CHEMISTRY ONLINE
— TUITION —

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CHEMISTRY

REVISION NOTES

KINETICS-1

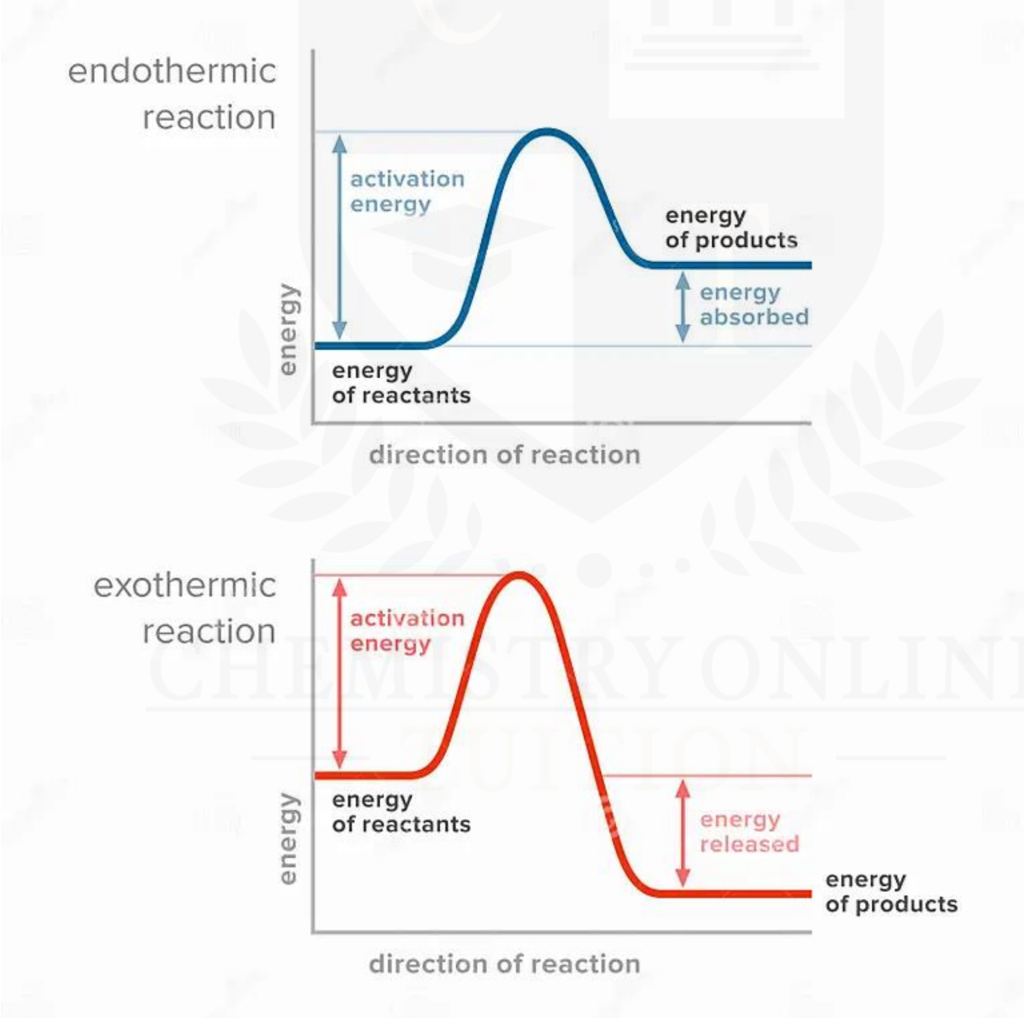
Kinetics

Collision Theory

For a reaction to occur, it is necessary for particles to collide with each other with enough energy. The energy is typically required to break the relevant bonds in one or both of the reactant molecules.
The minimum energy required for a chemical reaction to take place is referred to as the activation energy.

