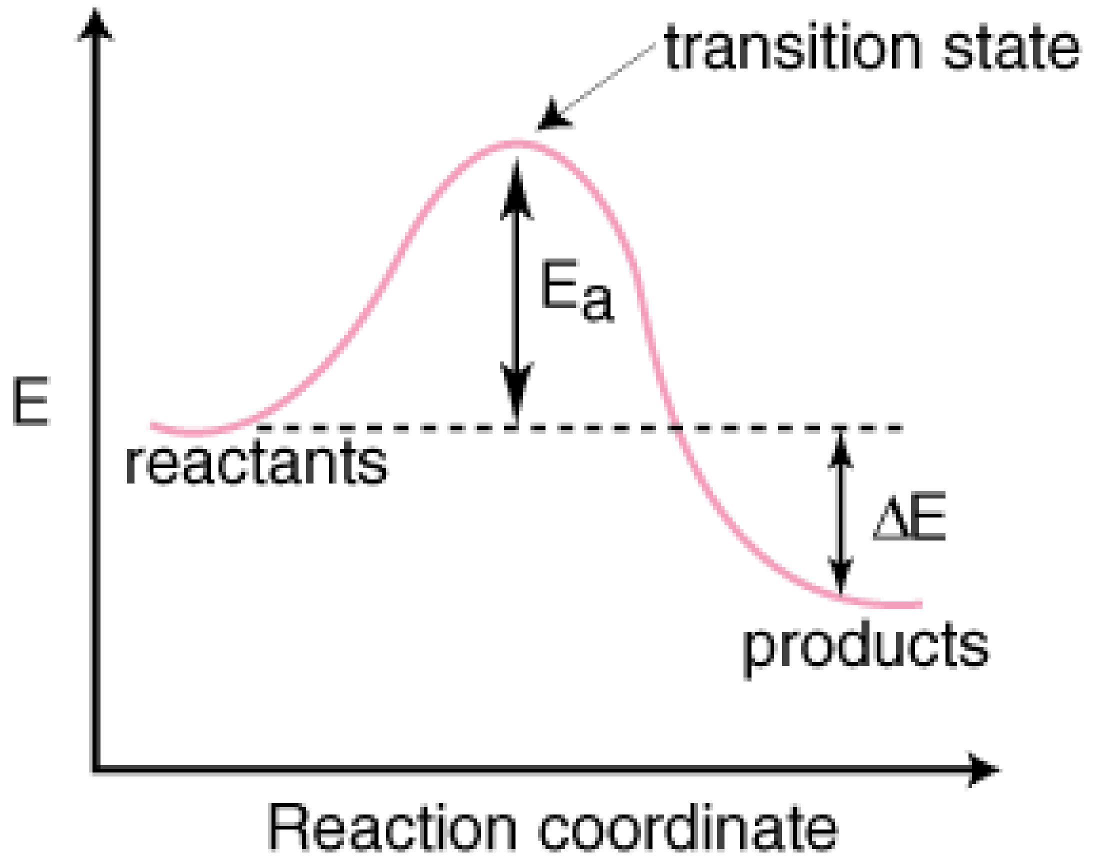
Coordinate Diagrams



Outcomes:

- Draw potential energy diagrams for endothermic and exothermic reactions.

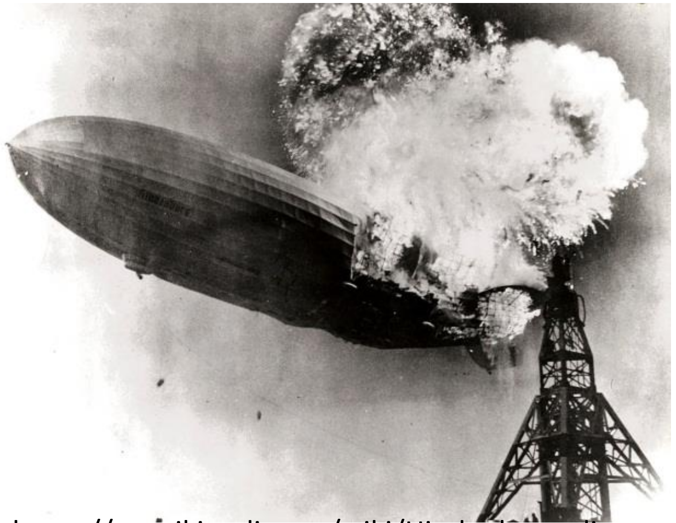
Coordinate Diagrams:

Activation Energy (E_A):

- For a reaction to occur, particles must collide with enough **ENERGY** to break and make bonds.
- The minimum amount of **K.E**. that particles need to produce a reaction is the **ACTIVATION ENERGY** ***(E_A).***
- The greater the **E_A**, the **SLOWER** the reaction rate.

