The investigation of the kinetics of chemical reactions is important in the study of physical chemistry. The temperature and the addition of a catalyst can both affect the progression of a chemical reaction.

	Learning outcomes Candidates should be able to:
8.1 Simple rate equations, orders of reaction and rate constants	a) explain and use the term *rate of reaction* b) explain qualitatively, in terms of collisions, the effect of concentration changes on the rate of a reaction **c) explain and use the terms *rate equation, order of reaction, rate constant, half-life of a reaction, rate-determining step*** **d) construct and use rate equations of the form rate = $k[A]^m[B]^n$ (for which m and n are 0, 1 or 2), including:** **(i) deducing the order of a reaction, or the rate equation for a reaction, from concentration-time graphs or from experimental data relating to the initial rates method and half-life method** **(ii) interpreting experimental data in graphical form, including concentration-time and rate-concentration graphs** **(iii) calculating an initial rate using concentration data** **(integrated forms of rate equations are not required)** **e) (i) show understanding that the half-life of a first-order reaction is independent of concentration** **(ii) use the half-life of a first-order reaction in calculations** **f) calculate the numerical value of a rate constant, for example by using the initial rates or half-life method** **g) for a multi-step reaction:** **(i) suggest a reaction mechanism that is consistent with the rate equation and the equation for the overall reaction** **(ii) predict the order that would result from a given reaction mechanism and vice versa** **h) devise a suitable experimental technique for studying the rate of a reaction, from given information**
8.2 Effect of temperature: on reaction rates and rate constants and the concept of activation energy	a) explain and use the term *activation energy*, including reference to the Boltzmann distribution b) explain qualitatively, in terms both of the Boltzmann distribution and of collision frequency, the effect of temperature change on the rate of a reaction **c) explain qualitatively the effect of temperature change on the rate constant and hence the rate of a reaction**

8.3 Homogeneous and heterogeneous catalysts including enzymes	a) explain and use the term *catalysis* b) explain that catalysts can be homogeneous or heterogeneous c) (i) explain that, in the presence of a catalyst, a reaction has a different mechanism, i.e. one of lower activation energy (ii) interpret this catalytic effect in terms of the Boltzmann distribution d) describe enzymes as biological catalysts (proteins) which may have specificity **e) outline the different characteristics and modes of action of homogeneous, heterogeneous and enzyme catalysts, including:** **(i) the Haber process** **(ii) the catalytic removal of oxides of nitrogen from the exhaust gases of car engines (see also Section 15.3(b)(i))** **(iii) the catalytic role of atmospheric oxides of nitrogen in the oxidation of atmospheric sulfur dioxide (see also Section 13.1(f))** **(iv) the catalytic role of Fe^{2+} or Fe^{3+} in the $I^-/S_2O_8^{2-}$ reaction** **(v) the catalytic role of enzymes (including the explanation of specificity using a simple lock and key model but excluding inhibition)**

Rate of reaction
OR
Reaction Kinetics

The study of speed of reaction is called reaction kinetics.
The increase in the concentration of products or decrease in the concentration of reactants per unit time is called the rate of reaction.

$$\text{Rate of reaction} = \frac{\text{Change in concentration}}{\text{Time}}$$

Unit of rate reaction is $mol\,dm^{-3}\,sec^{-1}$

Factors affecting rate of reaction in the light of collision theory

Collision theory:- According to collision theory, in order to react with each other particles must collide. If colliding particles do not have enough energy to react, an unsuccessful collision will take place.
If reacting particles have enough energy to react, they may change into products when they collide. This is called successful or effective collision.

Activation energy:- The minimum energy that colliding particles must possess in order to be converted

into products is called activation energy

According to collision theory
Rate of reaction increases if
⇒ the frequency of collisions increase
⇒ the proportion of particles with energy greater than activation energy increases.

Effect of concentration on the rate of reaction

Increase in concentration increases the rate of reaction because with the increase in concentration particles get closer together, this results in more frequent collisions between reacting particles.

