10: The reaction shown is second order with respect to NO and first order with respect to O_2.

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

If the concentration of NO is doubled and the concentration of O_2 is tripled, by what factor will the rate increase?

- ☒ **A** 6
- ☒ **B** 12
- ☒ **C** 18
- ☒ **D** 27

11: A chloroalkane, RCl, undergoes hydrolysis according to the equation shown.

$$RCl + OH^- \rightarrow ROH + Cl^-$$

The rate equation is rate = k[RCl]

Which chloroalkane is most likely to be RCl?

- ☒ **A** CH_3CH_2Cl
- ☒ **B** $(CH_3)_3CCl$
- ☒ **C** $CH_3CHClCH_3$
- ☒ **D** $(CH_3)_3CCH_2Cl$

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7 The decomposition of hydrogen peroxide is catalysed by iodide ions.

$$2H_2O_2(aq) \xrightarrow{I^-} 2H_2O(l) + O_2(g)$$

The mechanism for this reaction is shown.

Step 1: $H_2O_2(aq) + I^-(aq) \rightleftharpoons IO^-(aq) + H_2O(l)$ fast

Step 2: $H_2O_2(aq) + IO^-(aq) \rightarrow I^-(aq) + H_2O(l) + O_2(g)$ slow

What is the rate equation for this reaction?

☒ **A** rate = $k[H_2O_2]^2[I^-]$

☒ **B** rate = $k[H_2O_2][I^-]$

☒ **C** rate = $k[H_2O_2]^2[I^-][IO^-]$

☒ **D** rate = $k[H_2O_2][IO^-]$

(Total for Question 7 = 1 mark)

1 Which method would be most suitable to investigate the kinetics of the reactions shown?

(a) $(CH_3)_2C{=}CH_2(g) + HI(g) \rightarrow (CH_3)_3CI(g)$

(1)

☒ **A** colorimetry

☒ **B** measurement of change in volume

☒ **C** measurement of change in mass

☒ **D** quenching with ice-cold water followed by titrating with acid

(b) $HCOOCH_3(aq) + NaOH(aq) \rightarrow HCOONa(aq) + CH_3OH(aq)$

(1)

☒ **A** colorimetry

☒ **B** measurement of change in volume

☒ **C** measurement of change in mass

☒ **D** quenching with ice-cold water followed by titrating with acid

(Total for Question 1 = 2 marks)

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2 The equation for the reaction of bromate(V) ions with bromide ions in acid solution is shown.

$$BrO_3^-(aq) + 5Br^-(aq) + 6H^+ \rightarrow 3Br_2(aq) + 3H_2O(l)$$

The rate equation for the reaction is

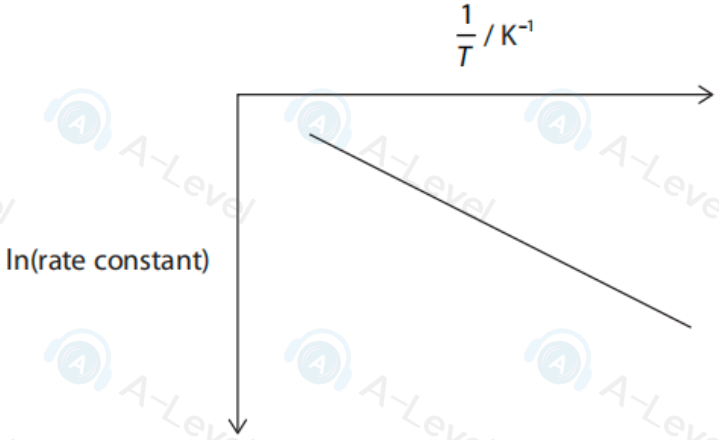
$$\text{rate} = k[BrO_3^-][Br^-][H^+]^2$$

The concentrations of all the reactants are doubled.
By what factor does the rate of reaction increase?

- ☒ **A** 2
- ☒ **B** 4
- ☒ **C** 8
- ☒ **D** 16

(Total for Question 2 = 1 mark)

4 The graph shown can be used to obtain a value for the activation energy, E_a, of a reaction.



The activation energy is related to the rate constant by the equation

$$\ln(\text{rate constant}) = -\frac{E_a}{R} \times \frac{1}{T} + \text{constant}$$

From the graph, the E_a is equal to

- ☒ **A** $\frac{(-\text{gradient})}{R}$
- ☒ **B** $\frac{(-\text{gradient})}{RT}$
- ☒ **C** (−gradient) × R
- ☒ **D** (−gradient) × RT

(Total for Question 4 = 1 mark)

1 Bromate(V) ions, BrO_3^-, react with bromide ions, Br^-, in aqueous acid.

$$BrO_3^- + 5Br^- + 6H^+ \rightarrow 3Br_2 + 3H_2O$$

The rate equation for the reaction is shown.

$$\text{rate} = k\,[BrO_3^-]\,[Br^-]\,[H^+]^2$$

(a) Which **continuous** monitoring method could be used to obtain kinetics data for this reaction?

