Catalysis

Catalysis is thought to arise primarily from a lowering of the activation energy. Using the Arrhenius model calculate the difference in activation energy using only the data at 460 K provided below.

T (K)	460
Cat (M^{-1} s^{-1})	130
Uncat (M-1 s^{-1})	0.25

Catalysis

Solution: Given the data

T (K)	460
Cat (M^{-1} s^{-1})	130
Uncat (M-1 s^{-1})	0.25

We can compare two rate constants with two different activation energies:

$$k_{cat} = A\,exp\left\{-\frac{E_{a,cat}}{RT}\right\}$$

and

$$k = A\,exp\left\{-\frac{E_a}{RT}\right\}$$

Catalysis

The ratio of the two equations is:

$$\frac{k_{cat}}{k} = exp\left\{\frac{E_a - E_{a,cat}}{RT}\right\}$$

We solve for the difference in the activation energies to find:

$$E_a - E_{a,cat} = RT\ ln\left(\frac{k_{cat}}{k}\right)$$

Inserting the numbers:

$$E_a - E_{a,cat} = (8.31)(460)\ ln\left(\frac{130}{0.25}\right)$$

Therefore,

$$E_a - E_{a,cat} = 23{,}900\ J/mol$$

Catalysis

In problem 1 we calculated the activation energies using the Arrhenius model. The difference between those values is:

$$E_{a,exp1} - E_{a,cat,exp1} = (70.5\ - 44.9)\ kJ/mol$$

$$E_{a,exp1} - E_{a,cat,exp1} = 25.6\ kJ/mol$$

Thus, the majority of the acceleration in rate is due to the lowering of the barrier. If the experimental error is 10% then the values obtained by the two considerations are within that range.