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# CHEMISTRY

## PHYSICAL CHEMISTRY II

Level & Board	AQA (A-LEVEL)
TOPIC:	RATE EQUATIONS
PAPER TYPE:	QUESTION PAPER - 2
TOTAL QUESTIONS	10
TOTAL MARKS	30

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## Rate Equations - 2

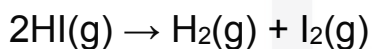
1. Define the term rate of reaction.

(2)

2. The Arrhenius equation can be written as

$$\ln k = -\frac{E_a}{RT} + \ln A$$

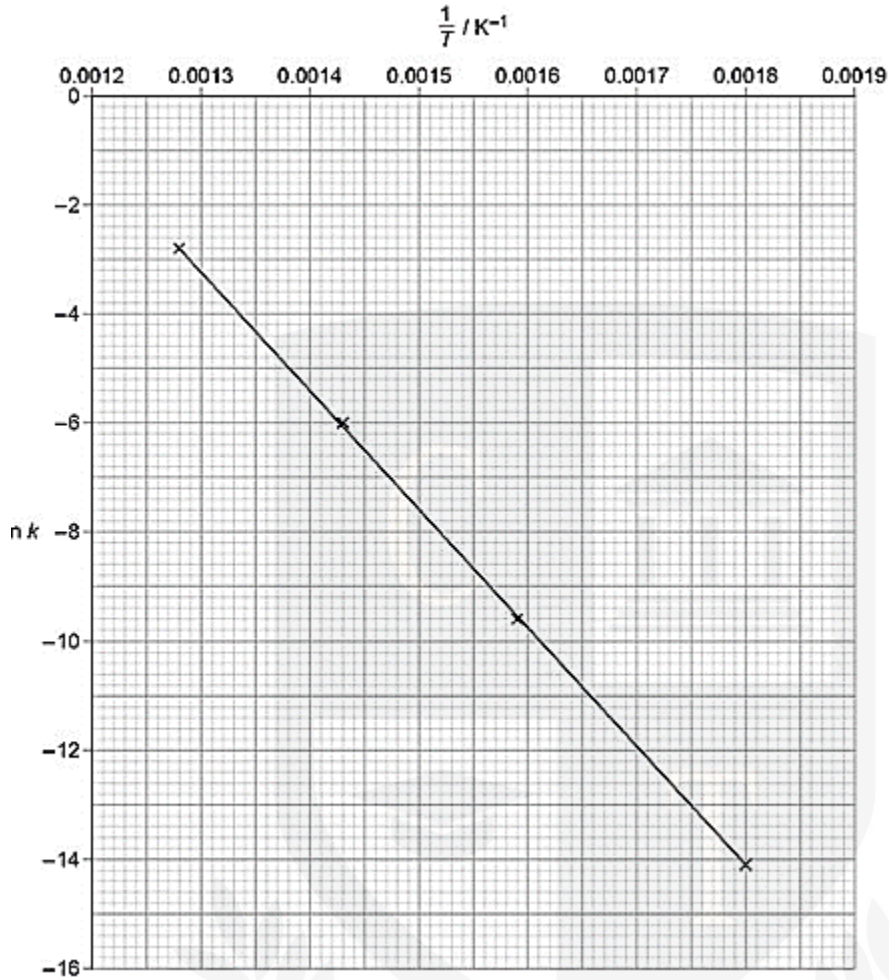
The figure below shows a graph of  $\ln k$  against  $1/T$  for the reaction



Use the figure above to calculate a value for the activation energy ( $E_a$ ), in  $\text{kJ mol}^{-1}$ , for this reaction.

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The gas constant  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

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(3)

3. A rate investigation was carried out on a reaction involving three reactants, X, Y and Z.

The concentrations of the reactants were varied and the relative rate for each mixture determined.

Experiment	[X]/mol dm <sup>-3</sup>	[Y]/mol dm <sup>-3</sup>	[Z]/mol dm <sup>-3</sup>	Relative rate
1	1 × 10 <sup>-3</sup>	1 × 10 <sup>-3</sup>	2 × 10 <sup>-3</sup>	1
2	2 × 10 <sup>-3</sup>	2 × 10 <sup>-3</sup>	2 × 10 <sup>-3</sup>	4
3	5 × 10 <sup>-4</sup>	2 × 10 <sup>-3</sup>	4 × 10 <sup>-3</sup>	0.5

The reaction is zero order with respect to Y. What is the overall order of reaction?

