AQA Chemistry A-level

Topic 1.9 - Rate Equations

Flashcards

Define the term rate of reaction

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Change in concentration (of any reactant or product) per unit time. State what is being monitored (usually production of a product)

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

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Rate of reaction = change in concentration / change in time

How could you measure the rate of reaction experimentally (different methods)?

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Use a colorimeter at suitable intervals if there is a colour change.

If gas is evolved, use a gas syringe to collect volume of gas evolved, or measure the change in mass of the reaction mixture.

How would you measure reaction rate for really fast reactions?

How would you measure reaction rate for really fast reactions?

Use a flash of light to break bonds, use probe flashes to record amount of light absorbed by a species; this can show its concentration. First used for $ClO_2 \rightarrow ClO\bullet + O\bullet$.

Can now monitor reactions that occur in times as fast as 10-12 seconds

How can you determine the rate constant and rate expression for a reaction?

How can you determine the rate constant and rate expression for a reaction?

Only experimentally

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

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

Temperature, nothing else

Write a generic rate expression and state what each term means

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Rate = $k [X]^x [Y]^y$;

k = rate constant for the reaction

[X] and [Y] are concentrations of species X and Y respectively

x and y are the orders of reaction with respect to X and Y

Do species need to be in the chemical equation to be in the rate expression?

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No - species in the chemical equation may be excluded and species not in the chemical equation e.g. catalysts, may be included

Define the term order of a reaction with respect to a given product.

Define the term order of a reaction with respect to a given product.

The power to which a species' concentration is raised in the rate equation.

Define the term overall order of reaction.

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The sum of the orders of reaction of all species in the rate expression e.g. (from earlier), total order = x + y

How would you calculate the units of the rate constant?

How would you calculate the units of the rate constant?

Units of rate are $mol dm^{-3} s^{-1}$ and units of concentration are $mol\ dm^{-3}$

Rearrange rate equation to get k=

Sub in units and cancel them out

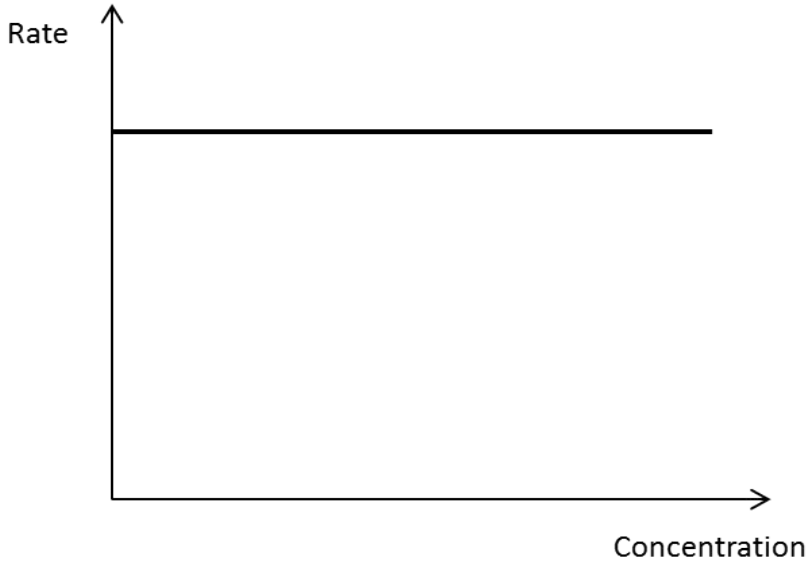
How would you draw a rate concentration graph?

How would you draw a rate concentration graph?

