Edexcel IAL Chemistry A-Level

Topic 11 - Kinetics

Flashcards

What is meant by ‘rate of reaction’?

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The change in concentration of reactants or products over time.

What is a rate equation?

What is a rate equation?

For a reaction between A and B:

Rate = $k[A]^m[B]^n$

Where m and n are integers representing the orders with respect to each reactant and k is the rate constant.

What is a rate constant?

What is a rate constant?

The constant of proportionality linking the rate of reaction and the concentrations of the reactants raised to the power of their orders in the rate equation.

How do you calculate the units of a rate constant?

How do you calculate the units of a rate constant?

- Rearrange the rate equation to make k the subject.
- Substitute units into the equation.
- Cancel the common units to find the units for k.

Use the example below to find the units of the rate constant, k

$$k = \frac{Rate}{[A][B]^2}$$

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$$k = \frac{Rate}{[A][B]^2}$$

$$k = \frac{\cancel{mol\ dm^{-3}}\ s^{-1}}{\cancel{mol\ dm^{-3}} \times (mol\ dm^{-3})^2} \quad = \quad k = \frac{s^{-1}}{mol^2\ dm^{-6}}$$

$$k = dm^6\ mol^{-2}\ s^{-1}$$

What is meant by term ‘order of reaction’?

What is meant by term ‘order of reaction’?

- The order with respect to a reactant is the power to which the concentration of the reactant is raised in the rate equation.
- Overall order of a reaction = the sum of all the individual orders of the reactants.

What do the different orders of reaction mean?

What do the different orders of reaction mean?

- <u>Zero order</u>: if rate $\propto [A]^0$ then the rate of reaction is unaffected by changing [A].
- <u>First order</u>: if rate $\propto [A]^1$ then rate of reaction increases at the same rate as [A] increases.
- <u>Second order</u>: if rate $\propto [A]^2$ then rate will increase by the square of the factor [A] increases by.

What is activation energy?

What is activation energy?

The minimum energy required for a particular reaction to occur.

What is a homogeneous catalyst?

What is a homogeneous catalyst?

A catalyst that is in the same state as the reactants.

What is a heterogeneous catalyst?

What is a heterogeneous catalyst?

A catalyst that is in a different state to the reactants.

Define ‘half life’

Define ‘half life’

The average time taken for the concentration of a reactant to halve, $t_{1/2}$.

How do you calculate half life from a concentration-time graph?

How do you calculate half life from a first order concentration-time graph?

Using the graph, find the time taken for the concentration to halve. Then find the time taken for it to halve again (to increase accuracy). Calculate the average of these values and this will be the half life.

If a reactant has a constant half life, what can you assume its order of reaction to be?

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First order

What are some different experimental techniques that allow you to obtain rate data?

What are some different experimental techniques that allow you to obtain rate data?

- Titration.
- Measuring the volume of gas released from a reaction over time.
- Measuring the change in mass of a reactant over time.
- Colorimetry.
- Measure the time taken for a colour change.

What are the two different types of method that can be used to investigate reaction rates?

What are the two different types of method that can be used to investigate reaction rates?

Initial-rate method: Experiments are carried out where different initial concentrations of one reagent are used.

Continuous monitoring method: The concentration/volume is continuously monitored so that a concentration or volume time graph can be produced from the data.

What does a rate-concentration graph look like for a zero order reactant?

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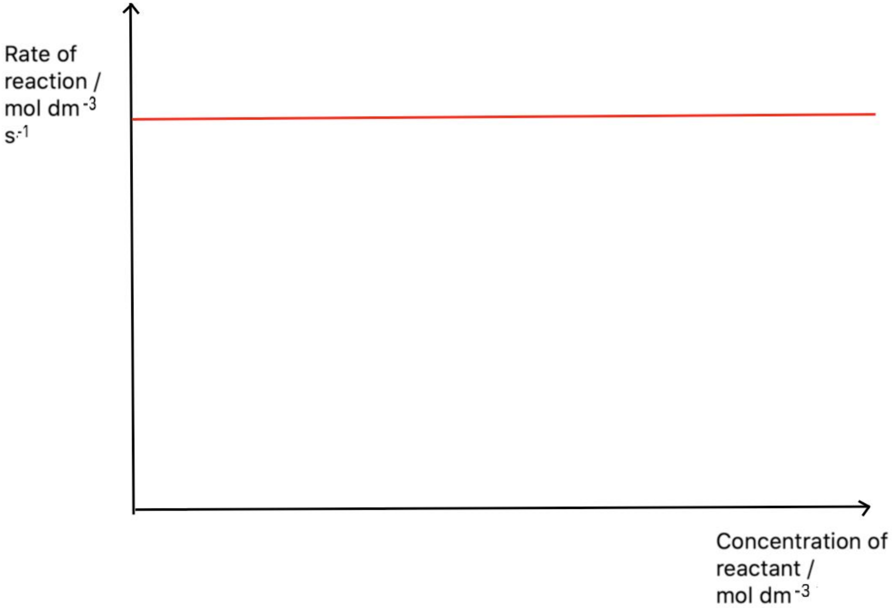

What does a rate-concentration graph look like for a first order reactant?

