08 Reaction Kinetics

Set B **Exam practice**

Name	Time 1 hour 15 minutes	Total 37 marks	Score ____ / 37

A Data Booklet may be used.

Marks by notes section For the marker: total each row. A score below the target means that section of the notes needs revising.

Notes section	Questions	Marks	Target	Score
1 Collision Theory	12(b)	3	2	
2 Factors Affecting Rate	10(f)	1	1	
3 Rate of Reaction	10(a)	2	2	
4 Energy Profile Diagrams	11(b)	2	2	
5 Catalysis	11(a), 12(a)	4	3	
6 The Rate Equation	3, 6(b), 7(b), 8(a), 10(d), 10(e)	8	5	
7 Mechanisms and the Rate Equation	5, 8(b), 8(c)	5	3	
9 Initial Rates Method	4, 6(a), 7(a)	6	4	
10 Graphical Methods	1, 2, 9, 10(b)	5	3	
11 Pseudo Order	10(c)	1	1	

A Multiple choice

5 MARKS

1 COMMON A certain first order reaction took 42 minutes for the initial concentration of the reactant to decrease from 0.48 mol dm^{-3} to 0.06 mol dm^{-3}. How long will it take for the concentration of the same reactant to decrease from 0.40 mol dm^{-3} to 0.10 mol dm^{-3}?

A 28 minutes **B** 30 minutes **C** 35 minutes **D** 42 minutes

Answer ____ [1]

/1

Source: ACJC 2018 Promo, via EJC 2022 Reaction Kinetics Topical Revision, Q1

2 The dissociation of a compound RS is shown below. $RS(g) \rightarrow R(g) + S(g)$

The rate equation for the reaction is rate = k[RS] and the rate constant is 3.6×10^{-3} s^{-1}. If the initial concentration of RS is 2.0×10^{-2} mol dm^{-3}, what will be the concentration of RS after 385 seconds?

A 1.0×10^{-2} mol dm^{-3} **B** 5.0×10^{-3} mol dm^{-3}

C 2.5×10^{-3} mol dm^{-3} **D** 2.0×10^{-3} mol dm^{-3}

Answer [1]

/1

Source: PJC 2007 Prelim P1 Q12, via EJC 2022 JC1 Reaction Kinetics Tutorial, A2

3 Which statements about order of reaction are correct?

1 Only first order reactions have constant half-lives.

2 Measurements of initial rates of reaction can be used to determine the overall order of a reaction.

3 The units of a rate constant are independent of the order of the reaction.

A 1, 2 and 3 **B** 1 and 2 only **C** 2 and 3 only **D** 1 only

Answer [1]

/1

Source: A Level 2006 P1 Q34, via EJC 2022 JC1 Reaction Kinetics Tutorial, A1

4 The following data were obtained from studies of the reaction between NO and O_2 in a vessel at constant temperature.

experiment	I	II	III	IV
total initial pressure / atm	1.00	1.60	2.00	x
initial pressure of NO / atm	0.40	0.40	0.80	0.20
initial rate of reaction / atm s^{-1}	1.08	2.16	8.64	1.08

Which of the following statements is correct regarding the above system?

A The reaction is first order with respect to NO. **B** The rate equation is rate = kp_{NO}^2.

C The rate constant k has units of atm^{-2} s^{-1}. **D** The value of x in the table above is 2.40.

Answer [1]

/1

Source: HCI 2018 Promo, via EJC 2022 Reaction Kinetics Topical Revision, Q4

5 The reaction of acidified aqueous potassium iodide with aqueous hydrogen peroxide, $2I^-(aq) + H_2O_2(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l)$, is thought to involve the following steps.

step 1	$H_2O_2 + I^- \rightarrow H_2O + OI^-$	slow
step 2	$OI^- + H^+ \rightarrow HOI$	
step 3	$HOI + H^+ + I^- \rightarrow I_2 + H_2O$	

Which of the following conclusions can be drawn from this information?

1 The acid is acting as a catalyst.

2 OI^- and HOI are intermediates.

3 Step 2 has a lower activation energy than step 1.

4 The reaction is overall second order.

A 1 and 2 only **B** 2 and 3 only **C** 1 and 3 only **D** 2, 3 and 4 only

Answer [1]

/1

Source: HCI 2018 Promo, via EJC 2022 Reaction Kinetics Topical Revision, Q6

B Structured questions

32 MARKS

6 COMMON At 800 K, nitrogen monoxide reacts with hydrogen according to the equation $2H_2(g) + 2NO(g) \rightarrow 2H_2O(l) + N_2(g)$. The table shows how the initial rate of this reaction depends on the initial partial pressures of the reactants.

experiment	p_{H_2} / atm	p_{NO} / atm	initial rate / atm s^{-1}
1	0.64	1.60	1.50×10^{-7}
2	0.64	0.80	3.75×10^{-8}
3	0.32	1.60	7.50×10^{-8}

(a) Determine the order of reaction with respect to H_2 and NO. Hence state, in terms of partial pressures, the rate equation for the reaction.

[3]

(b) Using the rate equation, calculate a value for the rate constant. Include units in your answer.

[2]

/5

Source: 2023 VJC J2 Prelim P2 Q4(a)

7 Isoprene, $CH_2=C(CH_3)CH=CH_2$, reacts with bromine. To determine the rate equation for this reaction, a student obtained the following data.

expt	[isoprene] / mol dm^{-3}	[Br_2] / mol dm^{-3}	initial rate / mol dm^{-3} s^{-1}
1	0.04	0.064	0.88×10^{-3}
2	0.08	0.064	1.76×10^{-3}
3	0.08	0.128	3.52×10^{-3}

(a) Using data from the table, determine the order of reaction with respect to Br_2 and isoprene, showing your working clearly.

