RATES OF REACTION 06 MAY 2013

Lesson Description

In this lesson, we:

- Define and discuss the rate of a reaction
- Discuss the collision theory
- Demonstrate some factors that influence the rate of a reaction
- Explain the factors that influence the rate of a reaction

Key Concepts

Rate of Reaction

A chemical reaction is a process when one or more substances are changed into other substances with new chemical and physical properties

The rate of a chemical reaction is a measure of how quickly or slowly a chemical reaction takes place.

The rate of reaction can be measured in several ways. Namely:

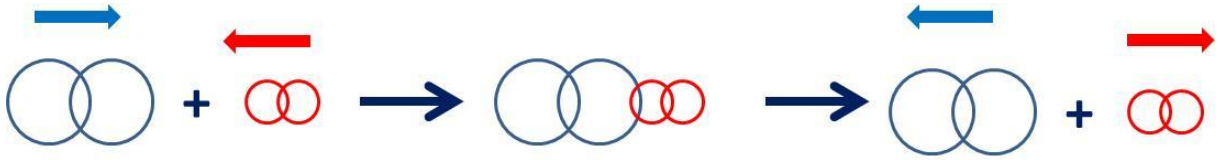
- the rate at which a gas is produced (that is the volume of the gas produced).
- the rate at which mass is lost in an open system.
- the rate at which a colour change is observed.

Collision Theory

In order for a chemical reaction to take place the particles involved need to collide with each other. For these collisions to be effective (i.e. produce the new substance) the following needs to happen:

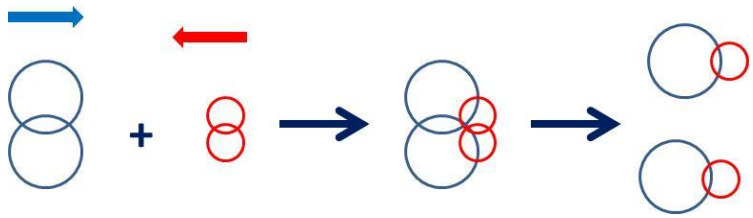
- The particles must collide with the correct orientation

  The diagram below shows two particles colliding with the incorrect orientation



  After the collisions the particles will move away as the same reactants

  The diagram below shows two particles colliding with the correct orientation



  After the collision a new substance has been formed.

- The particles must collide with sufficient energy. The minimum energy required for an effective collision is known as the activation energy. Therefore the particles must collide with energy that is equal to or greater than the activation energy.

Factors that influence the Rate of Reaction

1. Temperature

When the temperature of a reaction is increased the rate of reaction will increase too. With an increase in temperature the particles in the reaction gain more kinetic energy. This means that when the particles collide with each other they are more likely to collide with sufficient energy and thus the collision will be effective. This leads to a greater number of effective collisions and so the reaction rate will increase.

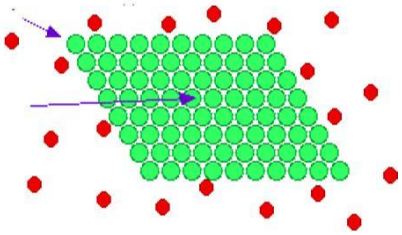
2. Concentration

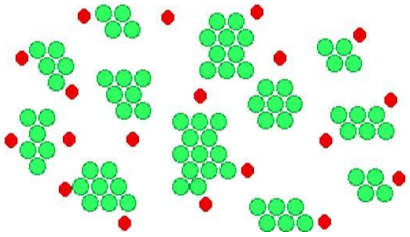
When the concentration of one of the reactants is increased it means that there are a larger number of particles taking part in the reaction. Due to the larger number of particles, there will be more collisions. A larger number of collisions will lead to more collisions having sufficient energy and the correct orientation. Thus a larger number of effective collisions will take place and the rate of reaction will increase.

3. Surface Area

The surface area of a solid is increased with the solid is crushed. This is sometimes referred to as the state of division.

When the solid is a large piece then the particles that are reacting are only the ones on the outer surface of the solid. The inner particles will only start to react once the outer particles have taken part in the reaction. Thus the reaction can be slow, as few collisions are taking place.





When the solid is crushed, more particles become available to take part in the reaction. This leads to more collisions taking place and thus a larger number of effective collisions can take place and the reaction rate increases.

4. Pressure

Pressure can only affect a reaction if at least one of the substances involved is a gas. By increasing the pressure on gas when the volume of the container is made smaller, the concentration of the gas increases. An increase in concentration will lead to an increase in the reaction rate. More particles are in smaller space and so will collide more often. This leads to a larger number of effective collisions and so the reaction rate increases.

5. Catalyst

When catalyst is introduced into a system it will lower the activation energy of the reaction. This means that less energy is required for the reaction to take place. Thus when the particles collide the amount of energy needed for an effective collision to take place is less and so a larger number of effective collisions will take place. In turn, this means that the rate of reaction will increase.

Demonstration

Aim

To investigate different factors which influence the rate of a reaction.