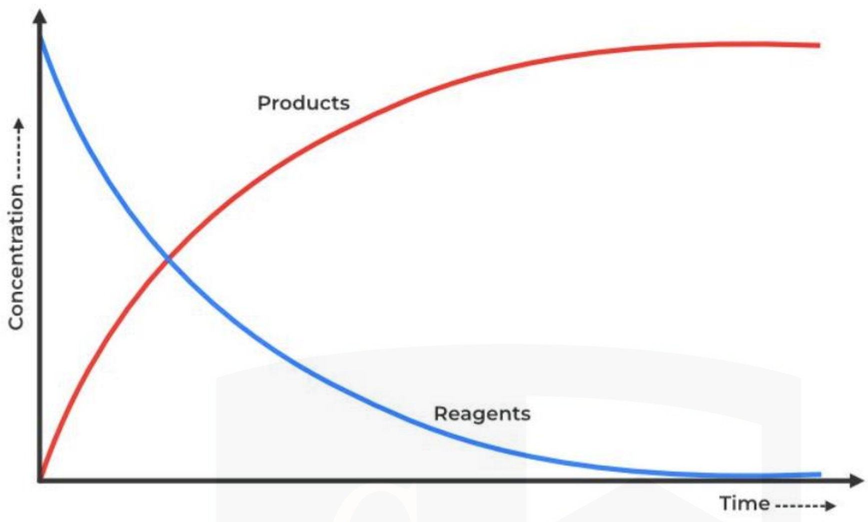
The activation energy (EA) is the minimum amount of energy required for particles to initiate a reaction through collision.

The graph below shows the activation energy for both types of reactions. You should be able to draw the energy profile diagram for both exothermic and endothermic reactions.



Measuring the rate of reaction

The rate of reaction is the change of concentration per unit time, commonly measured in mol dm^{-3} s^{-1}.

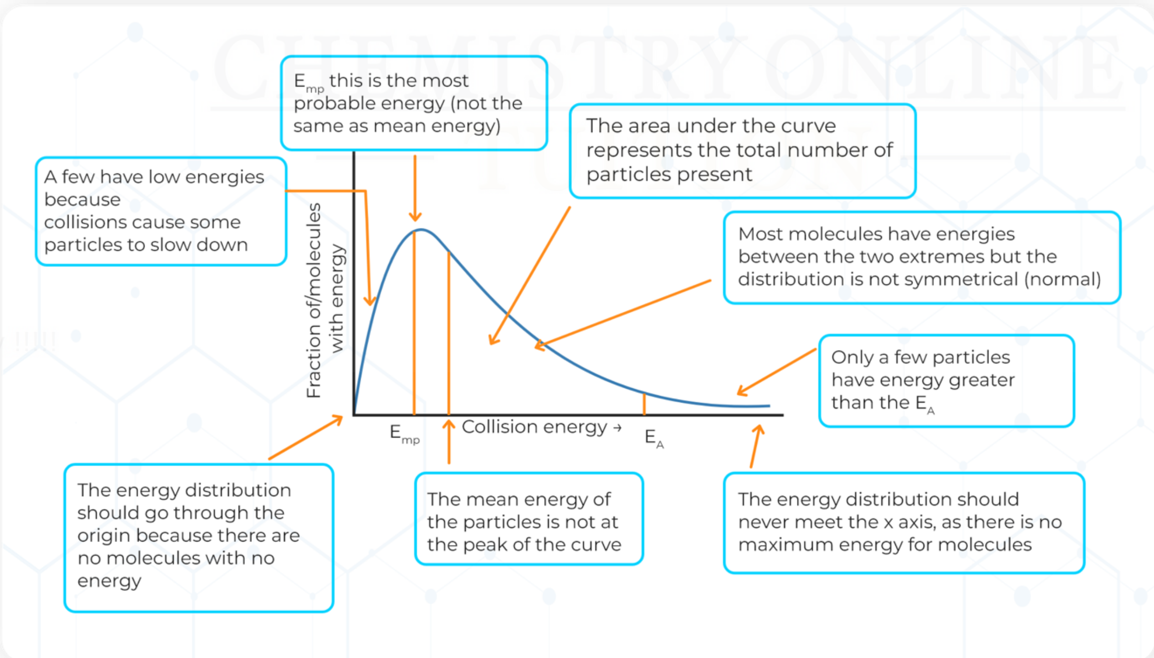


When observing the progress of a reaction, the concentration of the reactant can be plotted against time.

