

Edexcel Chemistry A-level

Topic 16 - Kinetics II

Flashcards

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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?



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

Rate of reaction = change in concentration /
change in time



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



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

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.

Use titration to time how long it takes for the end-point to occur



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 $\text{ClO}_2 \rightarrow \text{ClO}\cdot + \text{O}\cdot$.

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



Write a generic rate expression and state what each term means

$$\text{Rate} = k [X]^x [Y]^y;$$

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?



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

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.



Define the term overall order of reaction.

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 $\text{mol dm}^{-3} \text{s}^{-1}$ 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?

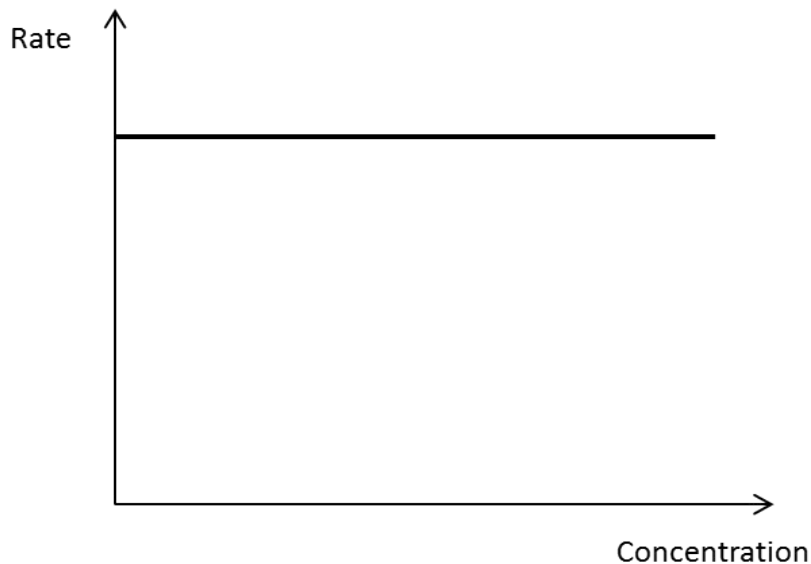
Plot $[A]$ against time, draw tangents at different values \rightarrow draw a secondary graph of rate against $[A]$



Draw a rate concentration graph for a zero order reactant.



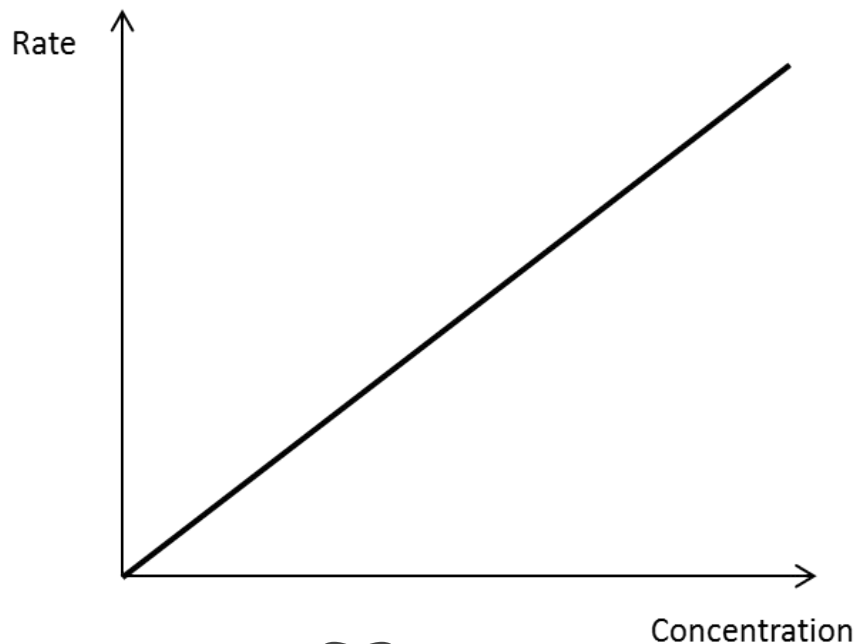
Draw a rate concentration graph for a zero order reactant.



