Chemical Energetics

Saturday, October 17, 2020 3:25 PM

6.1:
Energetics of a Reaction

Energetics is the study in Chemistry which pays particular focus on how energy is transformed during reactions.

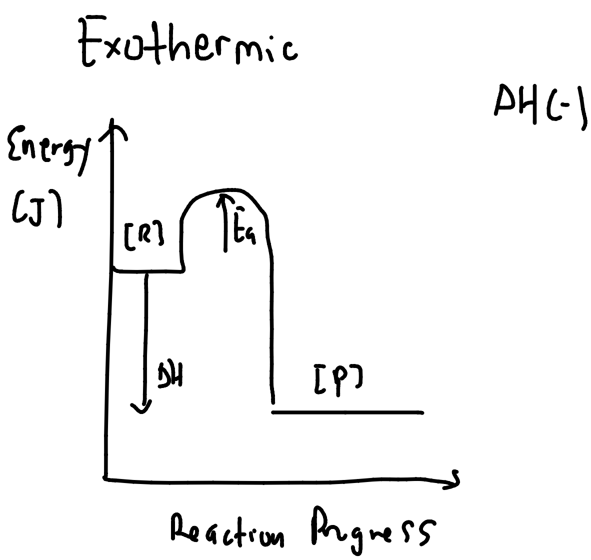
In our universe, reactions can be classified in so many ways. With that in mind, we can classify reactions into two types:
1) **Exothermic:** Reactions where energy is released from the system to the surrounding (Temperature increases)
2) **Endothermic:** Reactions where energy is absorbed from the surroundings (Temperature decreases)

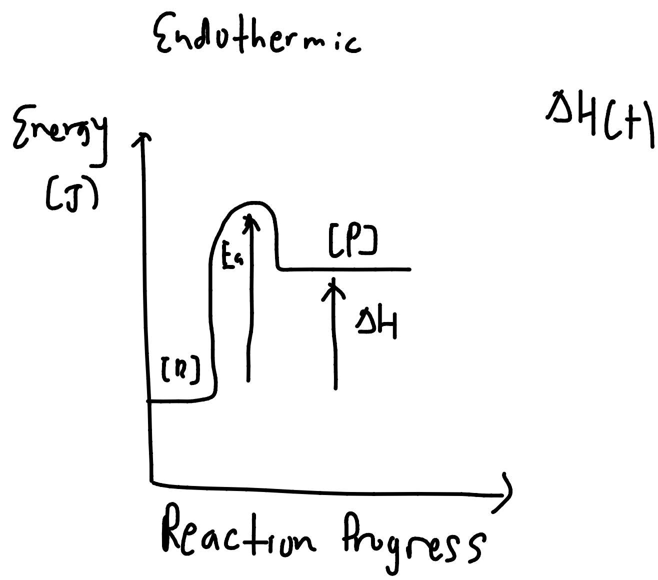
Do take note that energy released or absorbed is always relative to the system but increase or decrease in temperature is relative to surrounding. Hence, when the statement is 'temperature increases', one should understand that although energy is being released from *system to surrounding*, the surrounding's temperature increases.

The process of **bond breaking** would fall under endothermic as energy is required to break bonds whereas **bond forming** would fall under exothermic as when bonds form, energy is released.

With this information, we are able to deduce that if energy required(absorbed) to break the bonds is greater than the energy released when bonds are formed, we can classify that reaction as endothermic. Vice versa is true. If energy required(absorbed) to break bonds is lesser than the energy released when bonds are formed, we can classify that reaction as exothermic.

In energetics, we can draw **energy diagrams** to show whether or not the reaction is exothermic or endothermic.





They are several key terms to be familiar with. Before we dive into that, you might wonder why in exothermic, the energy starts of at a certain value, increases slightly then drops dramatically. Same for endothermic. It starts of at a certain value, increases dramatically then slightly drops.

This is opposite to what both exothermic and endothermic means as for exothermic, energy is released to the surrounding. Shouldn't energy increase as it is released to the surrounding as temperature increases.

One point to remember is that for energy diagrams, the 'energy' measured here is with respect to the system. Since in exothermic reactions energy is released from the system to the surrounding, the initial energy is greater compared to final.