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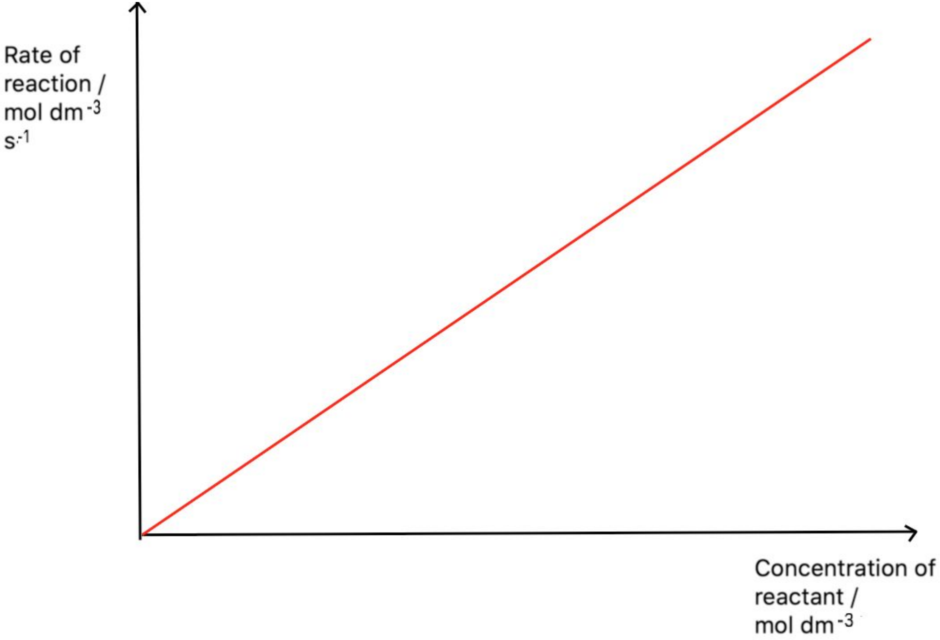

What does a rate-concentration graph look like for a second order reactant?

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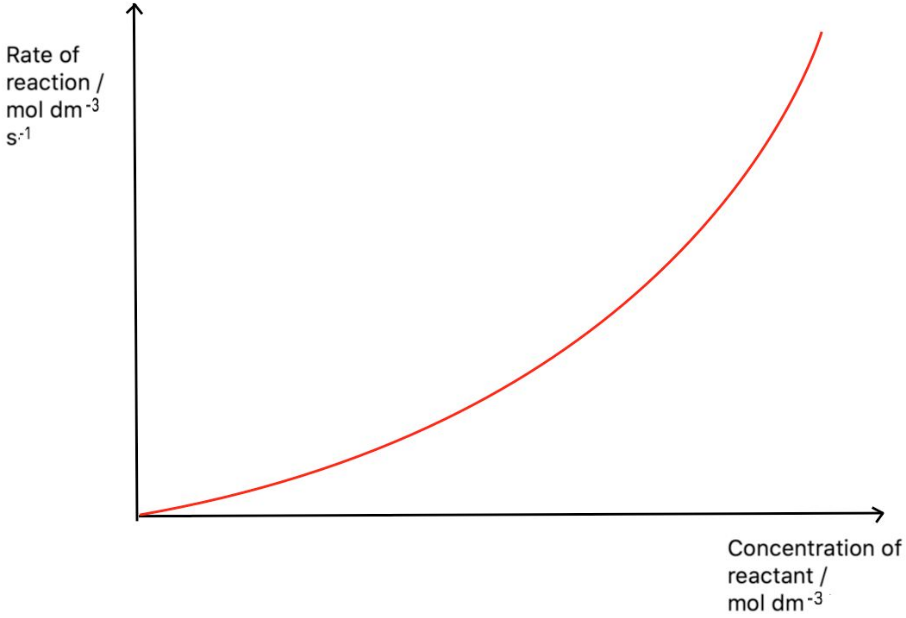

How do you calculate the rate constant, k, from half life, $t_{1/2}$?

