10^{-3}} = \frac{19.0 \times 10^3 \text{ J/mol}}{8.314 \text{ J/mol}} \left(\frac{1}{298} - \frac{1}{348} \right)$$

$$\ln \frac{k_2}{8.30 \times 10^{-3}} = 1.1018 \dots$$

$$\frac{k_2}{8.30 \times 10^{-3}} = e^{1.1018 \dots}$$

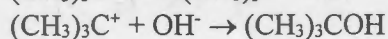
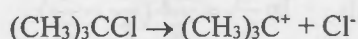
$$k_2 = 2.50 \times 10^{-2} \text{ M}^{-1}\text{s}^{-1}$$

Key

4.(5 Pts) In basic solution, $(\text{CH}_3)_3\text{CCl}$ reacts according to the equation below.



The accepted mechanism for the reaction is



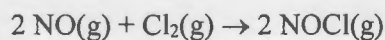
(slow)

(fast)

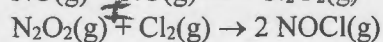
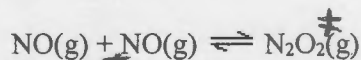
What is the rate law for the reaction?

$$\text{rate} = k [(\text{CH}_3)_3\text{CCl}]$$

5.(6 Pts) Nitrogen monoxide reacts with chlorine to produce NOCl.



A proposed mechanism for this reaction is



(fast, equilibrium)

(slow)

What is a rate law that is consistent with this mechanism?

from slow: $\text{rate} = k_2 [\text{N}_2\text{O}_2^{\ddagger}] [\text{Cl}_2]$

from fast: $k_1 [\text{NO}]^2 = k_{-1} [\text{N}_2\text{O}_2^{\ddagger}]$

so: $\frac{k_1}{k_{-1}} [\text{NO}]^2 = [\text{N}_2\text{O}_2^{\ddagger}]$

Substitution for the intermediate in slow rate law gives

$$\text{rate} = \frac{k_2 k_1}{k_{-1}} [\text{NO}]^2 [\text{Cl}_2]$$