InkChemistry

QUESTION WORKBOOK

The Arrhenius equation and the rate-determining step

Rate equations · Unit C09

AQA 3.1.9.1, 3.1.9.2 · OCR A 5.1.1 (i) to (k)

18 questions · 60 marks

PRINT EDITION

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SECTION A · Short, 1 to 2 marks

A1 AE-Q2

Give the Arrhenius equation, and the units in which Ea and T must be used in it when R = 8.31 J K^{-1} mol^{-1}. [2]

A2 AE-Q8

Explain, using the Arrhenius equation, why adding a catalyst increases the rate constant of a reaction. [2]

A3 AE-Q10

Explain why an intermediate formed before the rate-determining step never appears in the rate equation, and state what appears in its place. [2]

A4 AE-Q18

Identify the catalyst and the intermediate in this mechanism for the destruction of ozone: $Cl + O_3 \rightarrow ClO + O_2$, then $ClO + O \rightarrow Cl + O_2$. [2]

SECTION B · Standard, 3 to 5 marks

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B1 AE-Q5 Calculate the pre-exponential factor A for a first-order reaction with Ea = 75.0 kJ mol^{-1} and k = 3.2 × 10^{-4} s^{-1} at 300 K. [4]

B2 AE-Q11 Outline how the activation energy of a reaction could be found using a clock reaction at several temperatures. [4]

B3 AE-Q15 Compare the SN1 and SN2 mechanisms for the hydrolysis of halogenoalkanes by hydroxide ions. [4]

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B4 AE-Q16 Evaluate the mechanism $X + X \rightarrow X_2$ (slow), then $X_2 + Y \rightarrow X_2Y$ (fast), proposed for the reaction $2X + Y \rightarrow X_2Y$, whose rate equation is rate = $k[X][Y]$. [4]

B5 AE-Q1 State what is meant by the rate-determining step of a reaction. Then give the rate equation, and its overall order, for a reaction whose mechanism is $A + B \rightarrow AB$ (fast), then $AB + C \rightarrow D$ (slow). [3]

B6 AE-Q7 Explain, using the Arrhenius equation, why a small rise in temperature causes a large increase in the rate constant. [3]

B7 AE-Q9 Explain why tertiary halogenoalkanes are hydrolysed by an SN1 mechanism while primary halogenoalkanes are hydrolysed by SN2. [3]

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B8 AE-Q12 Suggest a two-step mechanism for $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$, whose rate equation is rate = $k[NO]^2[O_2]$, given that collisions of three molecules at once are very unlikely. [3]

B9 AE-Q13 Suggest which species take part in the rate-determining step of the reaction $H_2O_2(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l)$, whose rate equation is rate = $k[H_2O_2][I^-]$, and why H^+ does not appear. [3]

B10 AE-Q19 Calculate the factor by which the rate constant of a reaction at 300 K increases when a catalyst lowers its activation energy from 95.0 kJ mol^{-1} to 80.0 kJ mol^{-1}, assuming A is unchanged. [3]

B11 AE-Q21 Explain why, in the thiosulfate and acid method for the activation energy, a graph of ln(1/t) against 1/T has the same gradient as a graph of ln k against 1/T. [3]

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B12 AE-Q22 Show that raising the temperature from 310 K to 320 K roughly doubles the rate constant of a reaction whose activation energy is 60.0 kJ mol^{-1}. R = 8.31 J K^{-1} mol^{-1}. [3]

SECTION C · Long, 6 marks or more

C1 AE-Q17 Explain how the rate equations for the hydrolysis of 1-bromobutane and of 2-bromo-2-methylpropane by hydroxide ions show that they react by different mechanisms, and describe each mechanism. [6]

C2 AE-Q20 Explain how the mechanism of the acid-catalysed iodination of propanone accounts for its rate equation, rate = $k[CH_3COCH_3][H^+]$, and identify the intermediates and the catalyst in it. [6]

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