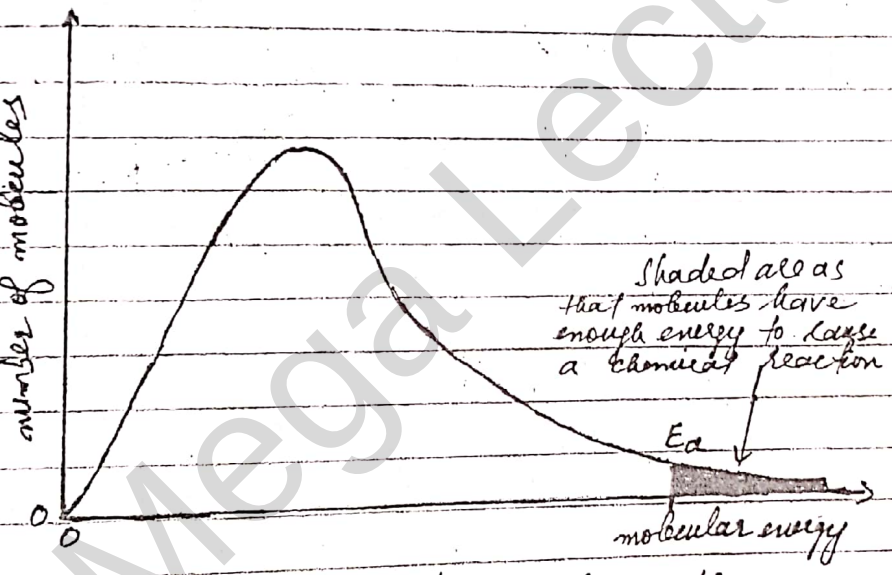
Effect of pressure (only applicable on gaseous reactions)

Increase in pressure, decreases the volume and brings particles closer together, this results in more frequent collisions between reacting particles and increases the rate of reaction.

Effect of temperature:- In order to understand the effect of temperature on the rate of reaction we need to keep in view this fact that in any substance at any given temperature, all the particles do not have

the same amount of energy. A few particles have relatively small amount of energy. A few particles have relatively large amount of energy. Most particles will have an amount of energy some where in between.

The distribution of energy at a given temperature can be shown with the help of a graph. This is called Boltzmann distribution curve.

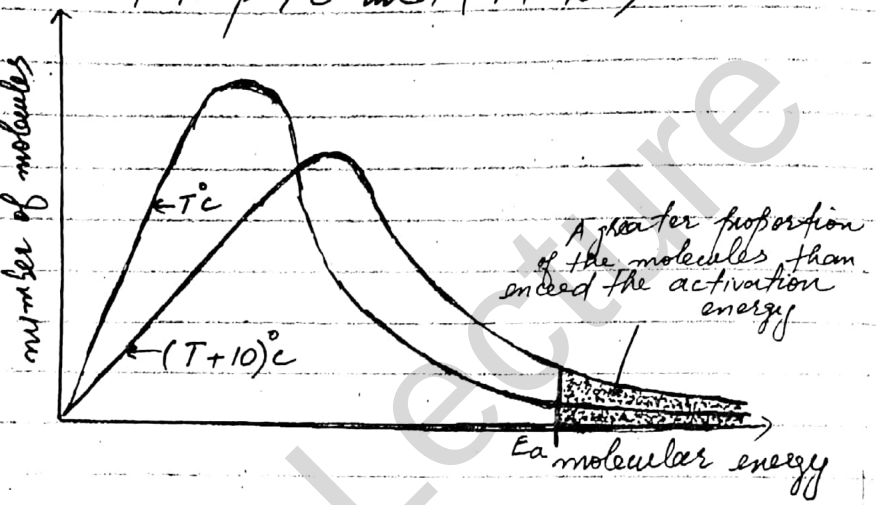


When we increase the temperature, the average kinetic energy of the particles increases, particles move faster and collide more frequently.

