16.2 Activation Energy

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Course	DP IB Chemistry
Section	16. Chemical Kinetics (HL only)
Topic	16.2 Activation Energy
Difficulty	Medium

To be used by all students preparing for DP IB Chemistry HL
Students of other boards may also find this useful

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The correct answer is **C** because:

- Statement I is incorrect
  - The gradient has a value of $-E_a / R$
- Statement II is correct
  - The intercept on the rate constant axis does give the value for ln A
- Statement III is correct
  - Provided that the temperature is measured in Kelvin and the gas constant is measured in J mol^{-1} K^{-1}, then an Arrhenius plot will give a value for activation energy in J mol^{-1}

A, **B** & **D** are incorrect as	statement I is incorrect

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The correct answer is **D** because:

- The equation to use is $k = A\, e^{(-E_a / RT)}$
- The values of A and R are given with no need for any conversions
- E_a is given in kJ mol^{-1} and needs to be converted in J mol^{-1}
  - Therefore, the activation energy is 96200 J mol^{-1}
  - A less common alternative would be to convert R into kJ K^{-1} mol^{-1}
- T is given in °C and needs to be converted into Kelvin
  - Therefore, the temperature for use in the equation is 298 K
- Substituting the numbers into the equation gives:

$$k = (2.57 \times 10^9) \times e^{(-96200 / 8.31 \times 298)}$$

A is incorrect as	E_a and T have not been converted into the correct units for use in the equation
B is incorrect as	E_a has not been converted into J mol^{-1}
C is incorrect as	T has not been converted into Kelvin

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The correct answer is **B** because:

- $\ln k = \frac{-E_a}{RT} + \ln A$
- $\frac{E_a}{RT} = \ln A - \ln k$
- $T = \frac{E_a}{R \times (\ln A - \ln k)}$
- $T = \frac{111 \times 10^3}{8.31 \times (\ln 4.55 \times 10^{13} - \ln 1.30 \times 10^{-4})}$

A is incorrect as	the activation energy has not been converted into J mol^{-1}
C is incorrect as	the ln k and ln A terms are the wrong way around

D is incorrect as	the gas constant has been converted into kJ K^{-1} mol^{-1} and the activation energy has been converted into J mol^{-1} so they are not in the same units The gas constant can be converted into kJ K^{-1} mol^{-1} **BUT** this means that the activation energy must remain in kJ mol^{-1}

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The correct answer is **A** because:

- Statement I is correct
  - An increase of 10 K can cause the initial rate of reaction to roughly double but this is only true of reactions with an E_a of around 50 kJ mol^{-1}
- Statement II is correct
  - For a second order reaction, rate = $k[X]^2$
  - So, $k = \frac{rate}{[X]^2} = \frac{mol\ dm^{-3} s^{-1}}{[mol\ dm^3]^2}$
  - This simplifies to $mol^{-1}\ dm^3\ s^{-1}$
- Statement III is incorrect
  - *A* relates to the number and orientation of collisions

B, **C** & **D** are incorrect as	statement III is incorrect

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The correct answer is **A** because:

- The graph showing the relationship between the rate constant, k, and temperature shows an exponential increase
- **Careful:** Don't confuse this question with the graph of ln k with $\frac{1}{T}$ which is linear

B & **D** are incorrect as	these graphs are linear
C is incorrect as	the curve shows rate decreasing as temperature increases