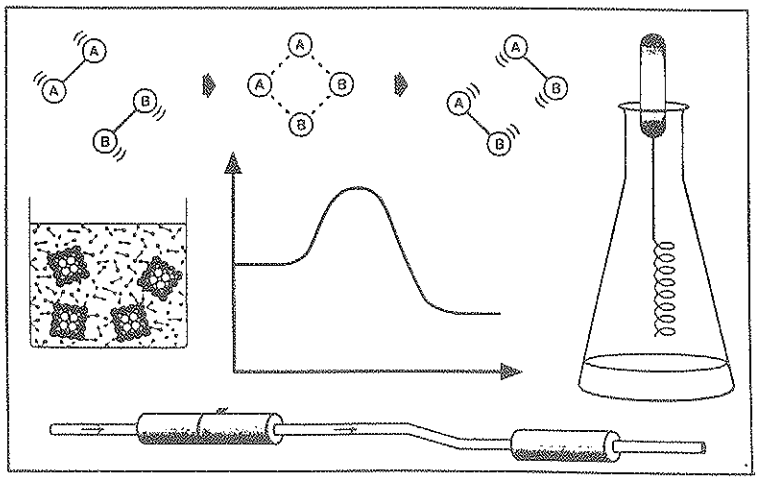
KIRKCALDY HIGH SCHOOL

CHALLENGE CHEMISTRY

– Higher –

UNIT 1: ENERGY MATTERS

SECTION 3



REACTION RATES

Name : _____

Class : _____ Teacher : _____

PROGRESS PAGE

Student:

SECTION 3: REACTION RATES

Lesson	Activities			Done	Checked
3.1 COLLISION THEORY	1	Concentration And Collisions			
	2	Particle Size And Collisions			
	3	Temperature And Collisions			
		Check Test	Score: / 8		
		Home Practice	Score: / 10		
3.2 CATALYSTS AT WORK	1	Catalytic Converters			
	2	Heterogeneous Catalysis			
	3	Homogeneous Catalysis			
		Check Test	Score: / 8		
		Home Practice	Score: / 10		
3.3 CONCENTRATION AND RATE	1	Considering The Investigation			
	2	The Experimental Work			
	3	Processing The Results			
		Check Test	Score: / 8		
		Home Practice	Score: / 10		
3.4 TEMPERATURE AND RATE	1	Considering The Investigation			
	2	The Experimental Work			
	3	Processing The Results			
		Check Test	Score: / 8		
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3.5 REACTION PROGRESS	1	Progress Of A Reaction			
	2	Calculating The Rate			
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		Check Test	Score: / 8		
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3.6 ACTIVATION ENERGY	1	Energy During Collision			
	2	Potential Energy Diagrams			
	3	Catalytic Effect			
		Check Test	Score: / 8		
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3.7 ENERGY DISTRIBUTION	1	Distribution Graphs			
	2	Concentration And Temperature			
	3	Catalytic Effect			
		Check Test	Score: / 8		
		Home Practice	Score: / 10		
CONSOLIDATION WORK		Consolidation A	Score: / 10		
		Consolidation B	Score: / 10		
		Consolidation C	Score: / 10		
		Consolidation D	Score: / 10		

END-OF-SECTION HOMEWORK	Score: %	Grade:

COLLISION THEORY 3.1

This whole section is about understanding in more detail why catalysts, concentration , temperature and particle size affect the rate of chemical reaction.

This first lesson looks at how the effects of concentration, particle size and temperature on the reaction rates can be explained in terms of collisions between reactant particles.

Learning Objectives

On completion of this lesson topic you should be able to:

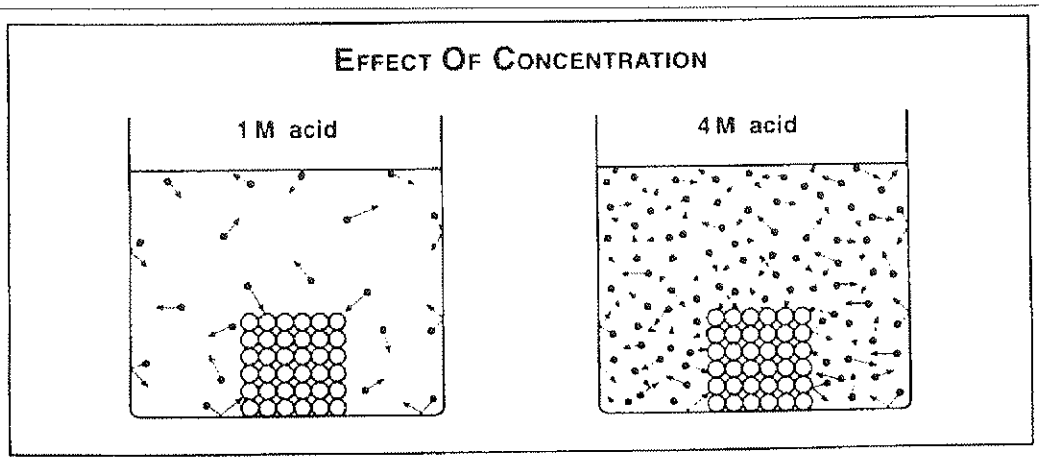
1. Give the two key points in the collision theory of chemical reactions
2. Explain in terms of collisions why increasing the concentration of a reactant increases the rate of chemical reaction.
3. Describe the effect that decreasing the particle size of a solid reactant has on its surface area.
4. Explain in terms of collisions why decreasing the particle size of a solid reactant increases the rate of chemical reaction.
5. Describe the two effects that increasing temperature has on the reactant particles.
6. Explain in terms of collisions why increasing the temperature of the reactants increases the rate of chemical reaction.