Plot [A] against time, draw tangents at different values → draw a secondary graph of rate against [A]

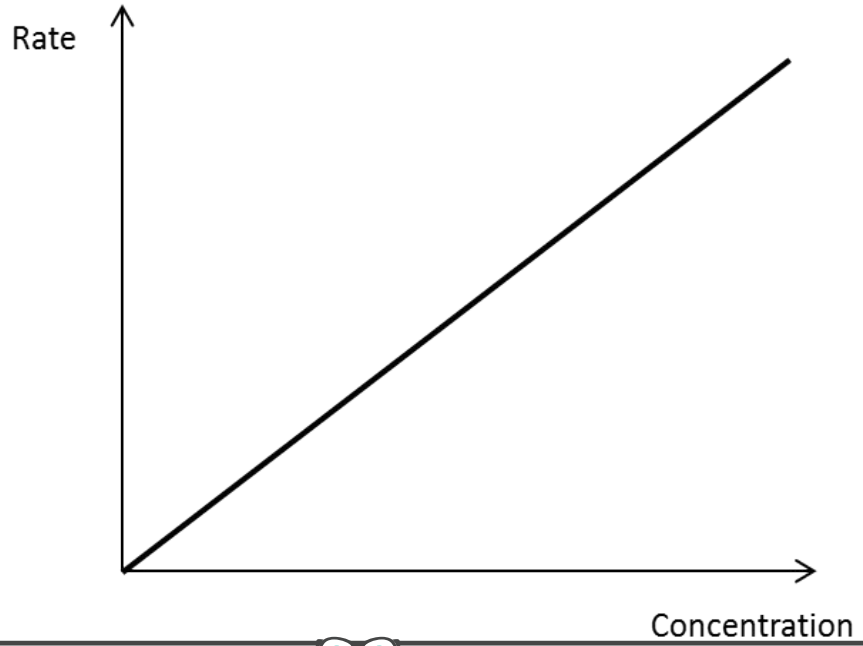
Draw a rate concentration graph for a zero order reactant.

Draw a rate concentration graph for a zero order reactant.



Draw a rate concentration graph for a first order reactant

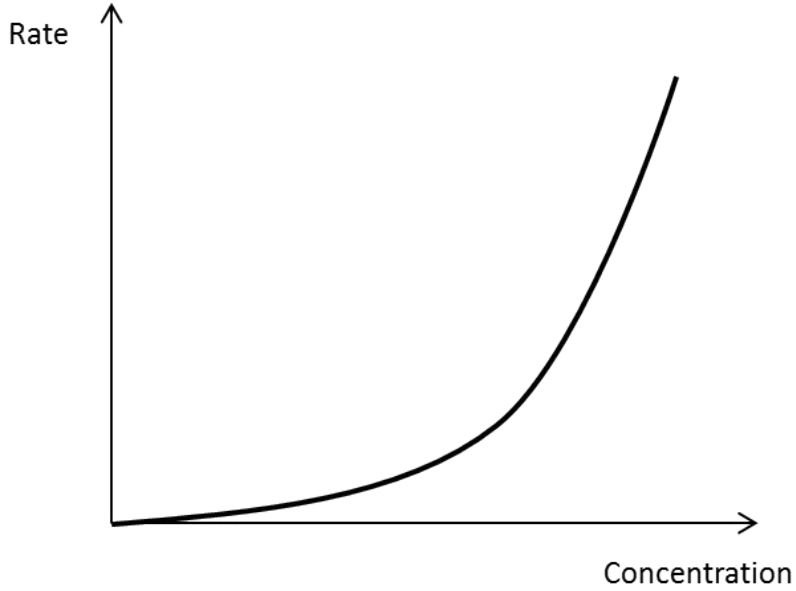
Draw a rate concentration graph for a first order reactant



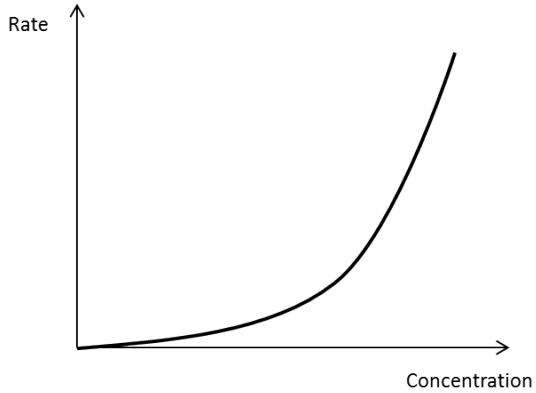
Draw a rate concentration graph from a second order reactant.

Draw a rate concentration graph from a second order reactant.