- A. 0  
B. 1  
C. 2  
D. 3

(1)

4. At a given instant, how could you calculate the rate of reaction?

(2)

5. The rate constant,  $k$ , for a reaction varies with temperature as shown by the equation

$$k = Ae^{-\frac{Ea}{RT}}$$

For this reaction, at 25 °C,

$$k = 3.46 \times 10^{-8} \text{ s}^{-1}$$

The activation energy  $E_a = 96.2 \text{ kJ mol}^{-1}$

The gas constant  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

Calculate a value for the Arrhenius constant,  $A$ , for this reaction.

Give the units for  $A$ .

(4)

6. The rate equation for the hydrogenation of ethene



At a fixed temperature, the reaction mixture is compressed to triple the original pressure.

What is the factor by which the rate of reaction changes?

- A. 6
- B. 9
- C. 12
- D. 27

(1)

7. The rate of hydrolysis of an ester X ( $\text{HCOOCH}_2\text{CH}_2\text{CH}_3$ ) was studied in alkaline conditions at a given temperature.

The rate was found to be first order with respect to the ester and first order with respect to hydroxide ions.

**(a)** Name ester X.

**(1)**

**(b)** Using X to represent the ester, write a rate equation for this hydrolysis reaction.

**(1)**

**(c)** When the initial concentration of X was  $0.024 \text{ mol dm}^{-3}$  and the initial concentration of hydroxide ions was  $0.035 \text{ mol dm}^{-3}$ , the initial rate of the reaction was  $8.5 \times 10^{-5} \text{ mol dm}^{-3} \text{ s}^{-1}$ .

Calculate a value for the rate constant at this temperature and give its units.

**(3)**

**(d)** In a second experiment at the same temperature, water was added to the original reaction mixture so that the total volume was doubled. Calculate the initial rate of reaction in this second experiment.

(1)

(e) In a third experiment at the same temperature, the concentration of X was half that used in the experiment and the concentration of hydroxide ions was three times the original value.

Calculate the initial rate of reaction in this third experiment.

(1)

(f) State the effect, if any, on the value of the rate constant  $k$  when the temperature is lowered but all other conditions are kept constant.

(2)

8. What affects the value of the rate constant for a given reaction?

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(2)

9. The initial rate of the reaction between two gases P and Q was measured in a series of experiments at a constant temperature.

The following rate equation was determined.  $\text{rate} = k[\text{P}]^2 [\text{Q}]$

(a) Complete the table of data below for the reaction between P and Q.

Experiment	Initial [P] /mol dm <sup>-3</sup>	Initial [Q] /mol dm <sup>-3</sup>	Initial rate /mol dm <sup>-3</sup> s <sup>-1</sup>
1	0.20	0.30	$1.8 = 10^{-3}$
2	0.40	0.60	
3	0.60		$5.4 = 10^{-3}$
4		0.90	$12.2 = 10^{-3}$

(3)

- (b) Use the data from Experiment 1 to calculate a value for the rate constant k and deduce its units.

(3)

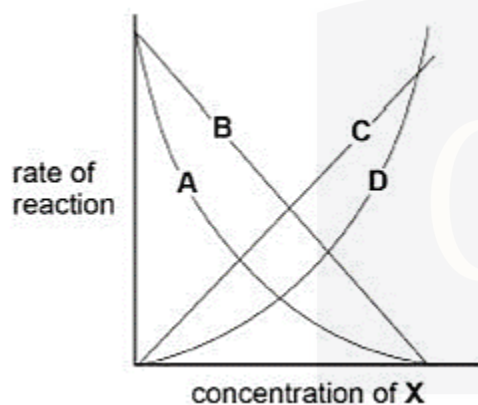
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10. A series of experiments was carried out to find the order of reaction with respect to reactant X.

In these experiments, only the concentration of X was changed.

Which graph would show that the reaction is second-order with respect to X?



- A. A
- B. B
- C. C
- D. D

(1)

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