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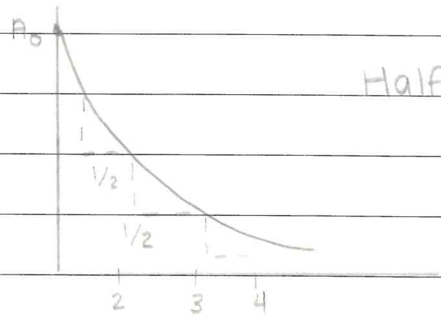
## vi. Half Lifes

1. Half life: the amount of time it takes for 1/2 of a reactant to be used up in the reaction
   - a. After 10 half lives, material is considered 'gone'
   - b. After one 1/2 life: $\frac{[A_t]}{[A_0]} = 1/2$
2. Integrated rate law: $\ln\frac{[A_t]}{[A_0]} = -kt$, so for half life: $\ln(1/2) = -kt_{1/2} \rightarrow$

   solve: $-0.693 = -kt_{1/2}$ or $t_{1/2} = \frac{0.693}{k}$
   - a. Half lives are constant if first order




Half-life graph if first order

3. Smedley example: $\ln[A_{10}] = \ln(250mg) - (.116h^{-1} \cdot 10h) \rightarrow [A]_{10} = 78mg$
4. Second Order Half Lives
   - a. Using integrated rate law: $\frac{1}{[A]_t} = \frac{1}{[A]_0} + kt \rightarrow t_{1/2} = \frac{1}{k[A_0]}$

## vii. Collision Theory

1. Collision theory explains why concentration affects rate
   - a. Higher concentration means more molecules collide
2. It also explains why temperature affects rate
   - a. more energy means more collisions & reactions need sufficient energy

3. Typically if temperature increases by 10°C, then reaction rate doubles

viii Activation Energy

1. At higher temperatures, there is a larger fraction of moles at higher energy states

2. Arrhenius, "molecules have to collide in proper orientation"

a. Arrhenius equation: incorporates effects of temperature, orientation, and frequency

i. $k = A e^{-Ea/Rt}$

$A$: frequency factor, reaction specific

ii. Graphically, $\ln k = -Ea/Rt + \ln a$, which gives a linear line

b. Example: for a given reaction, $E_a = -51$ kJ/mol. What is the value of k at 310K if k is 7.1 $m^{-1}s^{-1}$ at 320K?

i. $\frac{\Delta y}{\Delta x} = \frac{\ln k_2 - \ln k_1}{1/T_2 - 1/T_1} = \frac{\ln k_2 - \ln(7.1)}{1/310K - 1/320K} = -(51{,}000 J/mol)/8.314 J/molK)$

set equal & solve k

$k_2 = 3.8\ m^{-1}s^{-1}$

c. Example 2: $Mn(CO)_5(CH_3CN)^+ + NC_5H_5 \rightarrow Mn(CO_5)(NC_5H_5)^+ + CH_3CN$

i.

| $k\ (min^{-1})$ | $T\ (k)$ |
|---|---|
| 0.0409 | 298 |
| 0.0818 | 308 |

$\rightarrow \ln k = \ln A - \frac{Ea}{R} \cdot \frac{1}{T}$ ; $E_a = -\frac{R\Delta y}{\Delta x} \rightarrow \frac{\ln(.0409)}{1/308 - 1/298} \cdot -R$

$= 53$ kJ/mol