1. Concentration and Collisions

This activity looks at how collision theory can explain why the concentration of reactants affects the rate of a chemical reaction.

Collision theory states _____

_____

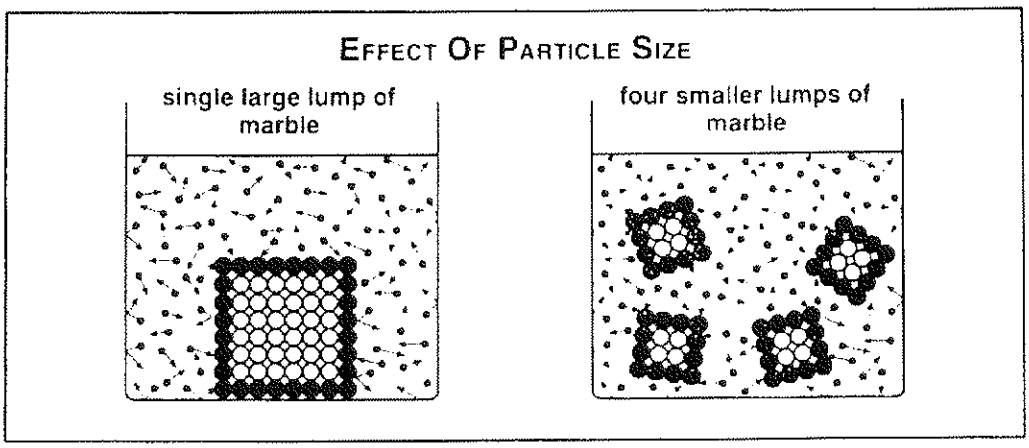


NOTE

2. Particle Size and Collisions

This activity looks at how collision theory can explain why the particle size of a solid reactant affects the rate of a chemical reaction.

'Particle' refers to lumps, grains and fine dust (all of which are made of millions of even tinier particles i.e. atoms, molecules or ions.)
In the reaction described below the only difference is the _____ _____ of the marble.



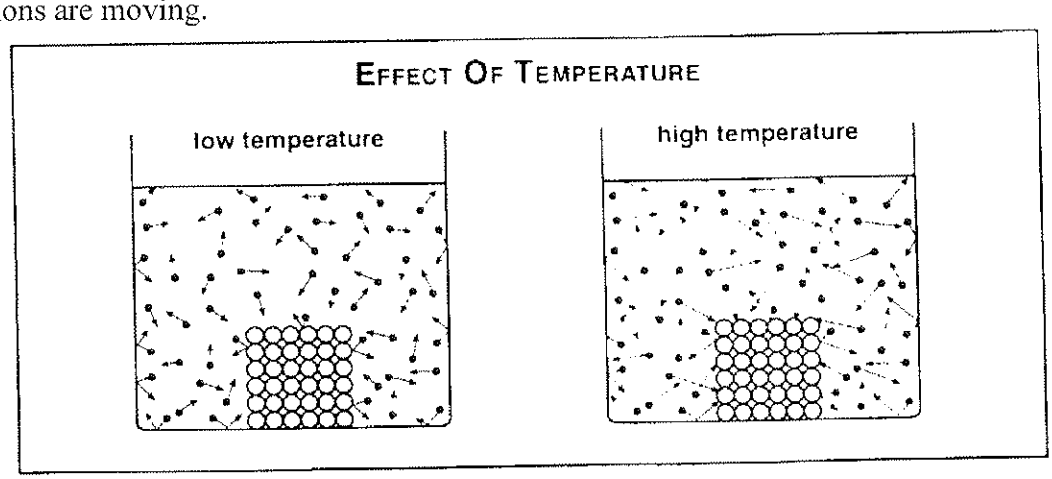
NOTE

3. Temperature And Collisions

This activity looks at how collision theory can explain why the temperature of the reactants affects the rate of a chemical reaction.

Increasing the temperature causes the reactant molecules to move faster. This means that they **collide more often** and also that they collide with **more kinetic energy** (movement energy).

In the experiment described below an increase in temperature affects the acid ions considerably since they are free to move about in the solution. The marble ions also vibrate more in the solid but they are still unable to move around. The only difference in the diagrams is the speed at which the acid ions are moving.



NOTE

SPACE FOR EXTRA NOTES

CATALYSTS AT WORK 3.2

This lesson considers catalysts at work in different kinds of chemical reactions.

