THE ARRHENIUS EQUATION

1. Don’t forget that you have to convert the temperatures into K, and that the activation energy has to be in joules per mole, not kilojoules per mole.

At 20°C (= 293 K), the fraction of molecules having energies equal to or greater than $E_A$ is

$$e^{-\frac{40000}{8.31 \times 293}} = 7.33 \times 10^{-8}$$

At 40°C (= 313 K), the fraction of molecules having energies equal to or greater than $E_A$ is

$$e^{-\frac{40000}{8.31 \times 313}} = 2.10 \times 10^{-7}$$

Assuming $A$ is constant, the value of the rate constant, $k$, will have increased by a factor of

$$\frac{2.10 \times 10^{-7}}{7.33 \times 10^{-8}} = 2.86$$

If the concentrations of reactants in the rate expression are still the same as before, then the rate will have increased by this same amount.

(Note: If the “rates double for an increase of 10°C” rule applied, this would give an increase in rate of 4 times. This rule only works for reactions with an activation energy of about 50 kJ mol$^{-1}$ at temperatures around room temperature.)

2. At 21°C, the fraction of molecules having energies equal to or greater than an $E_A$ of 50 kJ mol$^{-1}$ is

$$e^{-\frac{50000}{8.31 \times 294}} = 1.29 \times 10^{-9}$$

At 21°C, the fraction of molecules having energies equal to or greater than an $E_A$ of 35 kJ mol$^{-1}$ is

$$e^{-\frac{35000}{8.31 \times 294}} = 6.00 \times 10^{-7}$$

The number of sufficiently energetic molecules has therefore increased by a factor of

$$\frac{6.00 \times 10^{-7}}{1.29 \times 10^{-9}} = 465$$