Draw a rate concentration graph for a first order reactant



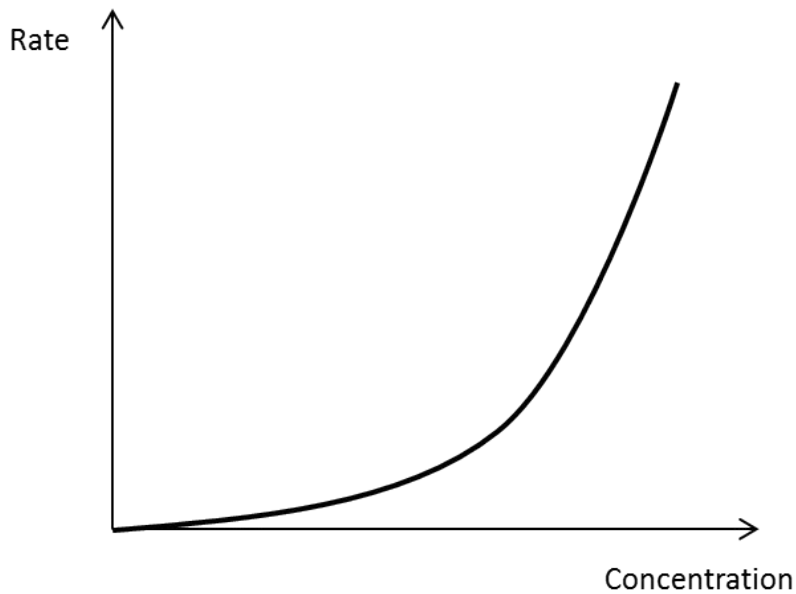
Draw a rate concentration graph for a first order reactant



Draw a rate concentration graph from a second order reactant.



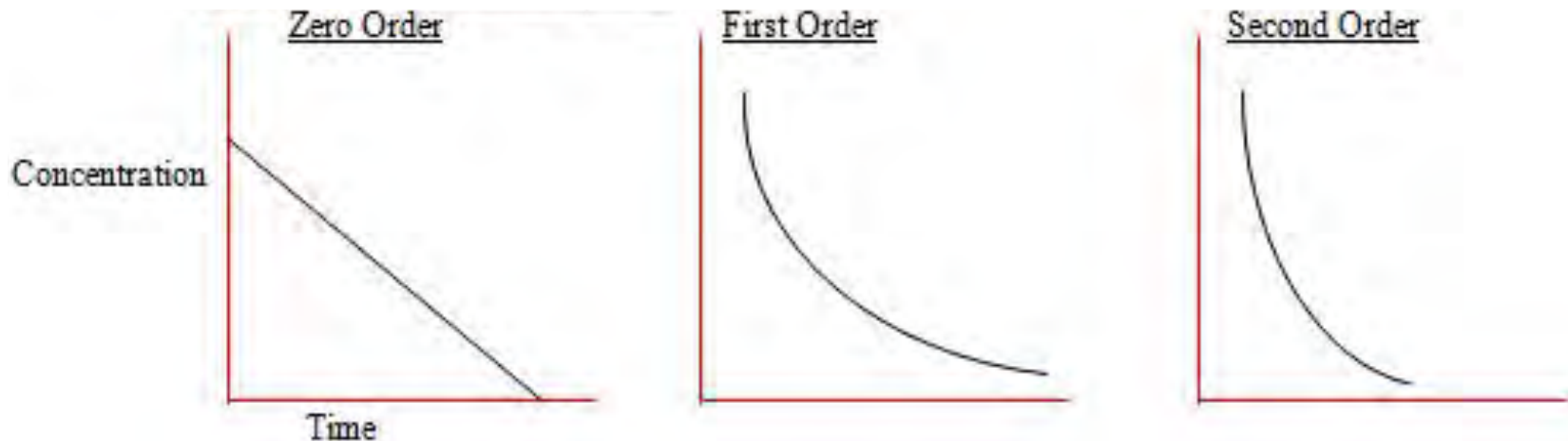
Draw a rate concentration graph from a second order reactant.



