2.4 Kinetics and Equilibria: 30-minute Pack

AQA 7405 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 This question tests key definitions used throughout the kinetics and equilibria topic.

(a) State the two conditions necessary, according to collision theory, for a reaction to occur when two particles collide. **(2)**

(b) Define activation energy. **(1)**

(c) State what is meant by the order of reaction with respect to a reactant. **(1)**

(d) State the Arrhenius equation. **(1)**

(Total for Question 1 is 5 marks)

2 A reaction between reactants A and B was investigated using the initial rates method. The table shows the results of three experiments carried out at the same constant temperature.

Experiment	[A] (mol dm-3)	[B] (mol dm-3)	Initial rate (mol dm-3 s-1)
1	0.10	0.10	2.0×10^{-3}
2	0.20	0.10	4.0×10^{-3}
3	0.20	0.20	1.6×10^{-2}

(a) Using experiments 1 and 2, determine the order of reaction with respect to A. Show your reasoning. **(2)**

(b) Using experiments 2 and 3, determine the order of reaction with respect to B. Show your reasoning. **(2)**

(c) Deduce the overall order of reaction and write the rate equation for this reaction. **(2)**

(d) Using the data from Experiment 1, calculate the rate constant, k, for this reaction, including its units. **(3)**

(Total for Question 2 is 9 marks)

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3 The concentration of reactant A was monitored during its decomposition at a constant temperature. The results are shown in the table.

Time (min)	0	10	20	30	40
[A] (mol dm-3)	0.800	0.400	0.200	0.100	0.0500

You may use: for a first order reaction, $k = \ln 2 / t(1/2)$; $[A]t = [A]0 \times e^{-kt}$, where [A]t is the concentration remaining after time t.

(a) Show that these data are consistent with the reaction being first order with respect to A. **(3)**

(b) Calculate the rate constant, k, for this reaction in s-1, giving your answer to 3 significant figures. **(3)**

(c) Using your value of k (or $k = 1.16 \times 10^{-3}$ s-1 if you did not obtain an answer to (b)), calculate the concentration of A remaining after 25.0 minutes have elapsed, giving your answer to 3 significant figures. **(2)**

(Total for Question 3 is 8 marks)

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Mark scheme · 2.4 Kinetics and Equilibria: 30-minute Pack

Question 1

(a) the particles must collide with energy equal to or greater than the activation energy **B1**

(a) the particles must collide with the correct orientation (geometry), oe **B1**

(a) Answer: Sufficient energy (≥ activation energy) and correct collision orientation.

(b) the minimum energy that colliding particles must have in order to react, oe **B1**

(b) Answer: The minimum energy needed for colliding particles to react.

(c) the power to which the concentration of that reactant is raised in the (experimentally determined) rate equation, oe **B1**

(c) Answer: The power to which that reactant's concentration is raised in the rate equation.

(d) $k = A e^{-Ea/RT}$, with terms defined (k = rate constant, A = Arrhenius constant/pre-exponential factor, Ea = activation energy, R = gas constant, T = temperature in K) **B1**

(d) Answer: $k = A e^{-Ea/RT}$

Question 2

(a) [A] doubles (0.10 to 0.20) with [B] constant, and the initial rate doubles ($2.0x10^{-3}$ to $4.0x10^{-3}$) oe **M1**

(a) order with respect to A = 1 cao **A1**

(a) Answer: Order with respect to A = 1

(b) [B] doubles (0.10 to 0.20) with [A] constant, and the initial rate increases by a factor of 4 ($4.0x10^{-3}$ to $1.6x10^{-2}$) oe **M1**

(b) order with respect to B = 2 cao **A1**

(b) Answer: Order with respect to B = 2

(c) overall order = 1 + 2 = 3 **M1**

(c) rate = $k[A][B]^2$ **A1**

(c) Answer: Overall order = 3; rate = $k[A][B]^2$

(d) k = rate / ($[A][B]^2$) = $2.0x10^{-3}$ / (0.10×0.10^2), ft from (c) **M1**

(d) k = 2.0 cao **A1**

(d) units: $mol^{-2}\ dm^6\ s^{-1}$ **A1**

(d) Answer: $k = 2.0\ mol^{-2}\ dm^6\ s^{-1}$

Question 3

(a) identifies successive half-lives: 0.800 to 0.400 takes 10 min; 0.400 to 0.200 takes a further 10 min; 0.200 to 0.100 takes a further 10 min; 0.100 to 0.0500 takes a further 10 min **M1**

(a) the half-life is constant at 10 min throughout the reaction **A1**

(a) a constant half-life (independent of concentration) is characteristic of first order kinetics, so the data are consistent with the reaction being first order with respect to A cso **A1**

(a) Answer: Half-life is constant at 10 min throughout, confirming first order kinetics with respect to A.

(b) t(1/2) = 10 min = 600 s **M1**

(b) k = ln2 / 600 **M1**

(b) $k = 1.16 \times 10^{-3}$ s-1 awrt **A1**

(b) Answer: $k = 1.16 \times 10^{-3}$ s-1

(c) converts t = 25.0 min to 1500 s and substitutes into $[A]t = [A]0 \times e^{-kt}$, ft from (b) **M1**

(c) [A]t = 0.141 mol dm-3 awrt (accept 0.140 if $k = 1.16 \times 10^{-3}$ s-1 is used) **A1**

(c) Answer: 0.141 mol dm-3 (0.140 mol dm-3 if $k = 1.16 \times 10^{-3}$ s-1 is used)

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