Apparatus

- 6 beakers
- Water
- Fizzy tablets
- Hydrochloric acid (dilute and concentrated)

Method

1.) Half fill the first two beakers with water

Into one beaker add a whole tablet and into the other add a crushed tablet

Note how quickly the reaction takes place

2.) In the next two beakers, half fill one beaker with cold water and the other with warm water.

Add a tablet to each beaker and note how quickly the reaction takes place

3.) In the next two beakers, half fill one beaker with very dilute hydrochloric acid and the other with slightly more concentrated hydrochloric acid

Add a tablet to each beaker and not how quickly the reaction takes place.

In the first demonstration the surface area of the tablet is being changed. How does the surface area affect the rate of the reaction?

In the second demonstration, the temperature of the reaction is being changed. How does temperature affect the rate of the reaction?

In the last demonstration, concentration is being changed. How does the concentration of the acid change the rate of the reaction?

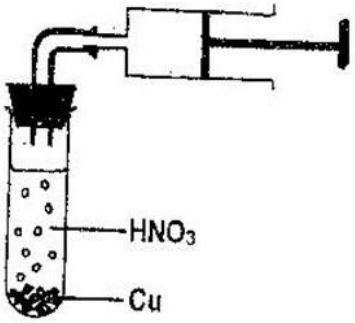
Can you explain these changes in terms of the collision theory?

Questions

Question 1

(Adapted from 2001 National Higher Grade Paper 2)

Pieces of copper are covered by an excess of concentrated nitric acid (HNO_3) in a test tube. A reddish brown gas forms in the reaction and it is noted that the contents of the test tube become hot. The test tube is connected via a tube to a syringe and the gas is collected in the syringe.



How will each of the following changes in the conditions affect the rate at which the gas develops? (Write only INCREASES, DECREASES or STAYS THE SAME)

a.) More copper is used
b.) The temperature of the acid is increased
c.) More concentrated HNO_3 is used.

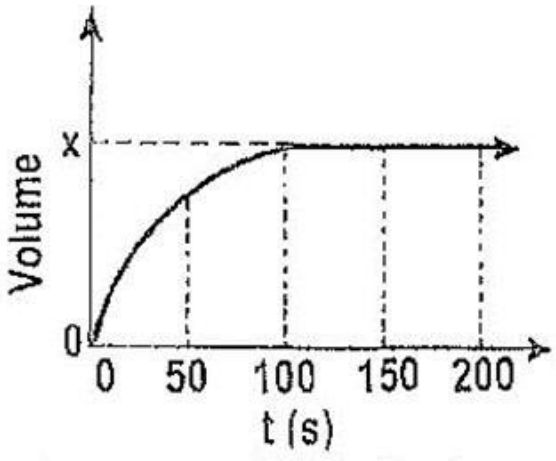
Question 2

(Adapted from 1999 Higher Grade OFS Paper 2)

A beaker contains a dilute solution of H_2SO_4 with a volume of 140 cm^3. The concentration of the acid is 0,1 $mol.dm^{-3}$ and the temperature is kept at 25°C all the time.

Na_2CO_3 powder is added to the H_2SO_4 solution and exactly neutralises the acid. The balanced equation of the reaction which takes place is:

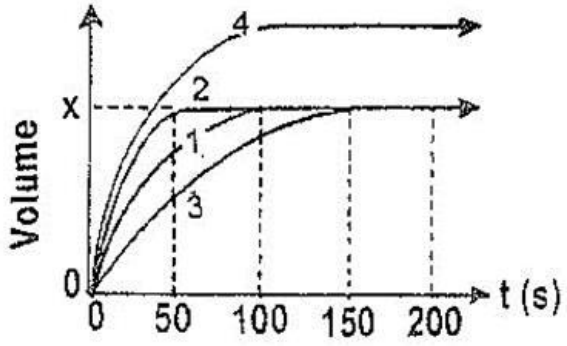
$Na_2CO_3(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + H_2O(l) + CO_2(g)$



The reaction rate of the above reaction is investigated and the following graph shows the volume of $CO_2(g)$ formed against time. The temperature is kept constant at 25°C.

a.) How long did the reaction between the two solutions take to reach completion?
b.) According the graph, the reaction rate is a maximum directly after the two reactants have been added together. Given an explanation for this.

An identical sample of Na_2CO_3 powder is added to a H_2SO_4 solution, again with a concentration of $0{,}1 mol.dm^{-3}$, in a further investigation. A catalyst is also added to the reaction mixture while the temperature is kept at 25^oC. Consider the following graphs for this:



c.) If graph 1 represents the conditions of the original investigation, which one of 2, 3 or 4 represents this investigation?

Links

1. Reaction of sodium thiosulphate and hydrochloric acid: http://www.youtube.com/watch?v=r4IZDPpN-bk
2. Rate of reaction and rate laws: http://www.youtube.com/watch?v=1jF6yOzZbws
3. Factors that affect rate of reaction: http://www.youtube.com/watch?v=S1sWvCOTUl8
4. Collision theory: http://www.youtube.com/watch?v=mBTSwJnZ6Sk