How do you calculate the rate constant, k, from half life, $t_{1/2}$?

$k = \ln 2 / t_{1/2}$

This equation applies to first-order reactants only.

What does a concentration-time graph look like for a zero order reactant?

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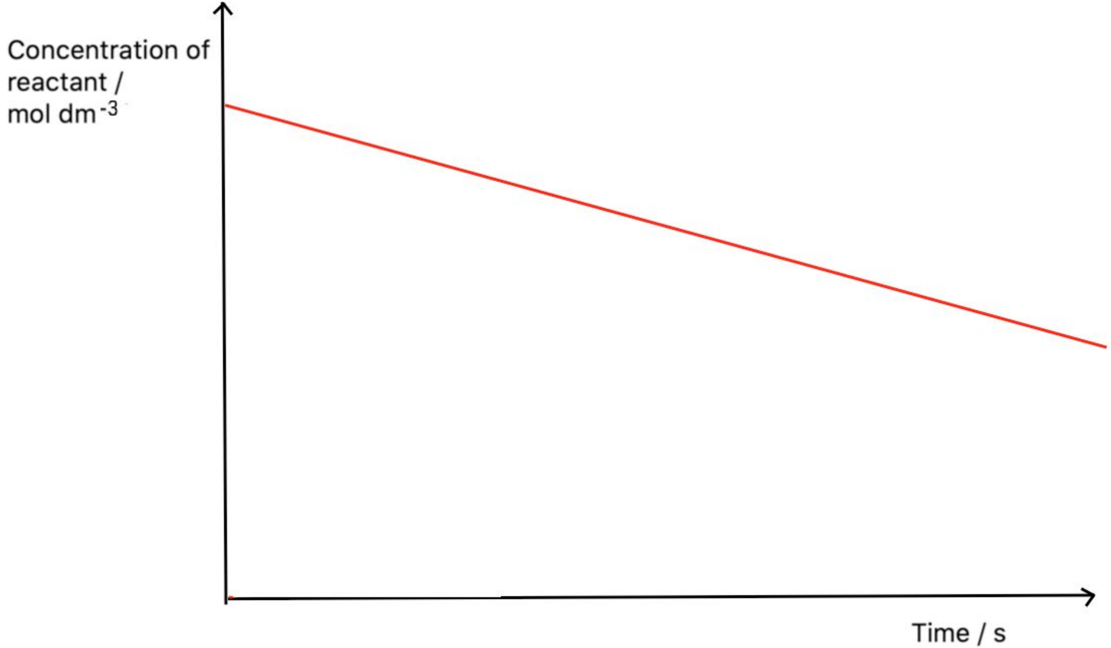
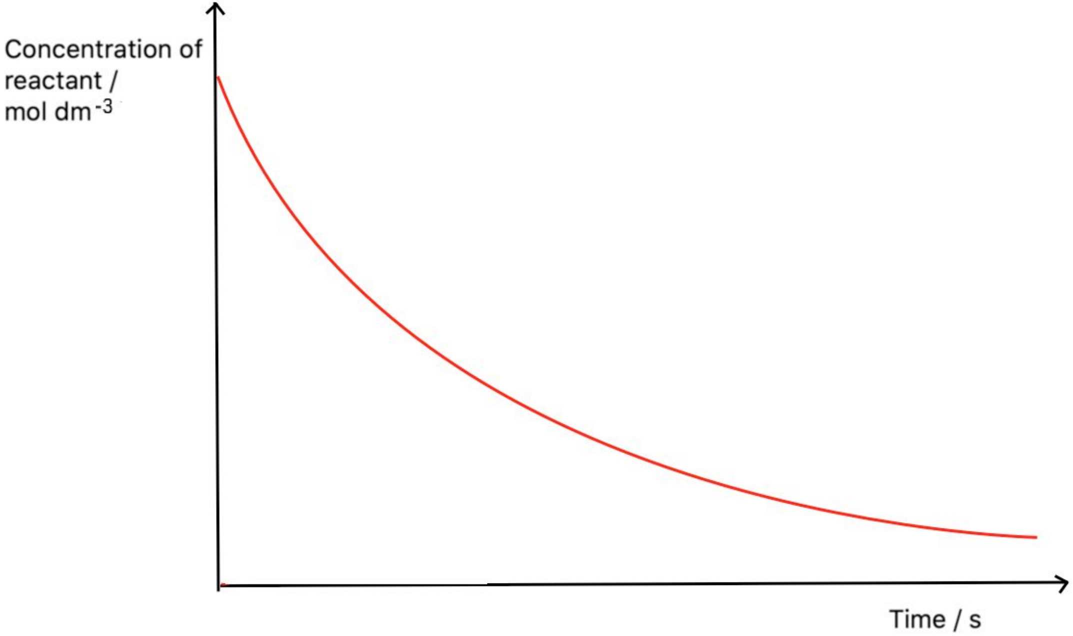


What does a concentration-time graph look like for a first order reactant?

