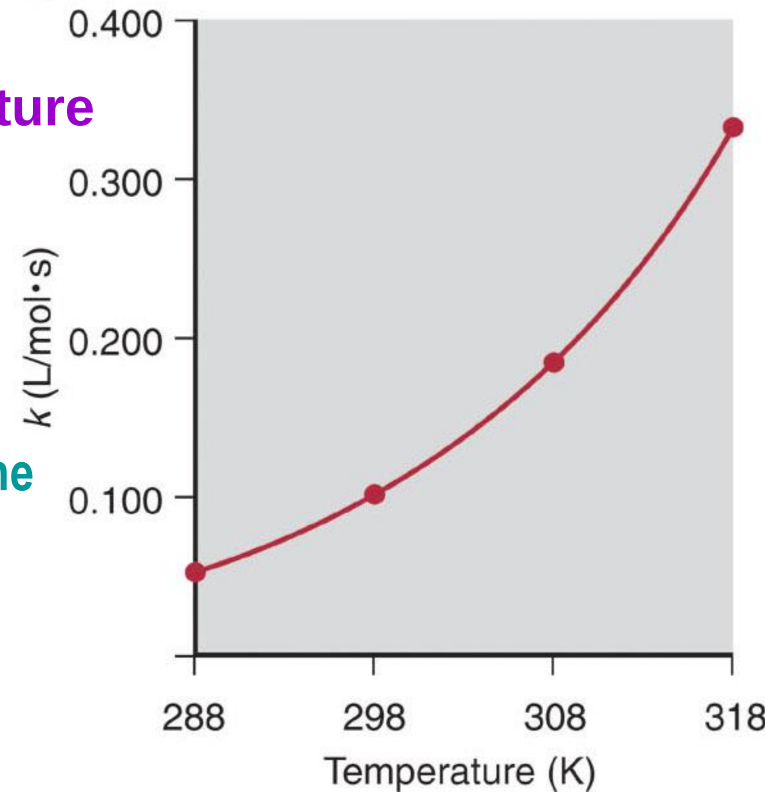
Figure 16.10

Dependence of the rate constant on temperature

$$CH_3COOCH_2CH_3 + H_2O \rightleftharpoons CH_3COOH + CH_3CH_2OH$$

The concentrations are held constant. The rate and the rate constant increase while temperature increases.

The rate constant *k* nearly doubles with each rise of 10K. A plot of rate constant vs. temperature for this reaction shows an exponentially increasing curve.



Exp't	[Ester]	$[H_2O]$	*T* (K)	Rate (mol/L•s)	*k* (L/mol•s)
1	0.100	0.200	288	1.04×10^{-3}	0.0521
2	0.100	0.200	298	2.02×10^{-3}	0.101
3	0.100	0.200	308	3.68×10^{-3}	0.184
4	0.100	0.200	318	6.64×10^{-3}	0.332

Constant $\Delta T = 10K$ rate doubles

The Effect of Temperature on Reaction Rate

The Arrhenius Equation

$$k = Ae^{-E_a/RT}$$

$$\ln k = \ln A - E_a/RT$$

where k is the kinetic rate constant at T

E_a is the **activation energy**

R is the energy gas constant

T is the absolute temperature

A is the frequency factor

$$\ln k_2 = \ln A - \frac{E_a}{R}\left(\frac{1}{T_2}\right), \quad \ln k_1 = \ln A - \frac{E_a}{R}\left(\frac{1}{T_1}\right)$$