Learning Objectives

On completion of this lesson topic you should be able to:

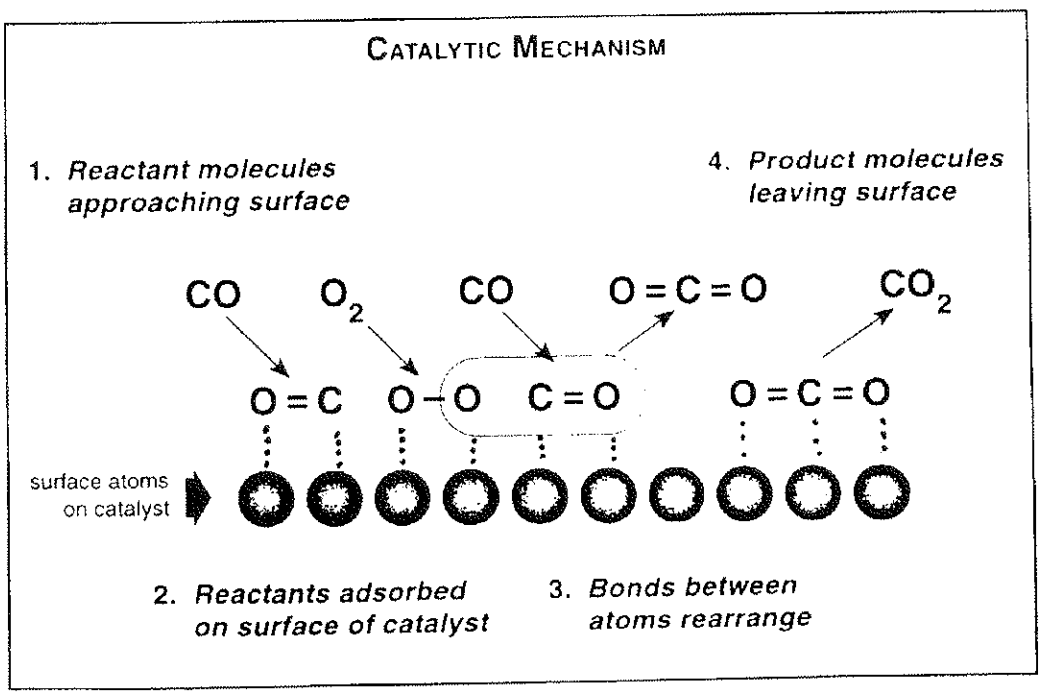
1. Explain why catalytic converters are fitted to modern cars and describe the reactions that take place in them.
2. Explain what adsorption involves and describe what happens on the surface of a solid catalyst.
3. Explain what 'poisoning' is and how it can reduce the surface activity of a catalyst.
4. Explain why lead-free petrol has to be used in cars that are fitted with catalytic converters.
5. Explain the term 'heterogeneous catalysis' and give some examples.
6. Describe what is meant by regenerating a catalyst and give an example of this in industry.
7. Explain the term 'homogeneous catalysis' and describe an example.
8. Explain what enzymes are and give some examples of enzymes in action.

1. Catalytic Converters

This activity looks at how the catalytic converter in a car exhaust system converts polluting gases into non-polluting substances.

Modern car exhaust systems are fitted with catalytic converters to get rid of polluting gases. In the two section converter the first section converts _____ __ _____ (e.g. ___ and _____) into harmless nitrogen and oxygen using _____ and _____ as catalysts. The second section converts poisonous _____ _____ into the safer _____ _____ using _____ and _____ as catalysts.

Equations

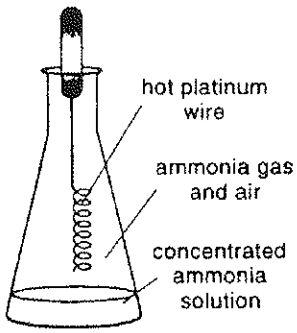


NOTE

2. Heterogeneous Catalysis

This activity is about examples of heterogeneous catalysis.

In **heterogeneous catalysis** _____.



You can tell that a reaction is taking place because _____ _____.

The reaction is exothermic because _____.

This is an example of heterogeneous catalysis because _____ _____

Examples Of Heterogeneous Catalysis			
Process	*Reactants*	*Catalyst*	*Important Product*

NOTE

3. Homogeneous Catalysis

This activity looks at examples of catalysis when the reactants and the catalyst are all in the same state, usually that of a solution.

In **homogeneous catalysis** _____.

A mixture of _____ _____ and _____ salt was warmed to ___ ^{o}C.
___ bubbles of gas were observed.
A little _____ cobalt chloride solution was added to the flask.
The solution turned to a _____ colour and _____ of gas were _____ given off.
As the reaction died down the colour of the solution changed back to _____ again.
The catalyst in this reaction was _____ _____.
We know it is unchanged at the end of the reaction because _____.
This is an example of homogeneous catalysis because _____
They are both in _____.

Enzymes are _____. They are _____
_____.

ENZYMES AT WORK		
Industry	*Enzyme or its source*	*Change achieved*
	invertase	sugar → and
wine making		→
yoghurt making		milk →
	yeast	→ beer

SPACE FOR EXTRA NOTES

CONCENTRATION AND RATE 3.3

This purpose of this lesson topic is to investigate in more detail the way that concentration of a reactant affects the rate of a chemical reaction.