Draw the concentration time graphs for zero, first and second order reactants.



Draw the concentration time graphs for zero, first and second order reactants.

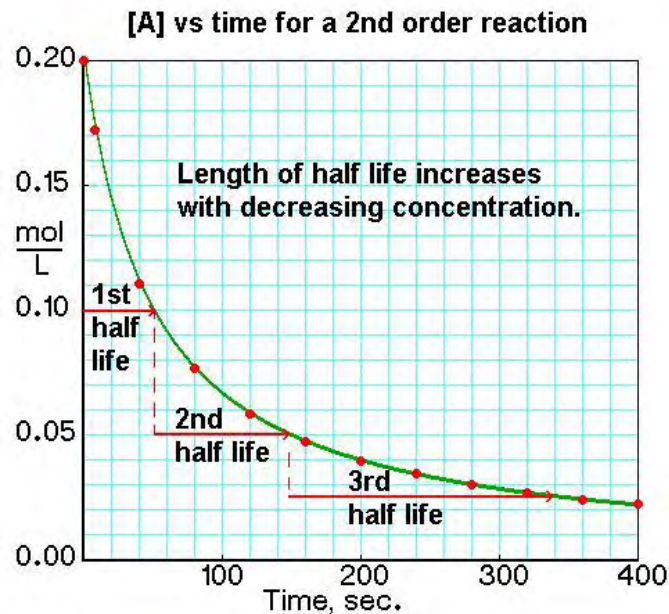
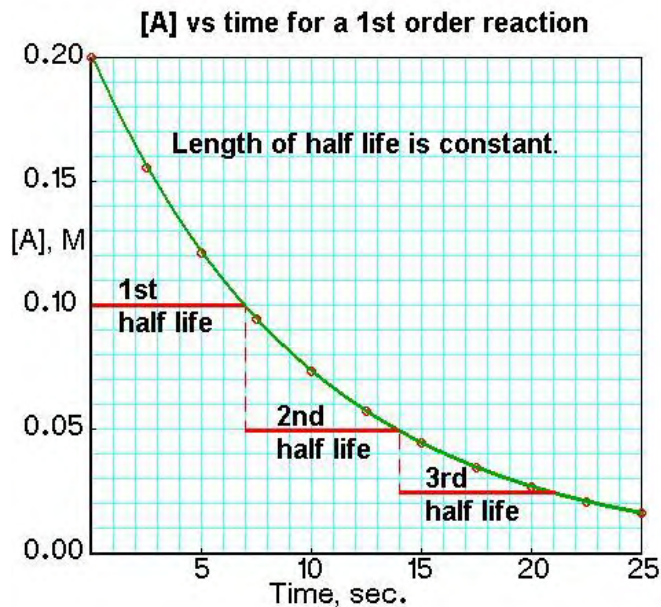


How can you tell the difference from first order and second order reactants from concentration time graphs?



How can you tell the difference from first order and second order reactants from concentration time graphs?

The concentration time graph for first order reactant has a constant half life



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

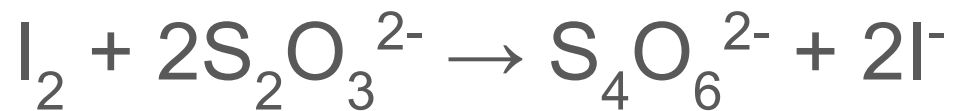


What must you add to react with the I_2 as it is produced for an iodine clock reaction?
(equation)



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

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



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 $\text{Na}_2\text{S}_2\text{O}_3$ 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?



