Arrhenius and activation energy

OCR A H432 · Full A-level

Answer on your own paper. Show your working where needed.

1. Explain the effect of temperature

The same reaction mixture is tested at two temperatures. Both runs have the same initial concentrations. Predict how the rate constant changes at the higher temperature. Explain your prediction.

2. Calculate a rate constant

Use $k = A\exp(-E_a/RT)$. $A = 4.20 \times 10^{8}$ s^{-1}, $E_a = 61.0$ kJ mol^{-1}, $T = 320$ K and $R = 8.31$ J K^{-1} mol^{-1}. Calculate k.

3. Rearrange for activation energy

Use $k = A\exp(-E_a/RT)$. For a first-order reaction, $k = 0.0450$ s^{-1}, $A = 3.00 \times 10^{10}$ s^{-1} and $T = 335$ K. $R = 8.31$ J K^{-1} mol^{-1}.

Calculate E_a in kJ mol^{-1}.

4. An Arrhenius plot

A plot of ln k against 1/T has a gradient of -7.30×10^{3} K.

Use $\ln k = -E_a/(RT) + \ln A$ and $R = 8.31$ J K^{-1} mol^{-1} to calculate E_a.

5. Two points on a best-fit line

Two points on an ln k against 1/T line are (0.00290 K^{-1}, −2.80) and (0.00340 K^{-1}, −6.55). Use $\ln k = -E_a/(RT) + \ln A$ and $R = 8.31$ J K^{-1} mol^{-1}.

Calculate E_a. Use your gradient and either point to determine A. The units of k are s^{-1}.

6. Predict k at a second temperature

A first-order reaction has $k_1 = 0.00640$ s^{-1} at $T_1 = 300$ K and $E_a = 50.0$ kJ mol^{-1}.

Use $\ln(k_2/k_1) = (E_a/R)(1/T_1 - 1/T_2)$, with $R = 8.31$ J K^{-1} mol^{-1}, to find k_2 at 320 K.

7. Compare two pathways

Two ln k against 1/T plots have gradients of −9000 K and −6200 K. Use $\ln k = -E_a/(RT) + \ln A$.

Identify the pathway with the lower E_a. Is the gradient alone sufficient to decide which pathway has the larger k at 300 K? Explain.

8. Rate constants at two temperatures

A first-order reaction has $k_1 = 0.0260$ s^{-1} at 310 K and $k_2 = 0.0920$ s^{-1} at 332 K.

Use $\ln(k_2/k_1) = (E_a/R)(1/T_1 - 1/T_2)$, with $R = 8.31$ J K^{-1} mol^{-1}, to calculate E_a in kJ mol^{-1}.

9. Extra challenge · Check a measured rate constant

Two points on an Arrhenius line are (1/T = 0.00320 K^{-1}, ln k = −5.00) and (1/T = 0.00350 K^{-1}, ln k = −7.40). Here k is in s^{-1}.

Calculate E_a and A, then find the factor by which a measured k of 0.0900 s^{-1} at 340 K exceeds the predicted k. Use $\ln k = -E_a/(RT) + \ln A$ and $R = 8.31$ J K^{-1} mol^{-1}.

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