Learning Objectives

On completion of this lesson topic you should be able to:

1. Describe how the reaction between iodide ions and hydrogen peroxide can be used to investigate the effect of concentration on the rate of reaction
2. Explain why starch is added to the reaction mixture in this experiment.
3. Describe how the stop-point for timing is determined.
4. Identify variables that require to be controlled in this investigation in order to obtain meaningful results.
5. State and use the expression for calculating the relative rate of reaction and give the unit used for relative rate.
6. Describe and interpret the shape of graph produced by the effect of changing the concentration of a reactant on the rate of reaction.

In acidic conditions, hydrogen peroxide reacts with potassium iodide to form water and _____:

$$H_2O_{2\,(aq)} + 2\,H^+_{(aq)} + 2\,I^-_{(aq)} \longrightarrow H_2O_{(e)} + I_{2\,(aq)}$$

The course of this reaction can be followed by carrying it out in the presence of small quantities of starch and sodium thiosulphate solutions. As the iodine molecules are produced they immediately react with the thiosulphate ions and are converted back to iodide ions:

$$I_{2(aq)} + 2\,S_2O_3^{2-}{}_{(aq)} \longrightarrow 2\,I^-_{(aq)} + S_4O_6^{2-}{}_{(aq)}$$

During this period the reaction mixture remains colourless. But once the thiosulphate ions have been used up, a _____/_____ colour suddenly appears because the iodine molecules now get the chance to react with the starch.

A series of experiments will be carried out in which only the _____ of one of the reactants will be varied. All other variables will be kept _____.

Since the number of moles of thiosulphate ions initially present will be the same in each experiment, the appearance of the blue/black colour will always represent the same extent of reaction. So if **t** is the time it takes for the blue/black colour to appear then we can take $^1/\mathbf{t}$ as a measure of the relative reaction rate.

Relative rate =

When **t** is in seconds (s), the relative rate is in ( ).

A series of experiments is carried out in which only the _____ of the potassium iodide is changed.

Conclusion : As the concentration of the potassium iodide increases the rate _____.
(Attach a copy of your assessment sheet to this pack for future reference.)

TEMPERATURE AND RATE 3.4

This purpose of this lesson topic is to investigate in more detail the way that the temperature of the reactants affects the rate of a chemical reaction.

Learning Objectives

On completion of this lesson topic you should be able to:

1. Outline how the reaction between potassium permanganate and oxalic acid can be used to investigate the effect of temperature on rate.
2. Describe how the stop-point for timing the reaction is determined.
3. Identify variables that require to be controlled in this investigation in order to obtain meaningful results.
4. State and use the expression for calculating the relative rate of reaction when investigating the effect of temperature.
5. Describe and interpret the shape of graph produced by the effect of temperature on the rate of reaction.
6. Estimate the temperature rise required to roughly double the rate of reaction.

Oxalic acid reacts with an acidified solution of potassium permanganate:

$$5\ (COOH)_{2\ (aq)} + 6\ H^{+}_{(aq)} + 2\ MnO_4^{-}{}_{(aq)} \longrightarrow 2\ Mn^{2-}{}_{(aq)} + 10\ CO_{2\ (g)} + 8\ H_2O_{(l)}$$

Initially the reaction mixture is _____ in colour due to the presence of the permanganate ions but it will turn _____ as soon as they are used up. This colour change allows us to follow the course of the reaction.

If the amount of permanganate ions initially present in a series of experiments is the same, then the point at which the _____ colour disappears will always represent the same extent of reaction. So if **t** is the time it takes for the colour change to occur then we can take 1/**t** as a measure of the reaction rate.

Relative rate =

When **t** is in seconds (s), the relative rate is in ( ).

A series of experiments is carried out in which only the _____ of the reactants is changed.

Conclusion : As the temperature of the reactants increases the rate _____.
(Attach a copy of your assessment sheet to this pack for future reference.)

REACTION PROGRESS 3.5

This lesson topic deals with some ways of following the progress of a chemical reaction.

Learning Objectives

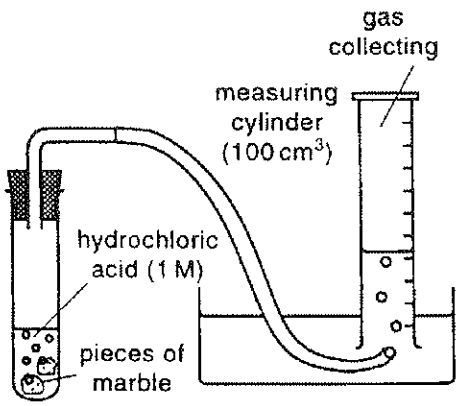
On completion of this lesson topic you should be able to:

1. Describe how the concentration of a reactant or product is affected as a reaction proceeds.
2. Outline some ways in which the progress of a reaction can be followed.
3. Plot and interpret a graph showing the progress of a reaction against time.
4. Explain how the rate of a reaction can be represented and give examples of possible units.
5. Work out the average rate of a reaction in a given time interval from a graph of reaction progress or from a given change in quantity of a substance.
6. Plot and interpret a graph showing the rate of reaction against time.
7. Compare and interpret progress graphs for reactions taking place under different conditions.

1. Progress Of A Reaction

The aim of the following experiment is to follow the progress of a reaction by recording the volume of gas produced at regular time intervals.

Equations



Some marble chips were added to hydrochloric acid as shown. The gas produced was collected and the volume measured every two minutes for ten minutes.