However experiments show us that the effect of temperature on rate of reaction cannot be totally explained by more frequent collisions. The key factor is that the proportion of successful collisions (those results in a reaction) increases because the proportion of

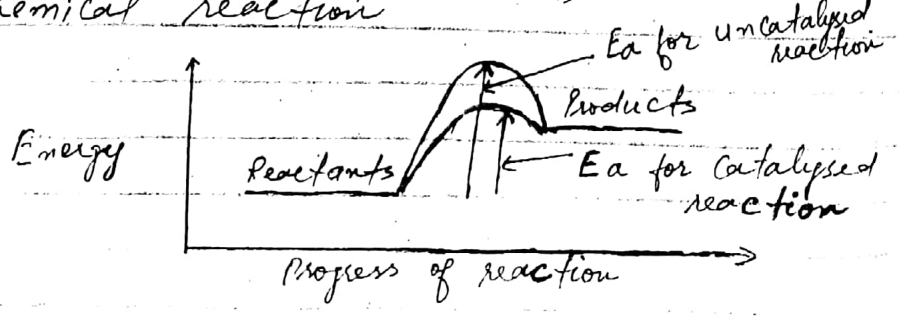
particles possessing energy greater than activation energy increases. This is the more important factor.
For a 10°c rise in temperature. the rate of a reaction doubles.

Boltzmann distribution curve of molecular energies at temp T°c and (T+10°c)

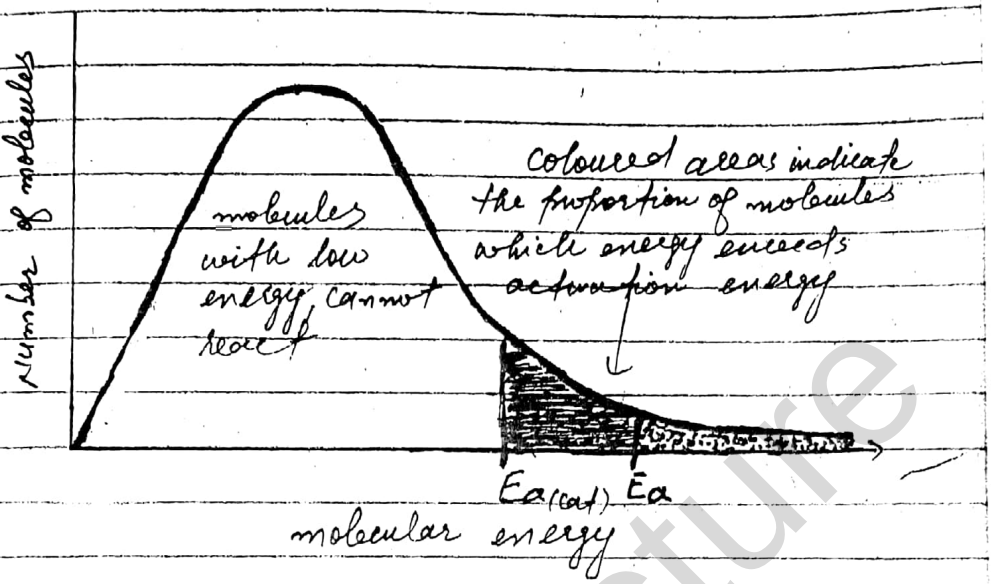


Effect of Catalyst on the rate of reaction

Catalyst is a substance which speed up a chemical reaction without being used up during reaction.
Catalyst speed up a reaction by lowering activation energy and by providing an alternate path for the chemical reaction



We can also show the effect of catalyst on a Boltzmann distribution curve



Catalyst does affect the shape of the Boltzmann distribution. However, by providing a lower activation energy a greater proportion of molecules have sufficient energy to react. The shaded areas under the curve represents the number of molecules which energy is greater than activation energy.

Enzymes as Biological catalyst

Enzymes are the biological catalysts. They are large protein molecules which speed up biochemical reactions which take place in living organisms.