What does a concentration-time graph look like for a first order reactant?



How do you calculate the rate from a first order concentration-time graph?

How do you calculate the rate from a first order concentration-time graph?

- Draw a tangent at the time you want to calculate the rate of reaction for.
- The gradient of this tangent will equal the rate of reaction.

How do you calculate k from a first order rate-concentration graph?

How do you calculate k from a first order rate-concentration graph?

- Calculate the gradient of the line of best fit.
- The gradient will equal the rate constant, k.

How do you calculate the gradient of a line/tangent?

How do you calculate the gradient of a line/tangent?

$$\text{Gradient} = \frac{\text{change in y}}{\text{change in x}}$$

What is a rate-determining step?

What is a rate-determining step?

- The slowest step of the reaction.
- Only the species that take part in the rate determining step (or steps that take place before it) affect the rate.

What is the relation between the rate-determining step and the orders with respect to the reactants?

What is the relation between the rate-determining step and the orders with respect to the reactants?

- The species present in the rate equation are those that take part in the rate determining step.
- For any reactant in the rate equation, the order related to it tells you how many molecules of it are involved in the rate determining step.

How does iodine react with propanone in acid?

How does iodine react with propanone in acid?

$$CH_3COCH_{3(aq)} + I_{2(aq)} \rightarrow CH_3COCH_2I_{(aq)} + HI_{(aq)}$$

- Solution goes from yellow to colourless
- The order with respect to iodine is zero and the order with respect to propanone and acid is first.
- Rate = $k[CH_3COCH_3][H^+]$

What are the rate equations for the hydrolysis of primary and tertiary halogenoalkanes?

What are the rate equations for the hydrolysis of primary and tertiary halogenoalkanes?

- The rate equation for the hydrolysis of a primary halogenoalkane is:
  Rate = $k[RX][OH^-]$
- The rate equation for the hydrolysis of a tertiary halogenoalkane is:
  Rate = $k[RX]$
- Where X is the halogen and R is the alkyl group.

How can we use the rate equation for the hydrolysis of primary halogenoalkanes to write a mechanism for it?

How can we use the rate equation for the hydrolysis of primary halogenoalkanes to write a mechanism for it?

$C_2H_5Br + OH^- \rightarrow C_2H_5OH + Br^-$ Rate = $k[C_2H_5Br][OH\text{-}]$

The first step is the rate determining step and consists of the species present in the rate equation:

$C_2H_5Br + OH^- \rightarrow [C_2H_5Br\text{-}OH^-]$ *slow*

$[C_2H_5Br\text{-}OH^-] \rightarrow C_2H_5OH + Br^-$ *fast*

How can we use the rate equation for the hydrolysis of tertiary halogenoalkanes to write a mechanism for it?

How can we use the rate equation for the hydrolysis of tertiary halogenoalkanes to write a mechanism for it?

$(CH_3)_3CBr + OH^- \rightarrow (CH_3)_3COH + Br^-$ Rate = $k[(CH_3)_3CBr]$

The first step is the rate determining step and consists of the species present in the rate equation:

$(CH_3)_3CBr \rightarrow (CH_3)_3C^+ + Br^-$ *slow*

$(CH_3)_3C^+ + OH^- \rightarrow (CH_3)_3COH$ *fast*

What is the difference between an S_N1 and S_N2 mechanism for the hydrolysis of halogenoalkanes?

What is the difference between an S_N1 and S_N2 mechanism for the hydrolysis of halogenoalkanes?

Both are examples of nucleophilic substitution mechanisms, however each occurs in a slightly different way.

- S_N1: There is only one reactant in the initial step (the halogenoalkane)
- S_N2: There are two reactants in the initial step (the halogenoalkane and the hydroxide ions)

How does the S_N1 mechanism for the hydrolysis of halogenoalkanes occur?

How does the S_N1 mechanism for the hydrolysis of haloalkanes occur?

In the first, rate determining step of an S_N1 mechanism, the halogenoalkane ionises to form a carbocation that can then rapidly react with OH^- ions in the second step.

What equation can be used to calculate activation energy?

What equation can be used to calculate activation energy?

The Arrhenius equation

Why are solid heterogeneous catalysts used in the gas phase of industrial processes?

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The solid provides a surface for the reaction to take place on.