- The **gradient of this curve** will indicate the rate at which the reaction is taking place.
- The **initial rate** is the fastest point of the reaction, which occurs at the beginning.
- To determine reaction rates, we can draw **tangents at different points in the curve** and calculate their gradients. This allows us to calculate the rate of the reaction at each of these points.

Maxwell Boltzmann Distribution

The Maxwell-Boltzmann energy distribution illustrates the range of energies possessed by molecules in a gas or liquid at a specific temperature.



Based on the graph, we can observe the following details:

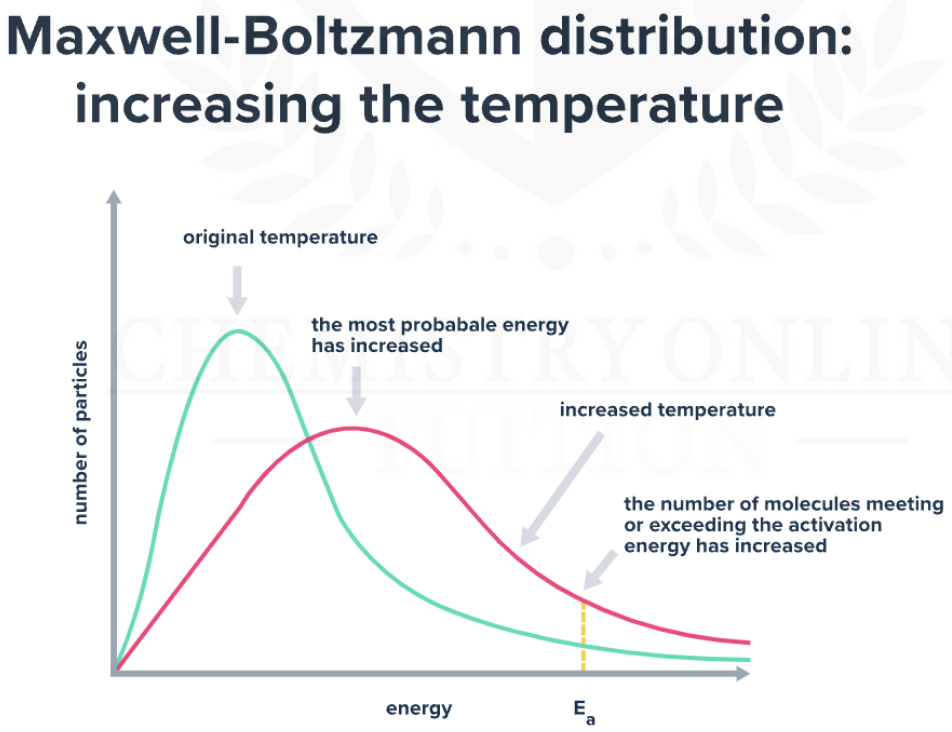
- No particles have negative or zero energy, as shown by the curve passing through the origin.
- A small proportion of particles exhibit an extremely high amount of energy, as depicted by the elongated right-hand side of the graph. It is worth noting that there is no upper bound to the amount of energy a particle can possess, and the graph continues indefinitely.
- The curve shows a large peak in the middle, indicating most particles have intermediate energy levels.

Increasing or Decreasing Temperature:

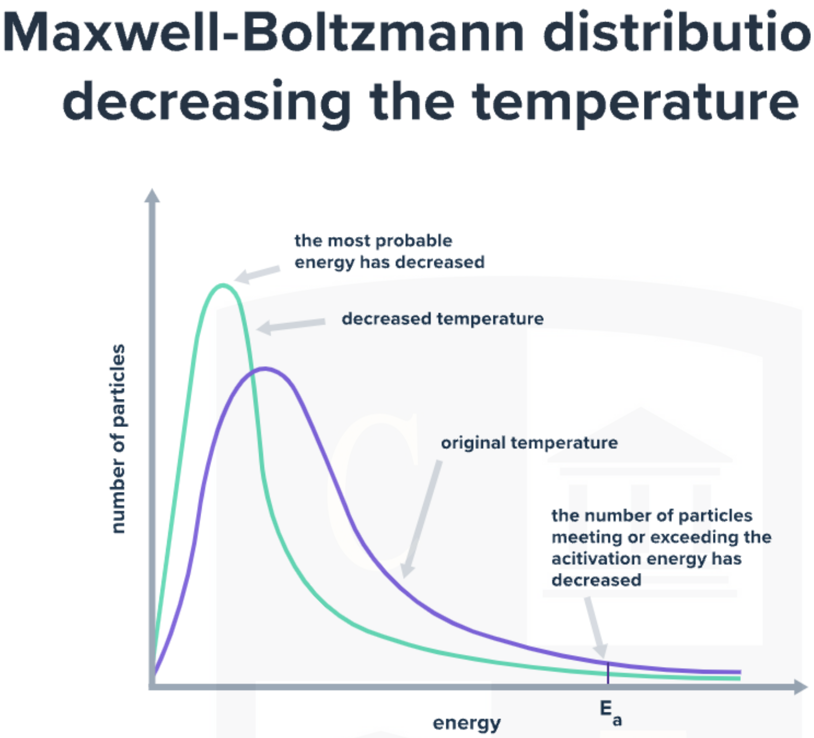
When we heat particles, we supply them with energy. This means two things.

- The particles have more energy overall, so a larger number of particles meet or exceed the activation energy.
- The particles also have more kinetic energy. On average, they move faster, and there are more collisions per second.

If you heat a gaseous system, there are more collisions per second, and on average, more of the colliding particles meet the activation energy. This means that the rate of reaction increases.

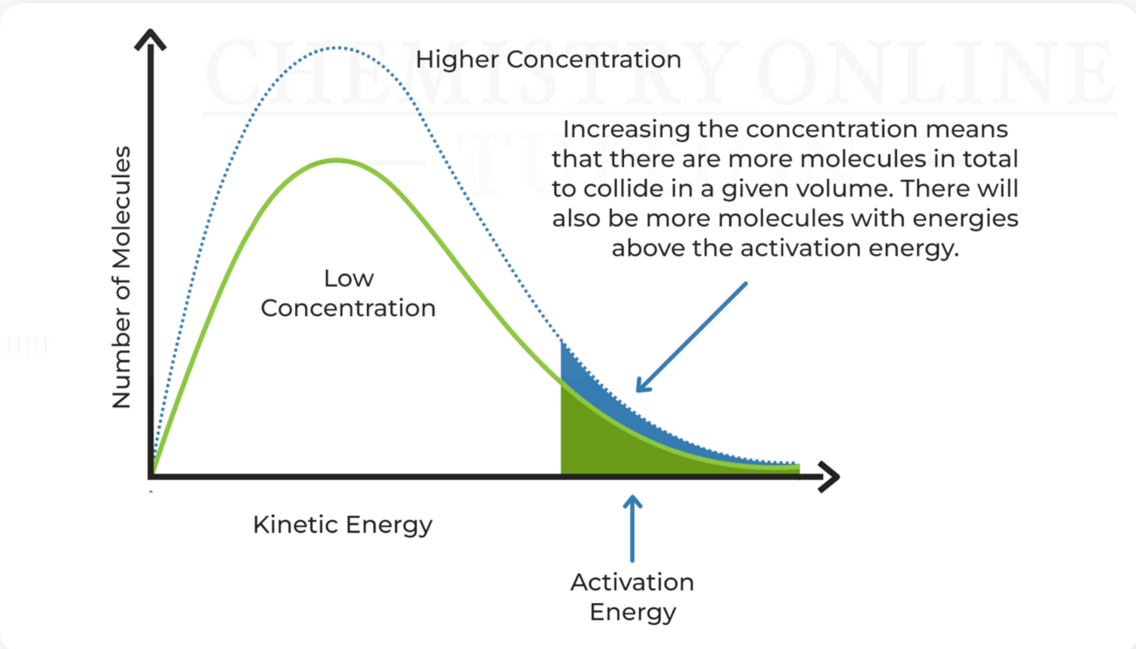


The graph depicts the Maxwell-Boltzmann distribution at a lower temperature.