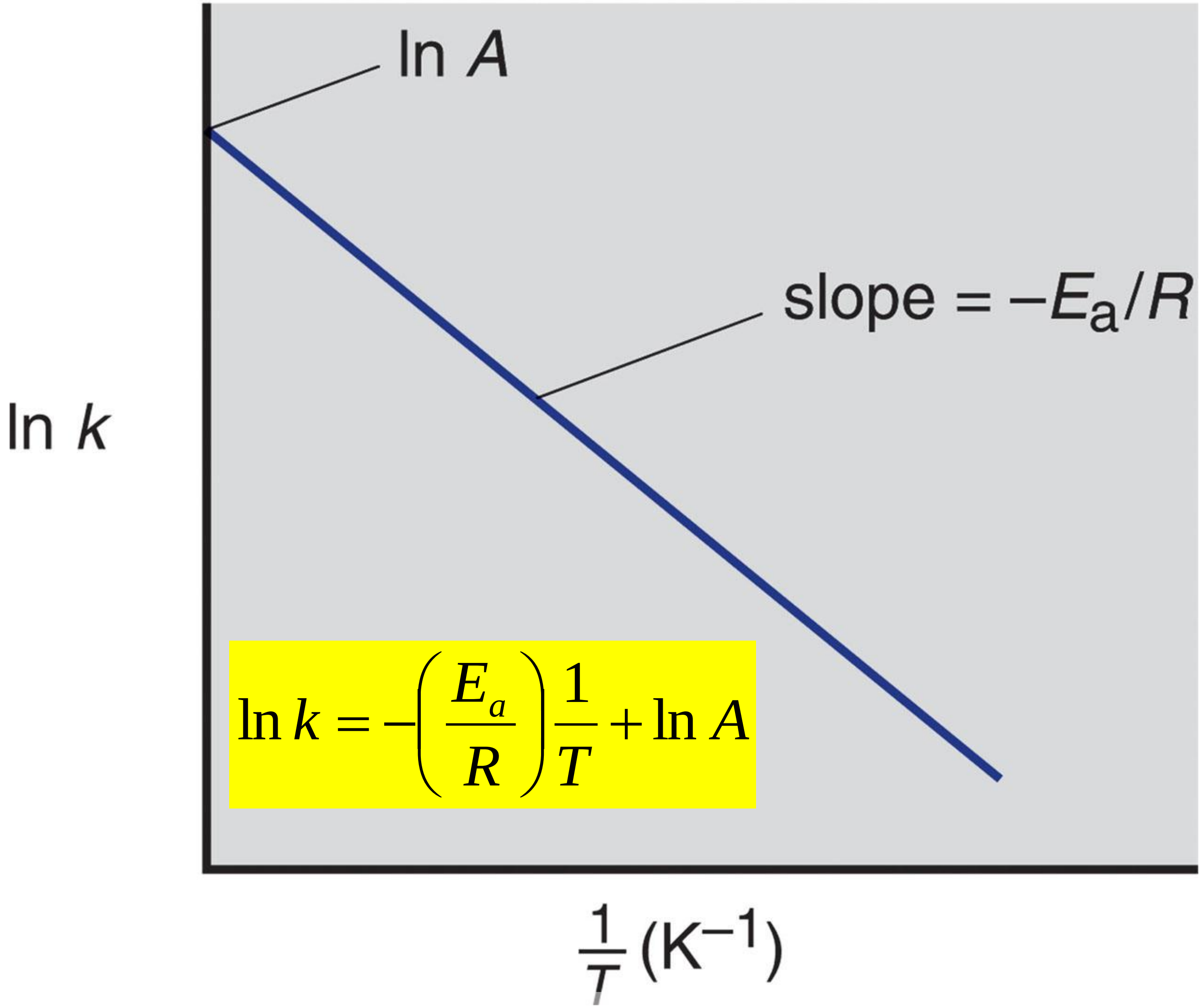
$$\ln k_2 - \ln k_1 = -\frac{E_a}{R}\left(\frac{1}{T_2}\right) + \frac{E_a}{R}\left(\frac{1}{T_1}\right)$$

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

If we measure rate constants at two different temperatures T_1 and T_2, we can solve for E_a.

Higher *T* results in larger *k* and increased rate.

Figure 16.11 **Graphical determination of the activation energy**



A plot of *ln k* vs. *T^{-1}* gives a straight line with slope $-E_a/R$.