In the energy diagram, we see something named Ea. Ea, also known as activation energy, is the minimum amount of energy required for a reaction to commence. Hence, here comes the logical part. Regardless of the fact that a reaction is exothermic, it still requires some energy for the reaction to start, which explains the small bump up. However, **the magnitude of energy released is more than energy absorbed,** or in other words, energy required for bond breaking is less than bond forming.

Hence, that is why the activation energy for endothermic is so much greater compared to exothermic reactions.

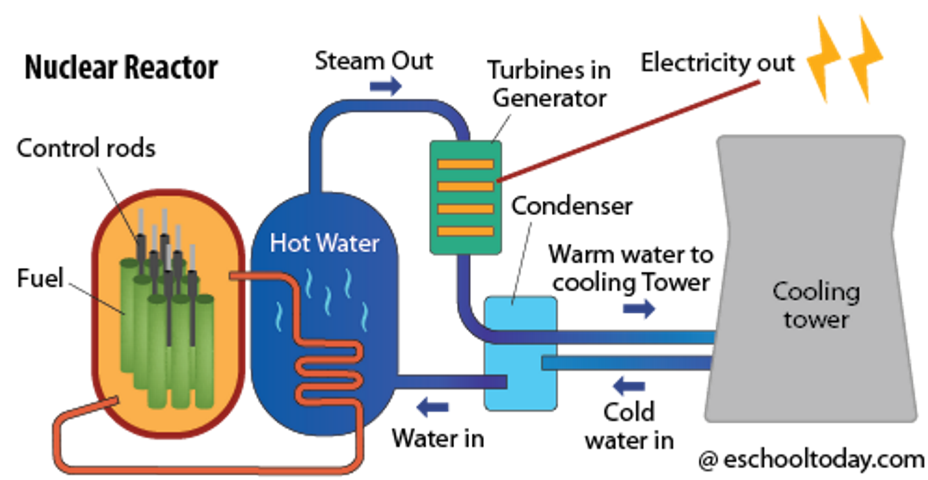
$\Delta H \rightarrow$ The change in enthalpy of a chemical reaction is a concept we discuss further in the course. However, it is worth taking note now that if delta H is negative, this signals that the reaction is exothermic and vice versa is true.

Common examples of exothermic and endothermic reactions:
- Exothermic: Combustion, respiration, neutralization, simple displacement, dissolving anhydrous salt, change of state (gas to liquid and liquid to solid)
- Endothermic: Photosynthesis, thermal decomposition, photolysis, electrolysis, dissolving ionic compound, acid + metal bicarbonate, change of state (solid to liquid and liquid to gas)

Combustion is a chemical reaction where a fuel reacts rapidly with oxygen to give of heat. In complete combustion, oxygen is in excess. The products will be that of carbon dioxide and water. However, in incomplete combustion, carbon monoxide will be produced.

This is why it is strongly recommended to avoid burning materials where air supply is very limited.

An unique example of fuel would be Uranium - 235. When it is bombarded with neutrons, it decays. During this decaying process, it releases huge amounts of energy. In a nuclear powerplant, this energy will be utilized to boil water. The steam would then pass through a turbine where it will then spin. This spinning will be used to generate electricity from kinetic energy.



https://www.eschooltoday.com/energy/non-renewable-energy/what-is-uranium.html

A common question asked in MCQ is about fuel cells. Fuel cells use hydrogen as a source of fuel. When it reacts with oxygen, **it only produces water.** This method is rather sought after as it does not produce any harmful products.

It is commonly asked as to how the raw materials of fuel cells are obtained. Hydrogen can be obtained through cracking of hydrocarbons and electrolysis of distilled water.

Oxygen is obtained through the decomposition of hydrogen peroxide.

Exam tips:

- It is extremely crucial to understand that temperature of system cannot be measured. Henceforth, temperature is always measured in **surrounding**
- Understand that in energy diagram, magnitude of energy is in the perspective of the system
- **Understand that reactions classified as exothermic do not only release energy and vice versa**. This designation is based on the **overall net energy.** No matter the reaction, energy must first be absorbed in order to break bonds(endothermic) and when bonds are formed, energy is released. Hence, if energy required to break bonds is less than energy released to form bonds, the reaction is exothermic
- Understand the concept of activation energy and that endothermic reactions has higher value for activation energy
- Remember that fuel cells **do not produce carbon dioxide**