Gas Volume Results	
Time (min)	*Volume of carbon dioxide (cm^3)*
0	
2	
4	
6	
8	
10	

The rate of reaction is fastest when the slope of the line is _____.
As the reaction slows down the graph becomes _____ steep.

2. Calculating The Rate

This activity examines how the rate of reaction can be calculated from a progress graph.

Rate of reaction is _____.

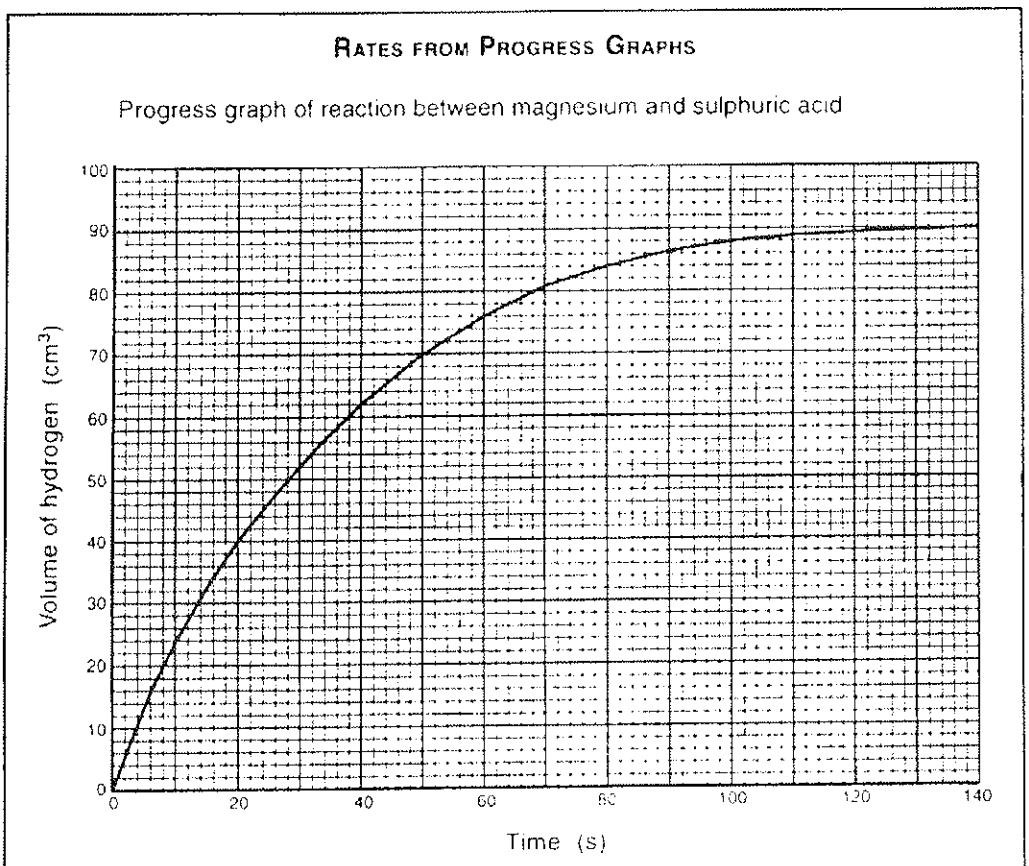
average rate =

The unit used for rate depends on the quantity which is measured. (e.g. _____, _____, _____)

It will also depend on the whether the time is in _____ , _____ or _____.

e.g. change in _____ could give units of grams per minute (g/min or g min^{-1})

change in _____ per second could give units of cm^3 s^{-1}.



Time interval (s)	*Change in volume (cm^3)*	*Average rate ($cm^3 s^{-1}$)*
0 – 20		
20 – 40		
40 – 60		
60 – 80		
80 – 100		
100 – 120		
120 – 140		

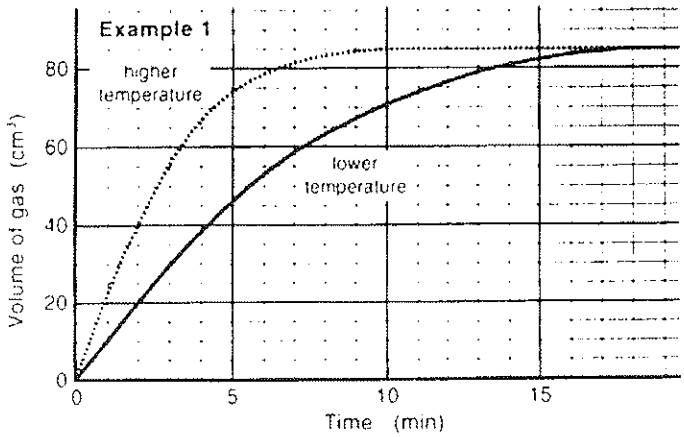
The rate of reaction is highest at the _____ of the reaction and it decreases _____.

When the reaction has stopped the reaction rate is _____.