(1)

- ☒ **A** colorimetry
- ☒ **B** mass change
- ☒ **C** titration with sodium thiosulfate
- ☒ **D** volume of gas evolved

(b) What are the units of the rate constant, *k*, for this reaction?

(1)

- ☒ **A** $\text{mol dm}^{-3}\text{ s}^{-1}$
- ☒ **B** $\text{dm}^3\text{ mol}^{-1}\text{ s}^{-1}$
- ☒ **C** $\text{dm}^6\text{ mol}^{-2}\text{ s}^{-1}$
- ☒ **D** $\text{dm}^9\text{ mol}^{-3}\text{ s}^{-1}$

(c) The concentrations of **all** reactants are halved.

By what factor does the rate of reaction change?

(1)

- ☒ **A** $\frac{1}{2}$
- ☒ **B** $\frac{1}{4}$
- ☒ **C** $\frac{1}{8}$
- ☒ **D** $\frac{1}{16}$

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2 The half-life of a first order chemical reaction is

- ☒ **A** half the time taken for the reaction to be complete
- ☒ **B** the time taken for the value of the rate constant to halve
- ☒ **C** the time taken for the concentration of a reactant to halve
- ☒ **D** the time taken for the concentration of a product to double

(Total for Question 2 = 1 mark)

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3 Two chemicals, **E** and **F**, react to form products **G** and **H**.

$$\mathbf{E} + 2\mathbf{F} \rightarrow \mathbf{G} + \mathbf{H}$$

The mechanism for the reaction occurs in two steps via the formation of an intermediate **J**.

$$\mathbf{E} + \mathbf{F} \rightarrow \mathbf{J} \qquad \text{slow}$$

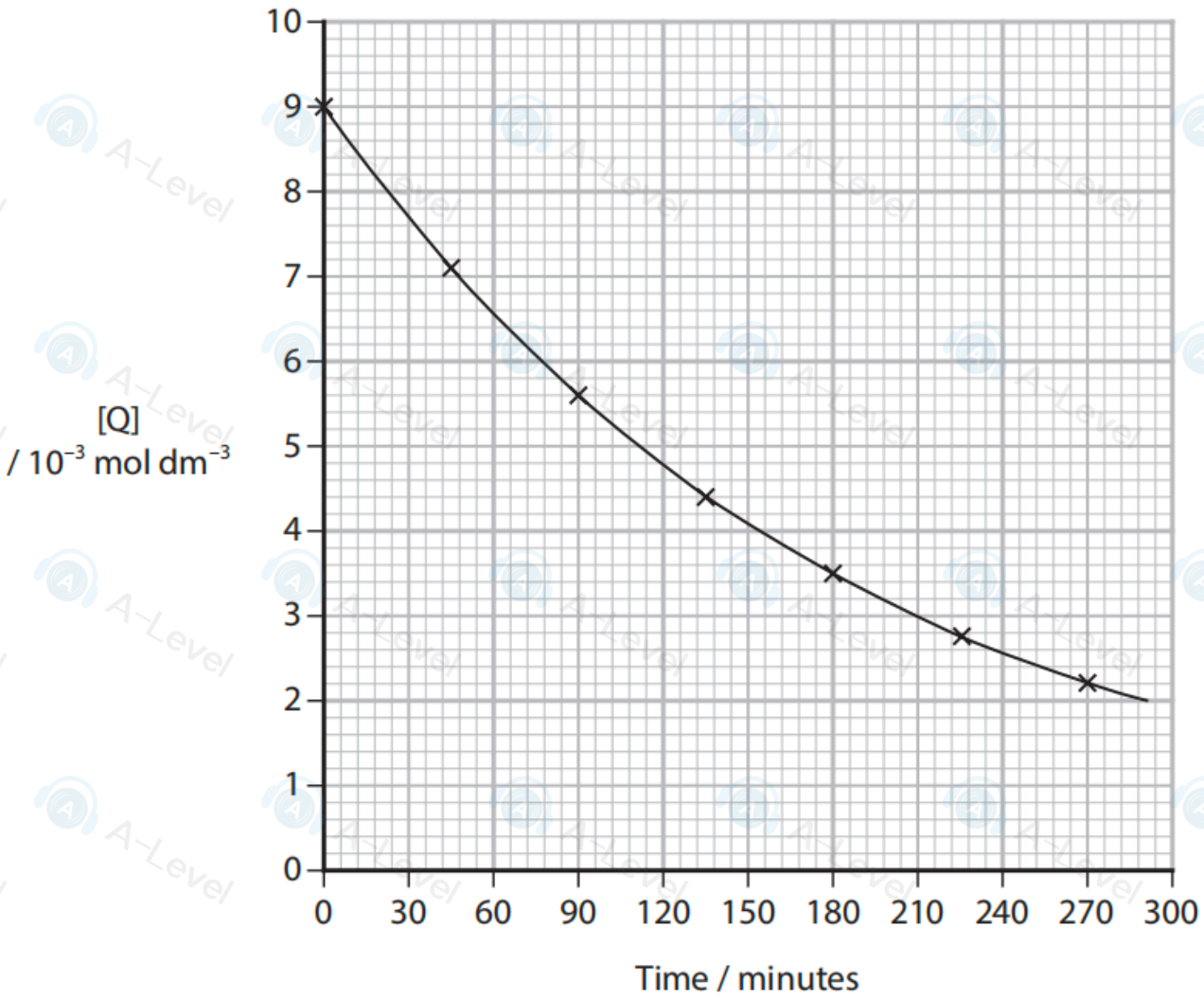
$$\mathbf{J} + \mathbf{F} \rightarrow \mathbf{G} + \mathbf{H} \qquad \text{fast}$$