Example:

- H_2 and O_2 can be kept in the same container at room temperature without reacting.
- If mixture is heated to 800°C, or a spark is introduced, they will react explosively. (now have the **NEEDED** **E_A**).

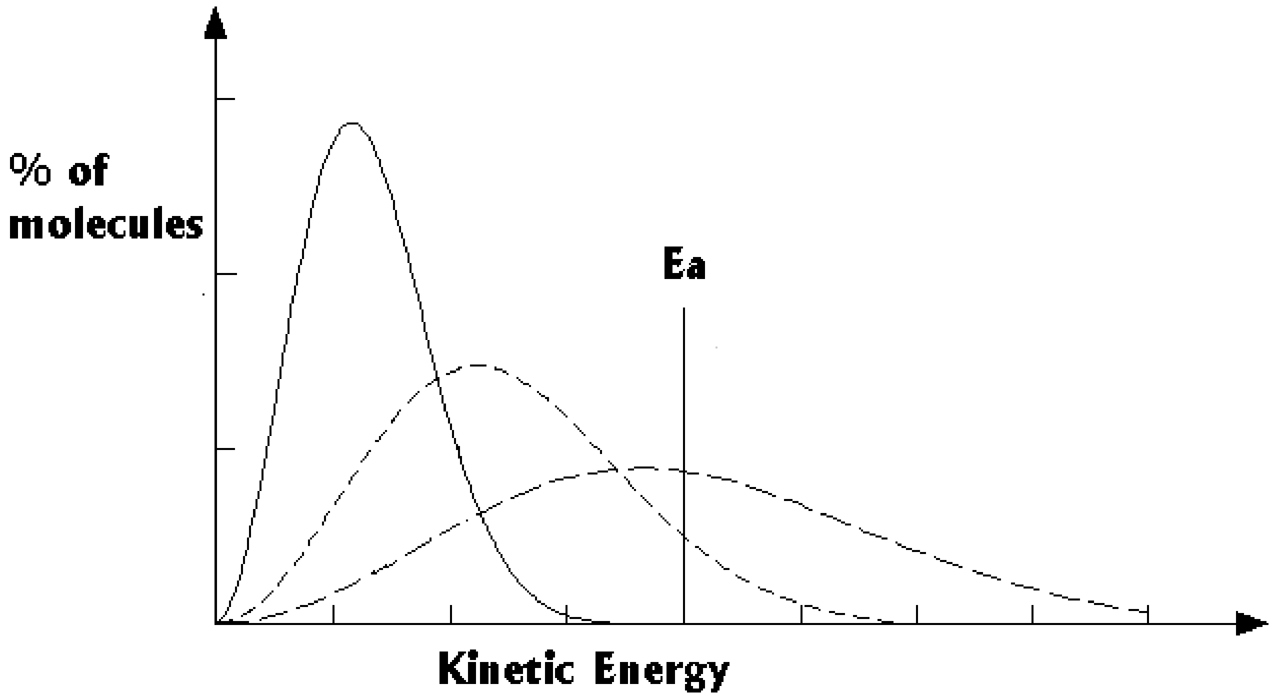


https://en.wikipedia.org/wiki/Hindenburg_disaster

Coordinate Diagrams:

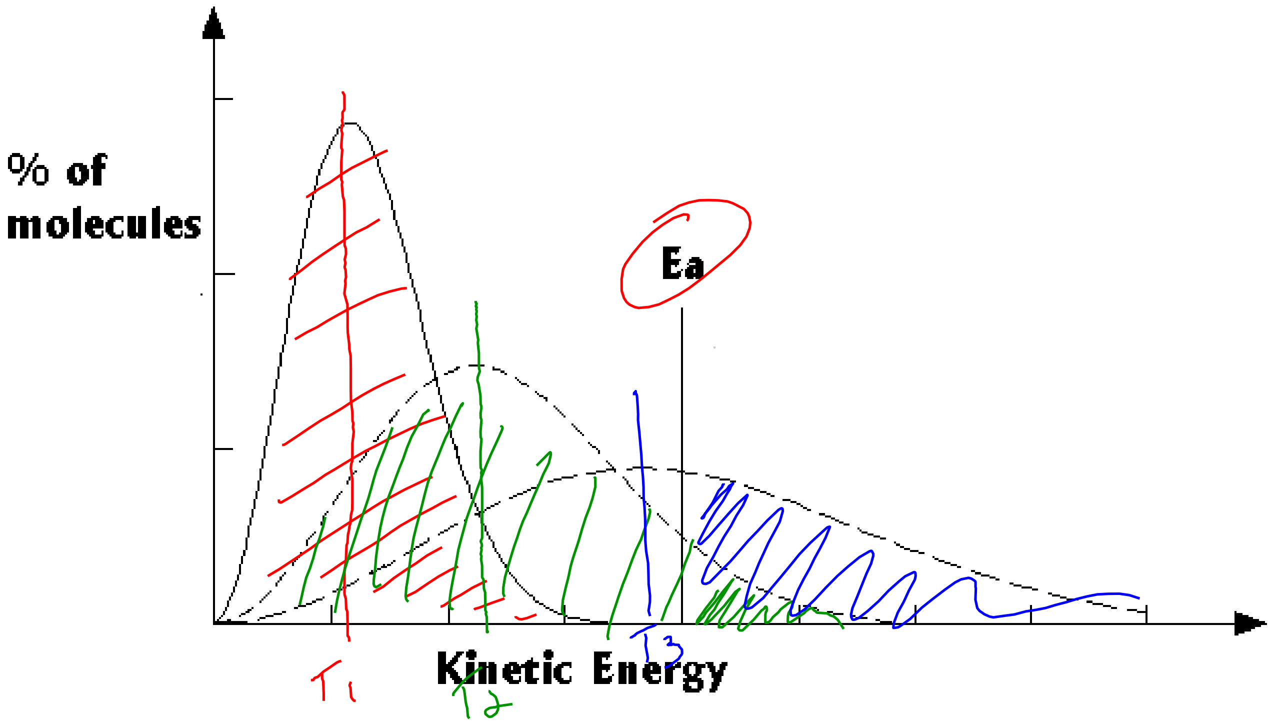
Kinetic Energy (Maxwell-Boltzman) Distribution:

- James Maxwell and Ludwig Boltzman found that not all particles have the same **VELOCITY** at a given **TEMPERATURE**.
- Some particles move **FAST**, others move **VERY** **SLOW**.
- Recall that **TEMPERATURE** is just the average **K.E.** of particles.
- They plotted a curve to reflect varying **K.E.'S**:



Coordinate Diagrams:

$KE = \frac{1}{2}mv^2$



- The area under the curve represents the **NUMBER OF PARTICLES AT A GIVEN KINETIC ENERGY**.
- The area under the curve to the right of the E_a line represents the **NUMBER OF PARTICLES WITH ENOUGH ENERGY TO REACT**.
- As temperature (K.E.) increases, so does the number of **PARTICLES WITH SUFFICIENT K.E. TO REACT**.

Coordinate Diagrams:

Enthalpy (H):

- Is the total **ENERGY** (**HEAT CONTENT**) possessed by particles in a system.
- The energy released or absorbed by a reaction is called the **CHANGE IN ENTHALPY *(ΔH)*** or **HEAT OF REACTION**, and is measured in Joules (J).

$$\Delta H = H_{products} - H_{reactants}$$

- If *ΔH* is **NEGATIVE**, heat flows out of the system, so the reaction is **EXOTHERMIC*.***
- If *ΔH* is **POSITIVE**, heat flows into the system, so the reaction is **ENDOTHERMIC*.***

Coordinate Diagrams:

Reaction Coordinate Diagrams:

- A.K.A **POTENTIAL ENERGY *(E_p)* DIAGRAM**.
- Represents the **ENERGY CHANGE** that occurs during a chemical reaction.
- Energy changes in reactions are like **ROLLER COASTERS**
  - Beginning of the ride is **LONG**, **SLOW** and **UPHILL**.
  - Once cars reach the top, they have enough **ENERGY** to complete the ride.