3. Comparing Reaction Progress

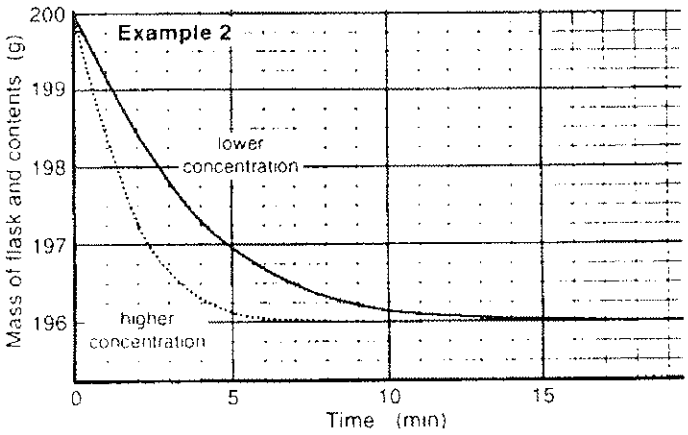
The purpose of this activity is to compare progress graphs for the same reaction taking place under different conditions.

Example 1 Hydrochloric acid + zinc at two different temperatures.



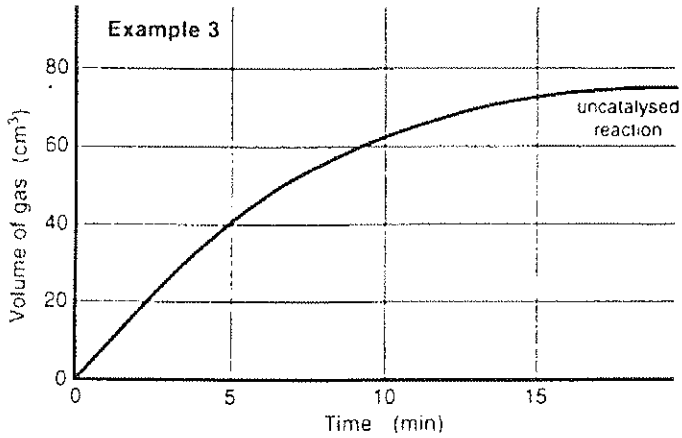
NOTE

Example 2 Marble + acid with two different concentrations.



NOTE

Example 3 Zinc + sulphuric acid with and without copper catalyst.



NOTE

SPACE FOR EXTRA NOTES

ACTIVATION ENERGY 3.6

This lesson topic explores the idea of activation energy and how it affects chemical reactions.

Learning Objectives

On completion of this lesson topic you should be able to:

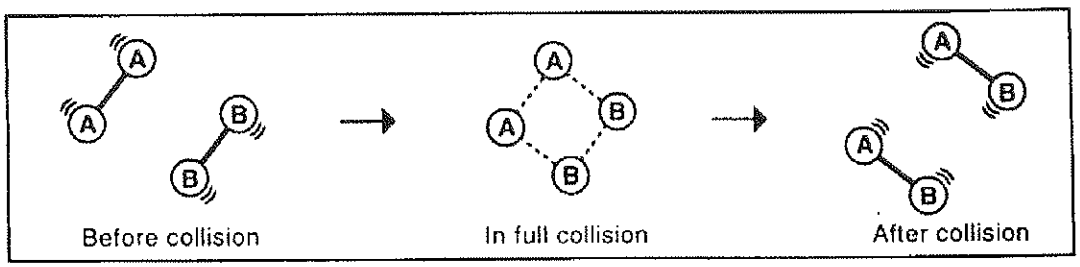
1. Draw and explain a potential energy diagram showing the energy pathway for a simple reaction.
2. Point out the activation energy and the potential energies of the reactants, products, and activated complex on a potential energy diagram for a reaction.
3. Explain the term 'activated complex' and draw a diagram of an activated complex in the reaction between two simple molecules.
4. Explain the term 'activation energy', write its symbol, and give the units used when stating activation energies.
5. Calculate an activation energy from a potential energy diagram
6. State the effect of a catalyst on : (i) the potential energies of the reactants and products, and (ii) the activation energy of a reaction.
7. Draw a potential energy diagram to illustrate how a catalyst affects the energy pathway for a reaction.

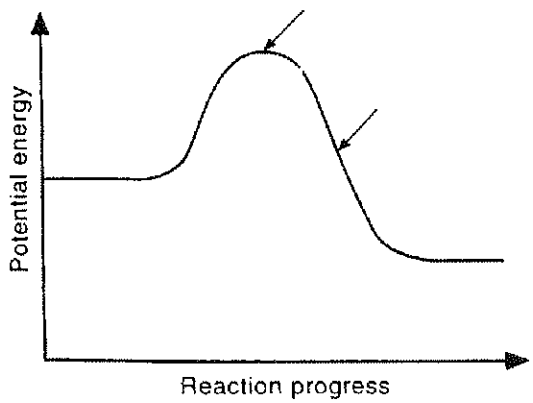
1. Energy During Collision

This activity looks at how the chemical energy of a reaction mixture changes as the reactant molecules collide and change to form the product molecules.