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

Doubles rate of reaction



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

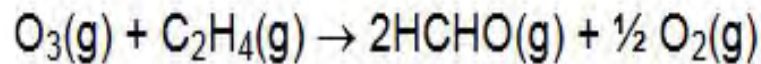


What is true of the half life of a first order reactant (concentration against time graph)?

Half life is constant



Complete this question



experiment	$[\text{O}_3(\text{g})]$ $/ 10^{-7} \text{ mol dm}^{-3}$	$[\text{C}_2\text{H}_4(\text{g})]$ $/ 10^{-8} \text{ mol dm}^{-3}$	initial rate $/ 10^{-12} \text{ mol dm}^{-3} \text{ s}^{-1}$
1	0.5	1.0	1.0
2	2.0	1.0	4.0
3	4.0	2.0	16.0

- (i) Analyse and interpret the results to deduce the order of reaction of each reactant and the rate equation.



Answer

Looking at experiment 1 and 2 the $[O_3]$ increases by 4 and the rate increases by 4 therefore its 1st order with respect to O_3 .

Looking at experiment 2 and 3 the $[C_2H_4]$ increases by 2 and the rate increases by 2 therefore its 1st order with respect to C_2H_4 .

$$\text{Rate} = k[O_3][C_2H_4]$$



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



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

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

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?

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

Graph of $\ln k$ against $1/T$ is a straight line:
gradient = $-E_A/R$ and y intercept is $\ln A$



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



Complete this question

Cyanide ions react with 2-bromo-2-methylpropane in the following way:



The rate equation for this reaction is

$$\text{rate} = k[(\text{CH}_3)_3\text{CBr}]$$

- (i) What information does this rate equation give about the mechanism of this reaction?
- (ii) Give the mechanism for this reaction consistent with the rate equation.



Answer

1st Mark

S_N1

Or

must be (at least) two steps (1)

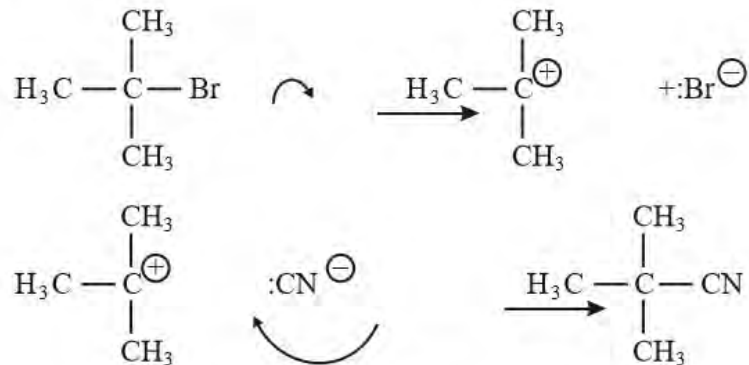
2nd Mark

only the halogenoalkane is involved in the r.d.s

OR

CN^- is **not** involved in r.d.s (1)

(ii)



Accept $(\text{CH}_3)_3\text{C}-\text{Br}$

first arrow must start from bond, not the carbon atom and not end past the bromine atom (1)

structure of carbocation (1) Br^- not essential

attack by cyanide, arrow must start from C or $-ve$ charge on C **not** N and $-ve$ charge must be present somewhere on ion; lone pair not essential (1)

IGNORE any references to rates of the steps



Complete this question

Substitution reactions of halogenoalkanes, can proceed via an S_N1 or S_N2 mechanism. When 1-bromobutane, $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$, 2-bromobutane, $\text{CH}_3\text{CH}_2\text{CHBrCH}_3$, and 2-bromo-2-methylpropane, $(\text{CH}_3)_3\text{CBr}$, are reacted separately with aqueous sodium hydroxide solution each gives the corresponding alcohol.

- (i) Give the mechanism for the S_N1 reaction between 2-bromobutane and hydroxide ions.



Answer

