[AQA A2 Paper 2 2017]

A series of experiments is carried out with compounds C and D. Using the data obtained, the rate equation for the reaction between the two compounds is deduced to be:

$$\text{Rate} = k[C][D]$$

In one experiment at 25 °C, the initial rate of reaction is 3.1×10^{-3} $moldm^{-3}s^{-1}$ when the initial concentration of C is $0.48 moldm^{-3}$ and the initial concentration of D is $0.23 moldm^{-3}$.

a) Calculate a value for the rate constant at this temperature and give its units.

① Rearrange the rate equation for K:

$$\text{Rate} = K[C][D]$$

$$\Rightarrow K = \frac{\text{Rate}}{[C][D]}$$

② Sub in values to find K:

$$K = \frac{3.1 \times 10^{-3}}{0.48 \times 0.23}$$

$$\Rightarrow 2.8 \times 10^{-2}$$

③ Use the rearranged equation to find the units of K:

$$\frac{mol\,dm^{-3}\,s^{-1}}{(mol\,dm^{-3})(mol\,dm^{-3})} \Rightarrow mol^{-1}\,dm^{3}\,s^{-1}$$

↑ cancel units

b) An equation that relates the rate constant, k, to the activation energy, Ea, and the temperature, T, is

$$\ln k = \frac{-Ea}{RT} + \ln A$$

Use this equation and your answer from part (a) to calculate a value, in kJ mol^{-1}, for the activation energy of this reaction at 25 °C.

For this reaction ln A = 16.9

The gas constant R = 8.31 J $K^{-1}mol^{-1}$

① Use part (a) value to find lnk:

$\ln k = \ln|2.8 \times 10^{-2}|$

$= -3.58$

② Rearrange equation for Ea:

$\ln k = \frac{-Ea}{RT} + \ln A$

Temperature in kelvin (+273)

$\Rightarrow -Ea = RT(\ln k - \ln A)$

③ Sub in values to find Ea:

$-Ea = 8.31 \times 298(-3.58 - 16.9)$

$= -50716.2...$

$Ea = 50716.2...\ (J mol^{-1})$

$\Rightarrow 50.7\ kJ mol^{-1}$

the question states the required units as $kJ mol^{-1}$!