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

(b) Hence, construct the rate equation for the reaction.

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

/3

Source: 2023 YIJC J2 Prelim P3 Q2(b)(i) and (ii)

8 The rate of reaction between propanone, CH_3COCH_3, and acidified iodine to give iodopropanone, CH_3COCH_2I, is found to be independent of [I_2], but directly proportional to [H^+] and directly proportional to [propanone].

(a) Write the rate equation for this reaction and state the overall order.

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

(b) Suggest, with reasons, which of the following two possible mechanisms, A or B, fits the observed kinetic data. X and Y are intermediates.

A	$CH_3COCH_3 + H^+ \rightarrow X$ (slow)	$X + I_2 \rightarrow$ products (fast)
B	$CH_3COCH_3 + I_2 \rightarrow Y$ (slow)	$Y + H^+ \rightarrow$ products (fast)

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..... **[3]**

(c) The reaction between propanone and bromine to give bromopropanone proceeds by a similar mechanism. Explain how the rate of the reaction between propanone and bromine would compare with that of the reaction between propanone and iodine.

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

/5

Source: RJC H2 Chemistry Tutorial 6 (Reaction Kinetics), Standard Q5

9 The half-life of a second-order reaction with respect to a reactant A can be calculated using $t_{½} = \frac{1}{k[A]_t}$, where k is the rate constant at a specific temperature and $[A]_t$ is the concentration of A at time t. The decomposition of nitrogen dioxide, $2NO_2(g) \rightarrow 2NO(g) + O_2(g)$, follows second-order kinetics. The rate constant at 300 °C is 0.54 mol^{-1} dm^3 s^{-1}. At 300 °C, a sample of NO_2 in a closed container took 46.3 s for its concentration to decrease to one-fourth of its original value. Use the formula to determine the original concentration, in mol dm^{-3}, of NO_2 in the container.

[2]

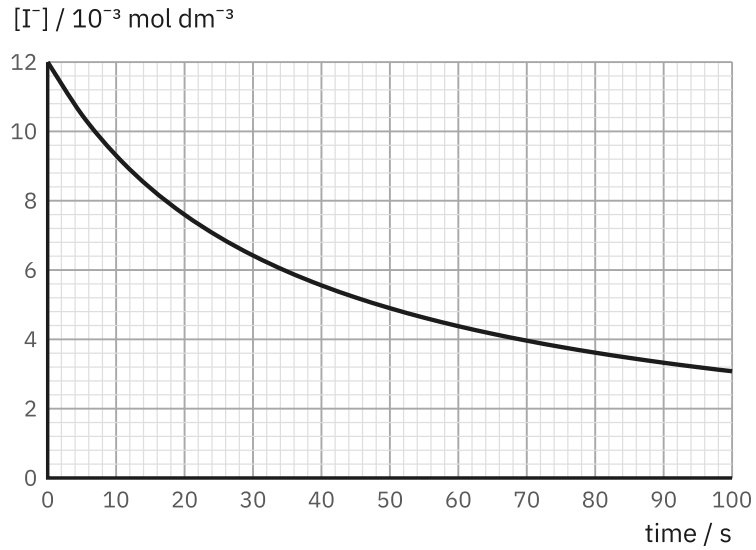
/2

Source: 2024 DHS J2 Prelim P3 Q2(d)(ii)

10 The reaction between iron(III) ions and iodide ions is shown. The initial concentration of $Fe^{3+}(aq)$ is 0.150 mol dm^{-3}.

$$Fe^{3+}(aq) + I^{-}(aq) \rightarrow Fe^{2+}(aq) + \tfrac{1}{2}I_2(aq)$$

The rate of this reaction was followed by the change in the concentration of $I^{-}(aq)$, shown in the graph.



(a) COMMON Use the graph to calculate the initial rate of reaction and the rate of reaction at 20 s. Show your working on the graph.

[2]

(b) Hence, determine the order of reaction with respect to iodide ions. Show your working.

[1]

(c) Explain why it is important that the concentration of $Fe^{3+}(aq)$ is in large excess compared with the concentration of $I^{-}(aq)$ in this experiment.

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[1]

(d) The reaction is first order with respect to $Fe^{3+}(aq)$. Write the rate equation for the reaction.

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[1]

(e) Use the rate equation and the initial rate from (a) to calculate the rate constant, stating its units.

[2]

(f) In a new experiment of the same reaction at a different temperature, the rate constant was found to be 2.10, in the same units. Deduce whether the new experiment was carried out at a higher or lower temperature than the original experiment.

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[1]

/8

Source: 2024 VJC J2 Prelim P2 Q2(a)

11 In the presence of chlorine atoms, ozone decomposes exothermically to produce oxygen. The reaction mechanism has two steps.

step 1 $O_3 + Cl\bullet \rightarrow ClO\bullet + O_2$ step 2 $O_3 + ClO\bullet \rightarrow Cl\bullet + 2O_2$

(a) Use this mechanism to state and explain the role of Cl•.

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[1]

(b) COMMON Complete the labelled energy profile diagram for this reaction.



[2]

/3

Source: 2025 NYJC J2 Prelim P2 Q5(d)(ii) and (iii)

12 CHALLENGE Explain each of the following observations as fully as you can.

(a) When ammonia gas is passed over platinum gauze in an enclosed vessel, the rate of decomposition of ammonia into nitrogen and hydrogen is independent of the partial pressure of ammonia, except at very low pressures, when the rate is directly proportional to the partial pressure of ammonia.

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(b) A relatively small increase in temperature can cause a large increase in the rate of a chemical reaction.

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..... **[3]**

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Source: RJC H2 Chemistry Tutorial 6 (Reaction Kinetics), Standard Q6(b) and (d)