Two diatomic molecules, A_2 and B_2 react according to the equation below:

$$A-A \; + \; B-B \longrightarrow 2\,A-B$$





NOTE

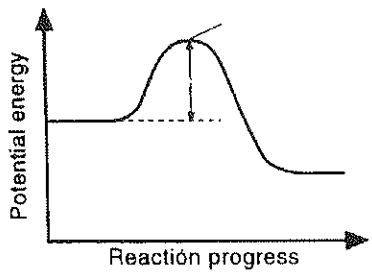
2. Potential Energy Diagrams

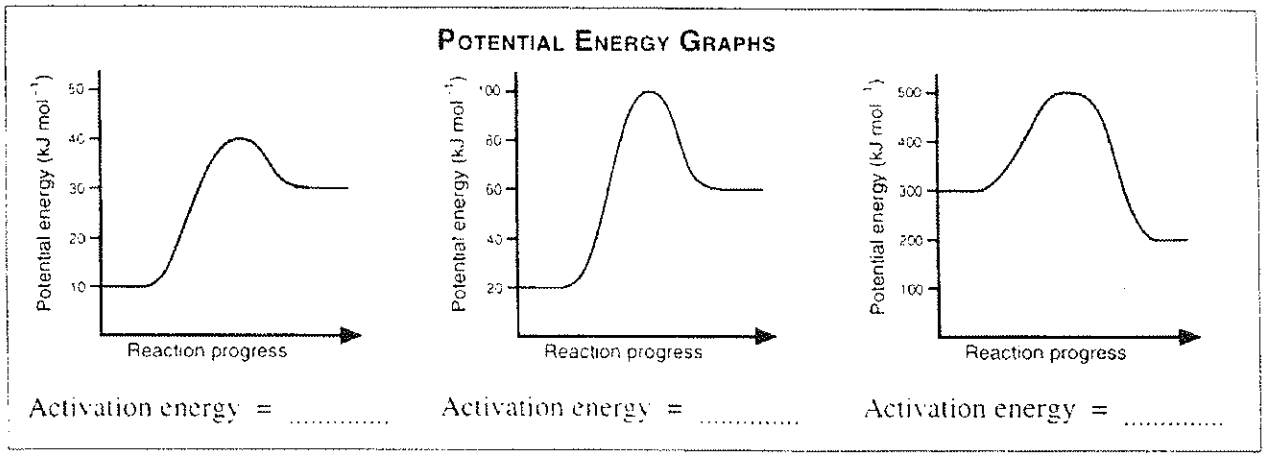
This activity looks further at potential energy diagrams for chemical changes.

An **activated complex** is _____
_____.

Activation energy is _____
_____.

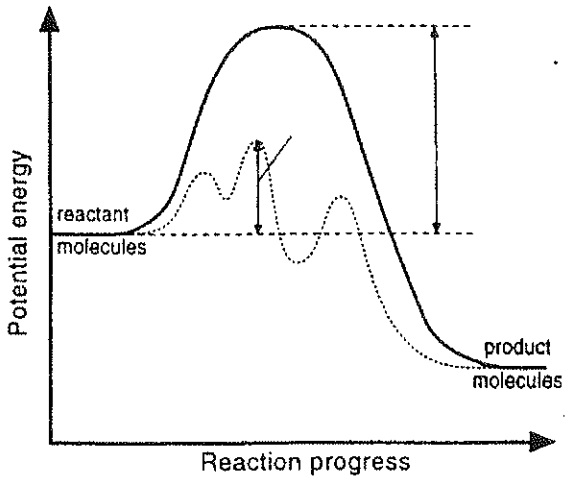
E_a = in units of _____ ( ).





3. Catalytic Effect

This activity explains the effect of a catalyst in terms of activation energy.



NOTE

SPACE FOR EXTRA NOTES

ENERGY DISTRIBUTION 3.7

This lesson looks at the effect of a distribution of kinetic energies on the rate of reaction..

Learning Objectives

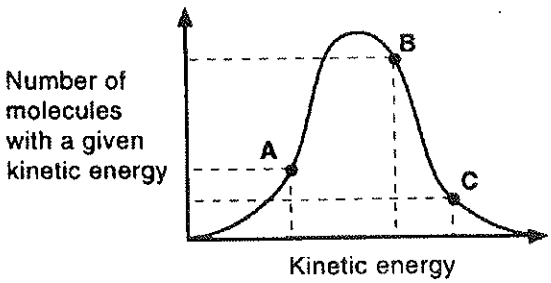
On completion of this lesson topic you should be able to:

1. Draw and explain the shape of an energy distribution graph for molecules.
2. Define activation energy in terms of kinetic energy of collisions and relate this to energy distribution graphs.
3. State why light can increase the rate of some reactions.
4. Describe temperature in terms of the kinetic energy of the particles in a substance.
5. Draw and interpret distribution graphs illustrating the effects of
   - (i) changing the concentration of a reactant,
   - (ii) changing the temperature
   - (iii) introducing a catalyst

1. Distribution Graphs

This activity looks at distribution graphs for kinetic energies.

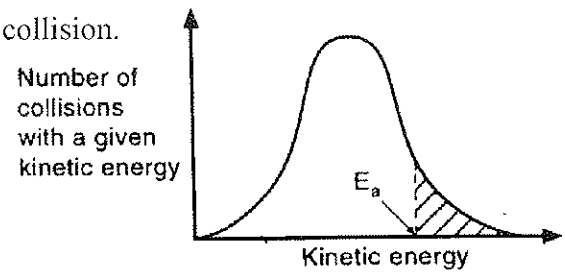
The graph shows how kinetic energy is distributed among molecules



Some molecules always have a _____ kinetic energy than the majority and some have a _____ kinetic energy. Most come in between, around about the _____ value.

