08 Reaction Kinetics

Set A Foundations

Name	Time 1 hour	Total 33 marks	Score ____ / 33

A Data Booklet may be used.

A From the lesson

10 MARKS

1 In $2N_2O_5 \rightarrow 4NO_2 + O_2$, N_2O_5 is used up at 2.0×10^{-4} mol dm^{-3} s^{-1}. At what rate does NO_2 form?

[1]

/1

Source: Learners' Alley, Reaction Kinetics slides

2 rate = k[NO]^2[H_2], with rate in mol dm^{-3} min^{-1}. Find the units of k.

[1]

/1

Source: Learners' Alley, Reaction Kinetics slides

3 COMMON For A + B → C, find the order with respect to A and B, and the rate equation.

expt	[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	2.0×10^{-3}
3	0.10	0.30	1.8×10^{-2}

[3]

/3

Source: Learners' Alley, Reaction Kinetics slides

4 COMMON Explain why increasing temperature increases rate.

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..... **[2]**

/2

Source: Learners' Alley, Reaction Kinetics slides

5 Define order of reaction with respect to a reactant.

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..... **[1]**

/1

Source: Learners' Alley, Reaction Kinetics slides

6 A first-order reaction has $t_{½}$ = 20 s. Find k.

[1]

/1

Source: Learners' Alley, Reaction Kinetics slides

7 What is a homogeneous catalyst?

..... **[1]**

/1

Source: Learners' Alley, Reaction Kinetics slides

B Practice

23 MARKS

8 COMMON Two colourless substances, X and Y, react to give a coloured substance Z. The time, t, taken for various initial concentrations of X and Y to produce Z is recorded in the table.

[X] / mol dm^{-3}	[Y] / mol dm^{-3}	t / s
0.05	0.05	44
0.05	0.10	22
0.10	0.05	44

What is the rate equation?

A rate = k[Y] **B** rate = k[X][Y] **C** rate = $k[Y]^2$ **D** rate = $k[X][Y]^2$

Answer ☐ **[1]**

/1

Source: HCI 2007 Prelim P1 Q9, via EJC 2022 JC1 Reaction Kinetics Tutorial, A4

9 Propanone reacts with bromine in the presence of an acid catalyst. $CH_3COCH_3 + Br_2 \rightarrow CH_3COCH_2Br + H^+ + Br^-$

The progress of the reaction was studied by finding the time taken for Br_2 to decolourise using different volumes of reactants.

expt	volume of Br_2 added / cm^3	volume of CH_3COCH_3 added / cm^3	volume of H^+ added / cm^3	volume of H_2O added / cm^3	relative rate
1	10	20	10	10	2
2	10	10	10	20	1
3	10	20	5	15	1
4	10	40	20	30	2

What is the rate equation for the reaction?

A rate = $k[CH_3COCH_3][H^+]$

B rate = $k[Br_2][H^+]$

C rate = $k[CH_3COCH_3][Br_2]$

D rate = $k[CH_3COCH_3][Br_2][H^+]$

Answer ☐ [1]

/1

Source: EJC 2018 Promo, via EJC 2022 Reaction Kinetics Topical Revision, Q7

10 COMMON At 700 °C, nitrogen monoxide and hydrogen react as follows. $2NO(g) + 2H_2(g) \rightarrow N_2(g) + 2H_2O(g)$

expt	initial [NO] / mol dm^{-3}	initial [H_2] / mol dm^{-3}	initial rate / mol dm^{-3} s^{-1}
1	0.0020	0.012	0.0033
2	0.0040	0.012	0.013
3	0.0060	0.012	0.030
4	0.012	0.0020	0.020
5	0.012	0.0040	0.040
6	0.012	0.0060	0.060

(a) Use the data to determine the order of the reaction with respect to nitrogen monoxide and with respect to hydrogen.

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..... **[2]**

(b) Use these answers to write a rate equation for the reaction. Determine a value for k, stating the units.

[2]

/4

Source: EJC 2022 JC1 Reaction Kinetics Tutorial, A5

11 The reaction between nitric oxide and oxygen is third order overall, and it has been suggested that the mechanism involves the following two steps. $2NO \rightarrow N_2O_2$ (fast) $N_2O_2 + O_2 \rightarrow 2NO_2$ (slow)

(a)(i) Construct a rate equation for this reaction.

[1]

(ii) Explain the meaning of the terms rate constant, order of reaction and rate-determining step.

[3]

(b)(i) The decomposition of hydrogen peroxide, $H_2O_2 \rightarrow H_2O + \frac{1}{2}O_2$, is a first order reaction. Both platinum and the enzyme catalase act as catalysts. Describe how the activation energy is affected by the presence of a catalyst, and explain how this increases the rate.

[2]

(ii) What effect will the presence of the catalyst have on the rate constant for this reaction? Explain your answer.

[1]

/7

Source: A Level 2005 P3 Q1, via EJC 2022 JC1 Reaction Kinetics Tutorial, A11

12 The rate equation for the reaction $3A(g) + B(g) \rightarrow C(g) + D(g)$ is rate = $k[A]^2[B]$. The rate is R for certain pressures of A and B, at constant temperature. Write down, in terms of R, the rate of reaction when

(a) the partial pressures of both A and B are doubled

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[1]

(b) the partial pressure of A doubles, but that of B remains constant

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[1]

(c) the volume of the reacting vessel is doubled

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[1]

(d) the total pressure is doubled by pumping an inert gas into the system

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[1]

/4

Source: RJC H2 Chemistry Tutorial 6 (Reaction Kinetics), Self-check Q4

13 **CHALLENGE** Sucrose is hydrolysed to glucose and fructose: $C_{12}H_{22}O_{11} + H_2O \rightarrow C_6H_{12}O_6 + C_6H_{12}O_6$. The reaction can be catalysed by dilute acid. The following results were obtained using hydrochloric acid as the catalyst.

expt	initial [HCl] / mol dm^{-3}	initial [sucrose] / mol dm^{-3}	initial rate / mol dm^{-3} s^{-1}
I	0.10	0.10	0.024
II	0.10	0.15	0.036
III	0.20	0.10	0.048
IV	0.25	y	0.048

(a) Deduce the order of reaction with respect to both HCl and sucrose. Hence, calculate the rate constant for the reaction, stating the units.

[3]

(b) Calculate the value of y.

[1]

(c) The half-life of sucrose in experiment I was 3.0 s. Predict the half-life of sucrose in experiment II and in experiment III, giving your reasoning.

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/6

Source: RJC H2 Chemistry Tutorial 6 (Reaction Kinetics), Standard Q1