Effect of Increasing Concentration and Increasing Pressure

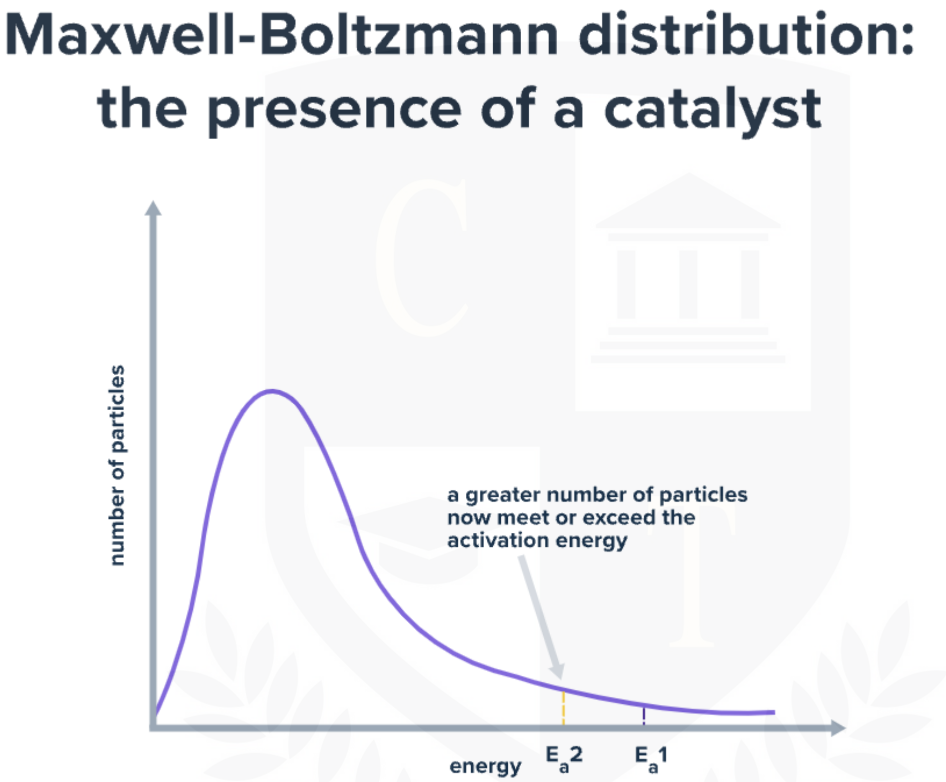
At higher concentrations and pressures, there are more particles per unit volume. As a result, the particles collide with a greater frequency and there is a higher frequency of effective collisions.



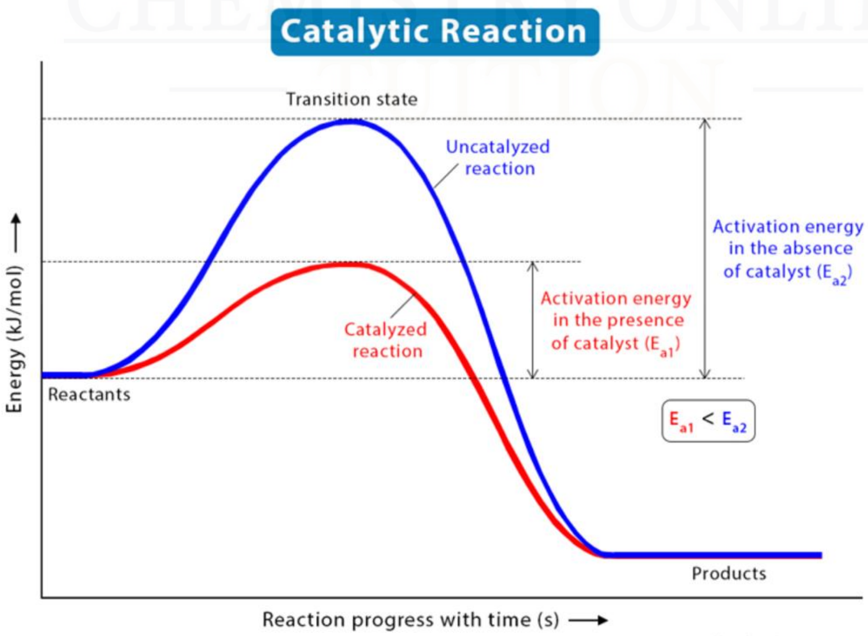
If concentration increases, the shape of the energy distribution curves remains the same, with the peak at the same energy. Therefore, both the Emp and the mean energy remain constant. The number of particles has increased, resulting in higher curves and greater area under them.