Point __ represents the fewest molecules. These molecules have a _____ kinetic energy.
Point __ represents the lowest kinetic energy.

This graph shows the distribution graph for energies of collision.



For a pair of molecules to react the energy of collision must be _____
_____.

NOTE

Light can increase the rate of some reactions because _____

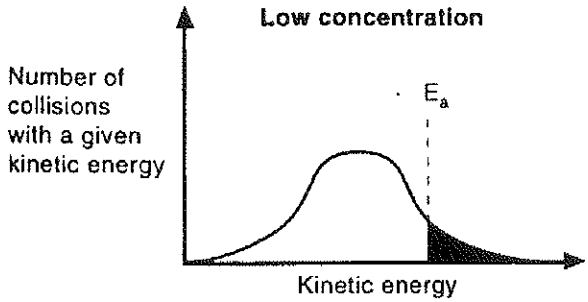
_____

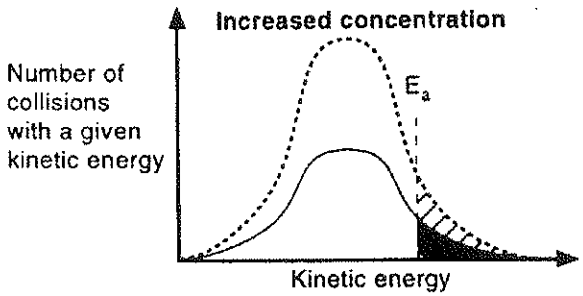
_____.

An example of this is the reaction between hydrogen and chlorine. The extra energy needed to over come the activation energy barrier can be provided by the electronic flash from a camera.
(This may be demonstrated.)

2. Concentration And Temperature

This activity looks at how increasing the concentration or increasing the temperature affects an energy distribution graph.





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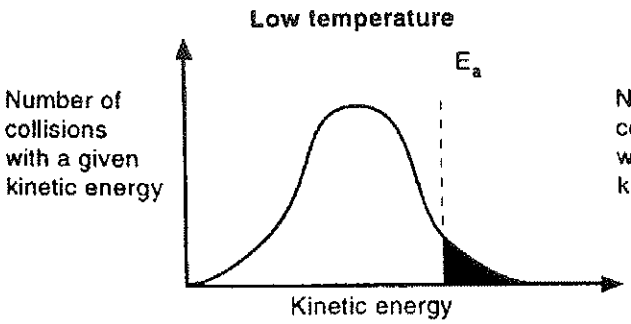
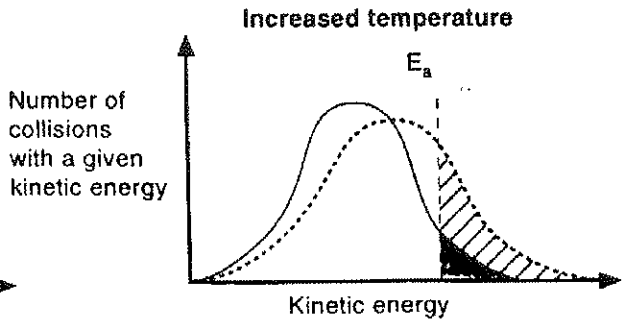
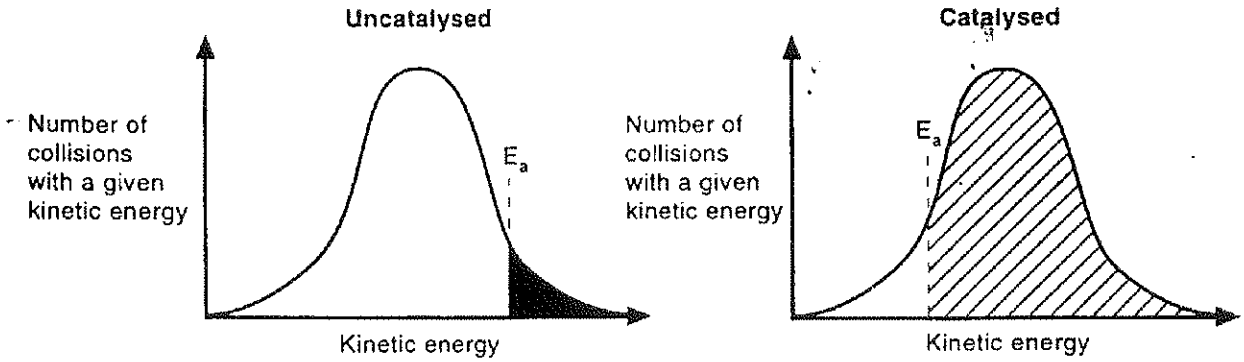




NOTE

3. Catalytic Effect

This activity explains how a catalyst speeds up a reaction without having any effect on the energy distribution of the molecules.



The concentration of the molecules and the temperature are kept the same in both the catalysed and uncatalysed reactions so the shape of the graphs will be the same.
The activation energy is lowered when a catalyst is used because it provides a different reaction pathway.

The graph shows that because of the _____ activation energy more collisions have more kinetic energy than the _____ energy. This leads to a _____ increase in the rate of reaction.

SPACE FOR EXTRA NOTES