What is the rate equation for the reaction?

- ☒ **A** rate = k[**E**][**F**]
- ☒ **B** rate = k[**E**][**F**]^2
- ☒ **C** rate = k[**F**][**J**]
- ☒ **D** rate = k[**E**][**F**]^2[**J**]

(Total for Question 3 = 1 mark)

15 A graph of the concentration of Q during decomposition is shown.



What is the half-life for this decomposition?

- ☒ **A** 93 minutes
- ☒ **B** 132 minutes
- ☒ **C** 146 minutes
- ☒ **D** 291 minutes

2 Nitrogen(V) oxide, N_2O_5, decomposes in a first order reaction.
At 45 °C, the half-life for this reaction is 1400 s.
In an experiment, the initial concentration of nitrogen(V) oxide is 1.0 mol dm^{-3}.

What is the concentration, in mol dm^{-3}, of nitrogen(V) oxide after 4200 s?

- ☒ **A** 0.875
- ☒ **B** 0.500
- ☒ **C** 0.250
- ☒ **D** 0.125

(Total for Question 2 = 1 mark)

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1 Two ways of writing an equation for the reaction between nitrogen monoxide and oxygen are shown.

$$2NO + O_2 \rightarrow 2NO_2 \qquad \text{Equation 1}$$

$$NO + \tfrac{1}{2}O_2 \rightarrow NO_2 \qquad \text{Equation 2}$$

(a) Which **pair** of rate equations could be correct for this reaction?

(1)

	Equation 1	Equation 2
☒ **A**	rate = $k[NO]^2[O_2]$	rate = $k[NO]^2[O_2]$
☒ **B**	rate = $k[NO]^2[O_2]$	rate = $k[NO][O_2]^{\frac{1}{2}}$
☒ **C**	rate = $k[NO_2]^2$	rate = $k[NO_2]^2$
☒ **D**	rate = $k[NO_2]^2$	rate = $k[NO_2]$

(b) Which two methods can be used for **continuous** monitoring of the progress of this reaction?

(1)

☒ **A** colorimetry and titration

☒ **B** colorimetry and volume change

☒ **C** mass change and volume change

☒ **D** mass change and titration

(Total for Question 1 = 2 marks)

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9: In an experiment to determine the rate of reaction between bromine and methanoic acid, which method would **not** be suitable?

$$Br_2(aq) + HCOOH(aq) \rightarrow 2H^+(aq) + 2Br^-(aq) + CO_2(g)$$

☒ **A** quenching and titrating with an acid

☒ **B** measuring the loss in mass

☒ **C** colorimetry

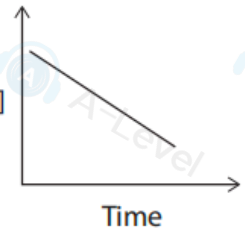
☒ **D** measuring the volume of gas produced

3 This question is about rates of chemical reactions.

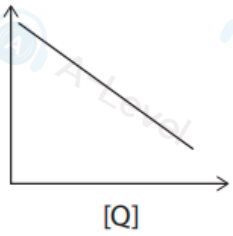
(a) Which graph shows a reaction that is zero order with respect to reactant Q?

(1)

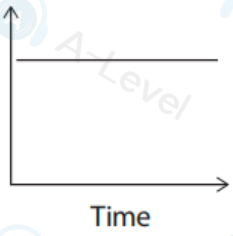
☒ **A**



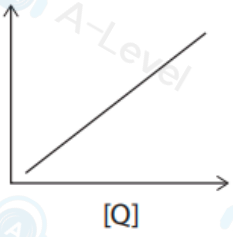
☒ **B**



☒ **C**



☒ **D**



(b) The equation for a gas phase reaction is shown.

$$A(g) \rightarrow B(g) + C(g)$$

The reaction is first order.
When the initial pressure of A is 2 atm the half-life of the reaction is 20 s.

What is the half-life of the reaction when the initial pressure of A is 4 atm?

(1)

☒ **A** 10 s

☒ **B** 20 s

☒ **C** 40 s

☒ **D** 400 s

(Total for Question 3 = 2 marks)