16.2 Activation Energy

* remember K is temp dependent (general measure of rate at particular temp)

↑T, ↑rate but rate = K[ ]#

↑ ↑ temp does not effect [ ]

∴ temp affects K

temp dependence of K depends on value of Ea

b/c higher Ea, ↑T, ↑# of particles colliding
low Ea, same ↑T, fewer particles affected

Arrhenius equation → temp dependence of K

$K = Ae^{-Ea/RT}$

K = rate constant

A = Arrhenius constant :
· frequency factor / same units as K

(A →) successful collision frequency based on collision geometry & Ea

Ea = activation energy

R = gas constant ($8.314\ J\ mol^{-1} K^{-1}$)

T = absolute temp (K)

natural log allows for formation of <u>straight line</u>

$\ln K = -Ea/RT + \ln A$

↓ Arrhenius plot

remember $y = mx + b$

$\ln k = (y)$ vs $1/T = (x)$ $-E_a/R = (m)$

E_a ↓ derive from slope of graph; R → constant

$$\text{gradient} = \frac{\Delta \ln k \ (y)}{\Delta \ 1/T \ (x)} = \frac{-E_a}{R}$$

$\therefore E_a \ (J\,mol^{-1}) = \text{measured gradient } (k) \times 8.314 \ J K^{-1} mol^{-1}$

To graph:

1. convert k to ln k (calc)
2. T (°C) to $1/T$ (K)
3. Draw plot
4. measure gradient
5. solve → calculate $\dfrac{\Delta \ln k}{\Delta 1/T}$

Solving simultaneous equations

Ea can be calculated from k values at 2 temps.

$$T_1 : \ln k_1 = \frac{-E_a}{RT_1} + \ln A$$

$$T_2 : \ln k_2 = \frac{-E_a}{RT_2} + \ln A$$

$$\ln \frac{k_1}{k_2} = \frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$ subtrat 2nd from 1st)

example (pg 303)

T_1 : 283°C → 556K
T_2 : 508°C → 781 K

$$\ln\left(\frac{3.52\times10^{-7}}{3.95\times10^{-2}}\right) = \frac{E_a}{8.314}\left(\frac{1}{781} - \frac{1}{556}\right) = 1.87\times10^5 \text{ Jmol}^{-1}$$