The presence of a catalyst

When a catalyst is added to a reaction, it doesn't change the energy of the particles involved. Rather, it reduces the amount of energy that's needed for the reaction to occur. This means that more particles can now meet or exceed the required energy level, thereby increasing the overall reaction rate.



Energy profile diagram if a catalyst is used



Effect of Increasing Surface Area

Increasing surface area will cause successful collisions to occur more frequently between the reactant particles and this increases the rate of the reaction.

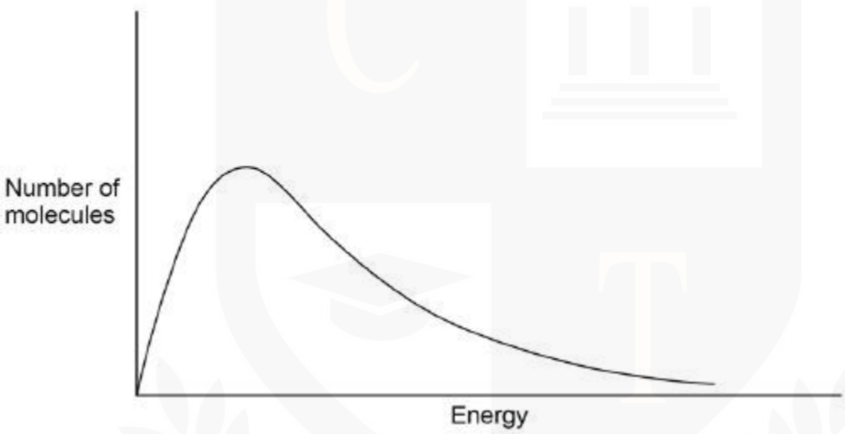
Exam Question

Nitryl chloride reacts with nitrogen monoxide according to the equation:

$$ClNO_2(g) + NO\ (g) \longrightarrow NO_2(g) + ClNO(g)$$

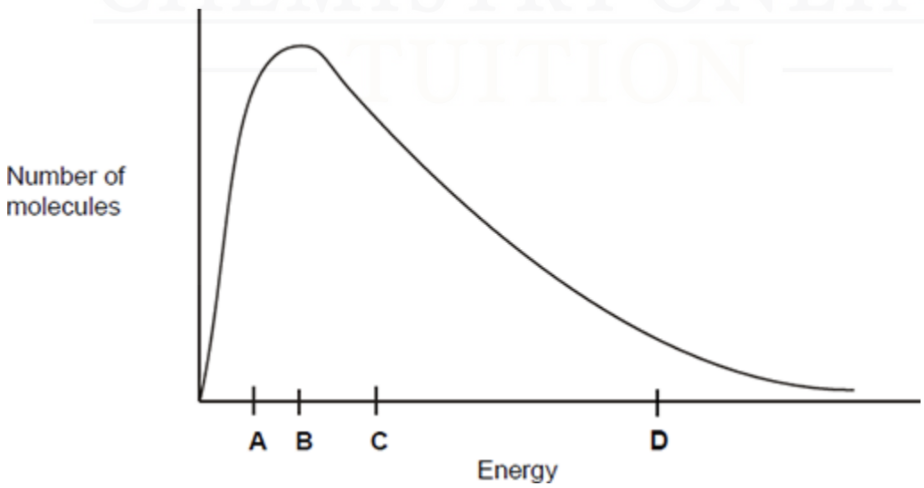
The Maxwell–Boltzmann distribution curve in **Figure 1** shows the distribution of molecular energies in 1 mol of this gaseous reaction mixture (sample **1**) at 320 K.

Figure 1



(a) On the same axes, draw a curve for sample **1** at a lower temperature.

This question is about the Maxwell–Boltzmann distribution of molecular energies in a sample of a gas shown in the figure below.



Which letter best represents the mean energy of the molecules?

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