(remember you can't tell if this is second order or of an order greater than 2)



How could you confirm that this reactant was second order?



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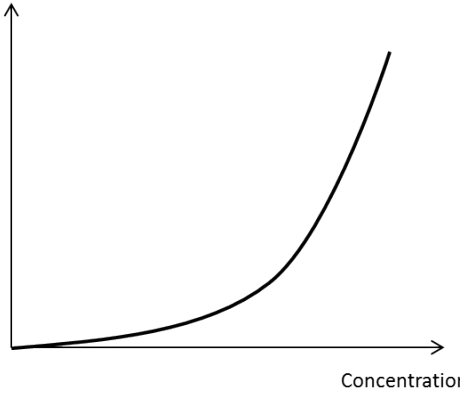
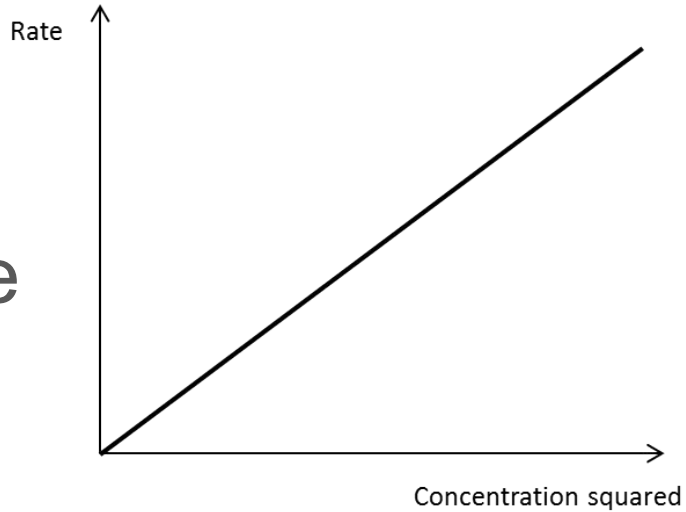


Graph of rate against concentration squared would be a straight line through the origin



How could you find the rate expression using the initial rate method?

How could you find the rate expression using the initial rate method?

Do a series of experiments, during which you vary concentrations, so the concentration of just one reactant changes each time.

Plot a graph of concentration against time for each reactant and use a tangent at t=0 to find the initial rate of reaction.

Compare rates and concentrations between each experiment to find order of reactants and overall rate equation

What must you add to react with the I_2 as it is produced for an iodine clock reaction? (equation)

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Known moles of sodium thiosulfate and a little starch; Reacts with I_2 in 1:2 ratio

$$I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^-$$

When does the starch turn a blue-black colour in an iodine clock reaction and why?

When does the starch turn a blue-black colour in an iodine clock reaction and why?

When all of the $Na_2S_2O_3$ has been used up and so I_2 is produced, which reacts with starch, leading to a blue black colour

How can you calculate the rate of reaction from the data from an iodine clock reaction?

How can you calculate the rate of reaction from the data from an iodine clock reaction?

Record time taken for colour change to occur.

Use rate = 1/t. This is effectively the initial rate

What is the effect of a 10K temperature increase on the rate of reaction, roughly?

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Doubles rate of reaction

What is true of the half life of a first order reactant (concentration against time graph)?

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Half life is constant

What is the Arrhenius equation? What does each term mean?

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

k = rate constant for reaction
A = pre-exponential factor (number of collisions between reactant molecules)
e = mathematical quantity
R = gas constant
T = temperature in Kelvin
E_A = activation energy for reaction in Joules

How can you convert the Arrhenius equation into a useful form for plotting a graph?

How can you convert the Arrhenius equation into a useful form for plotting a graph?

$\ln k = -Ea/RT + \ln A$

Graph of lnk against 1/T is a straight line:

gradient = $-E_A/R$ and y intercept is lnA

What is the rate determining step?

What is the rate determining step?

The slowest step in a reaction mechanism, which determines the overall rate of reaction

How does the rate determining step link to the species involved in the rate expression?

How does the rate determining step link to the species involved in the rate expression?

Any species involved in the rate determining step appear in the rate expression. Species only involved after the rate determining step do not appear in the rate expression