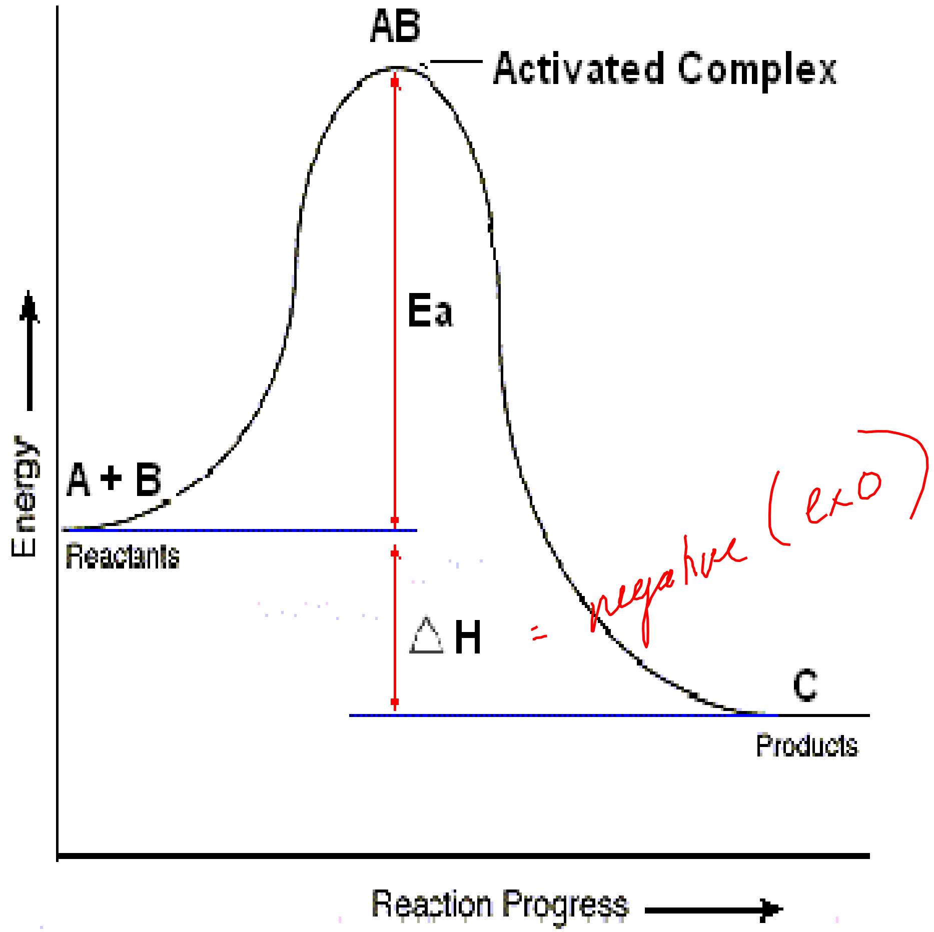
Activated Complex:

- Reactants with the appropriate amount of **ACTIVATION ENERGY** for the reaction to proceed.
- In a chemical reaction, energy is added to overcome the E_A, and to form the **ACTIVATED COMPLEX**.

Coordinate Diagrams:

Example:

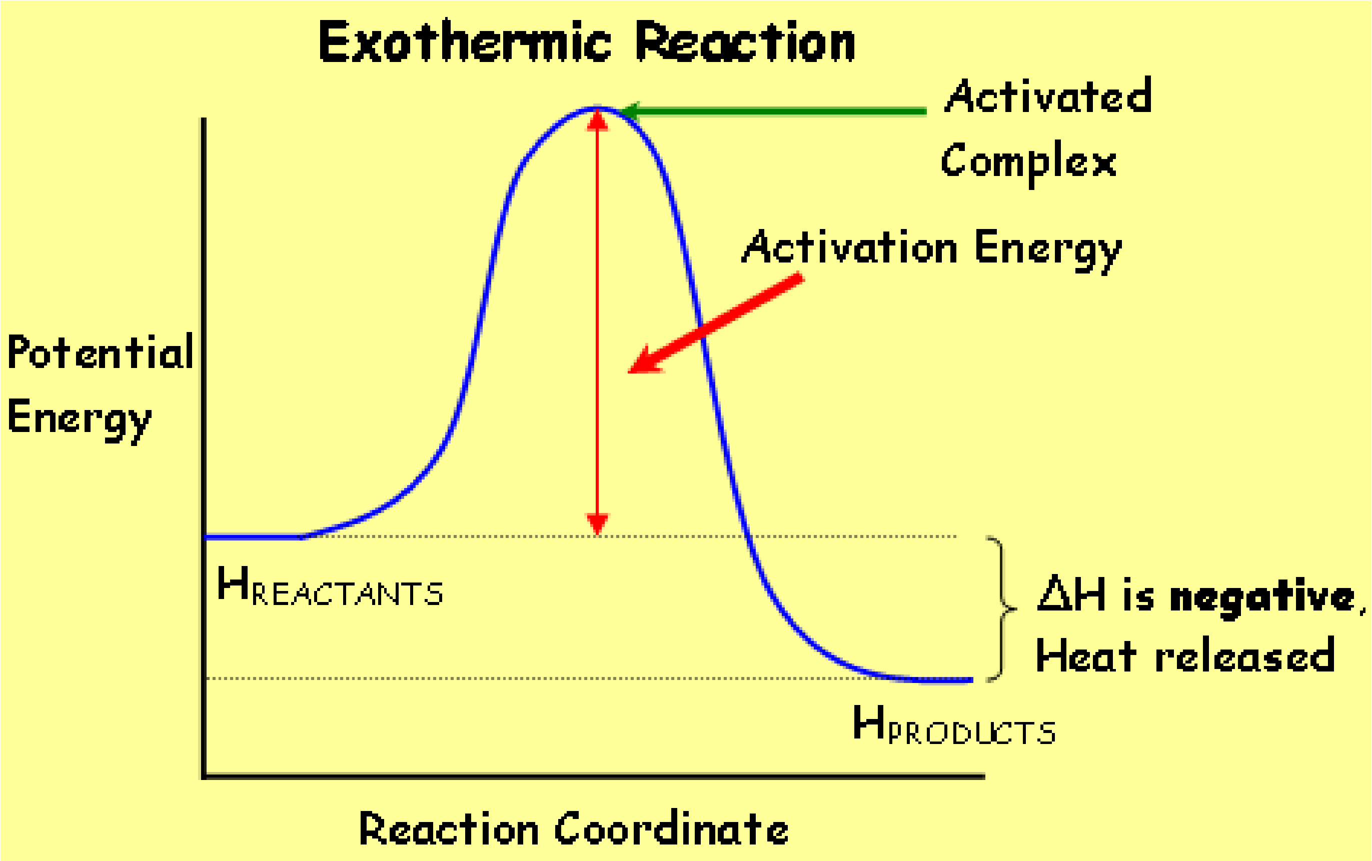
- For the reaction: A + B → C, the coordinate diagram may look like:



Coordinate Diagrams:

Exothermic Reactions:

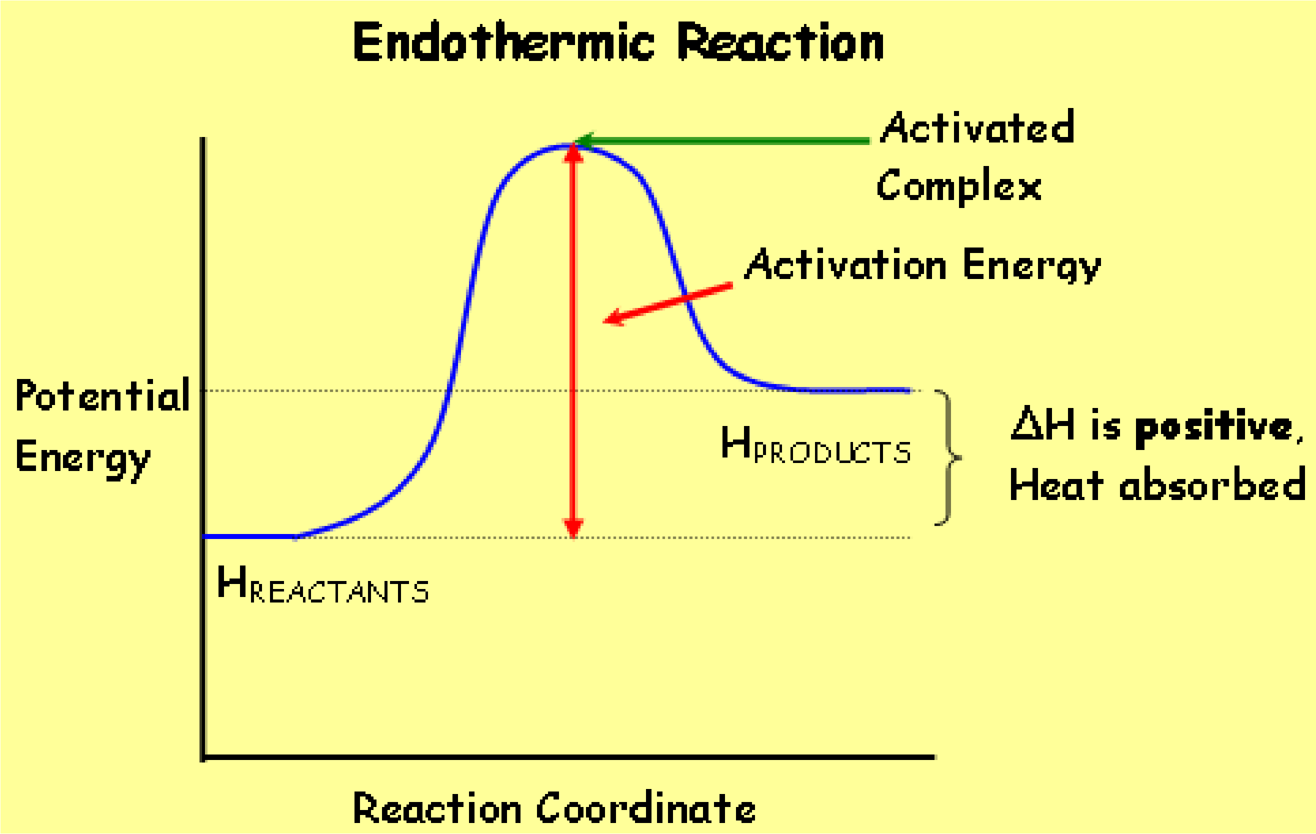
- In an exothermic Reaction, the products possess **LESS ENERGY**, ΔH is **NEGATIVE**, and a coordinate diagram would look like:



Coordinate Diagrams:

Endothermic Reactions:

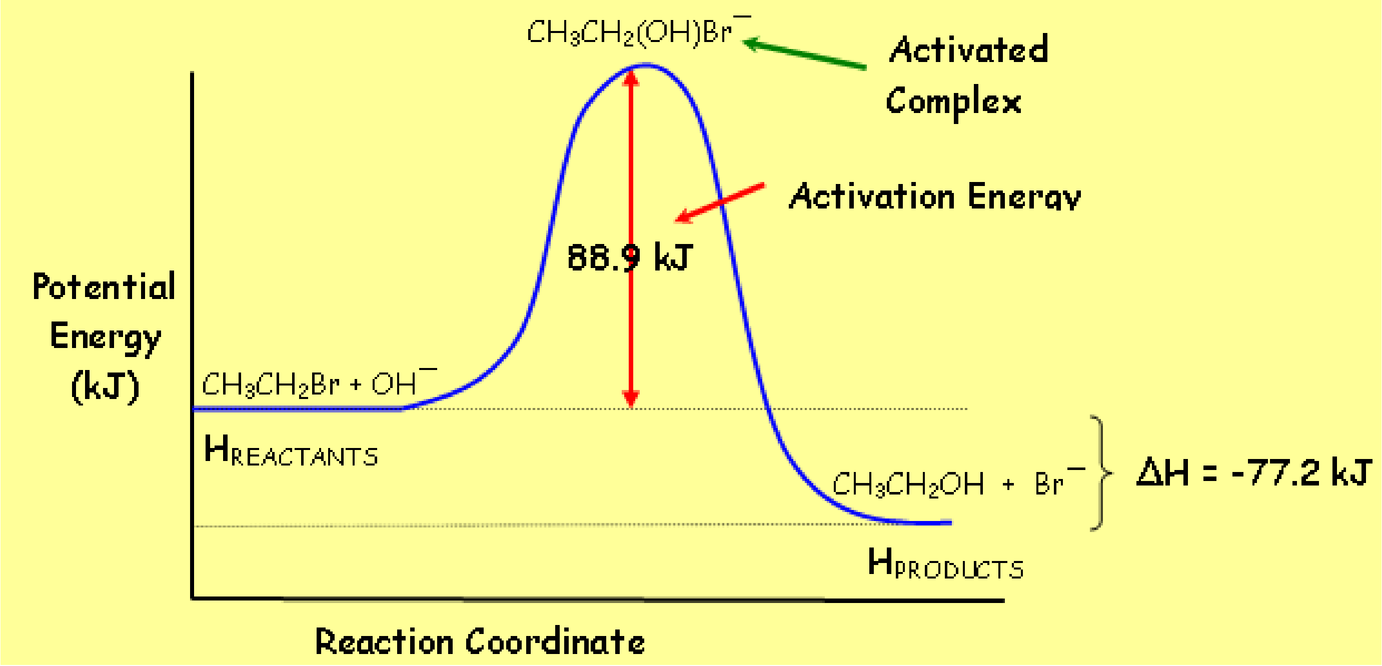
- In an endothermic reaction, the products have **MORE ENERGY**, ΔH is **POSITIVE**, and a coordinate diagram would look like:



Coordinate Diagrams:

Example:

For the reaction: ***$CH_3CH_2Br + OH^-$ → $CH_3CH_2OH + Br^-$*** the reaction coordinate diagram is as follows:

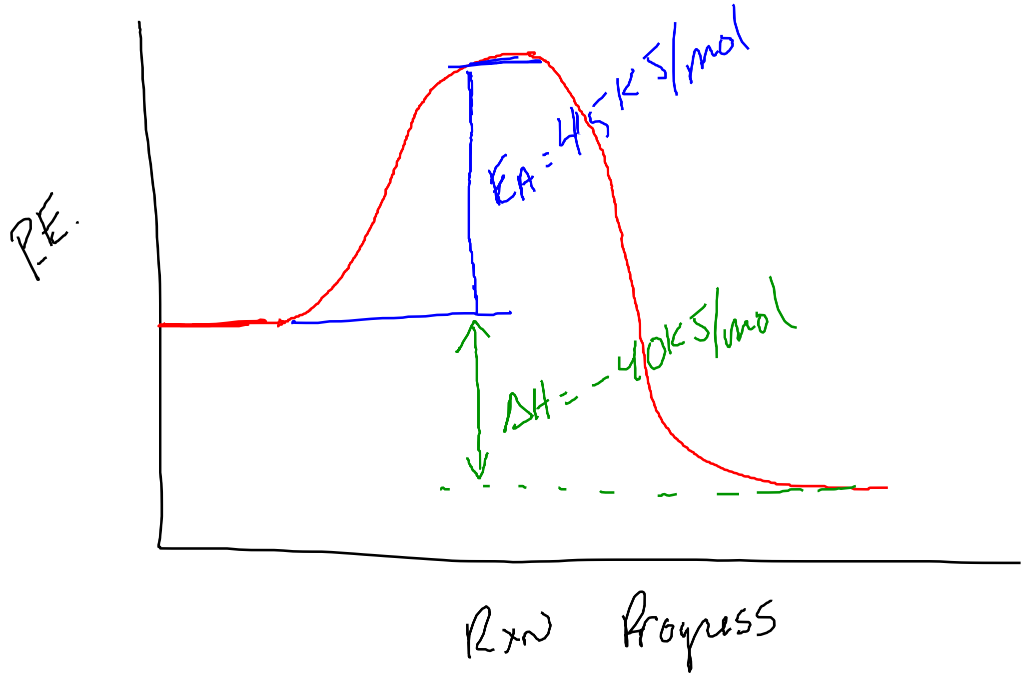


- The ***Activated Complex*** is *$CH_3CH_2(OH)Br^-$*
- The ***Activation Energy (E_A)*** is *88.9 kJ/mol CH_3CH_2Br*
- The ***Enthalpy change*** is *–77.2kJ*, ∴ reaction is exothermic.
- For the ***reverse reaction***, the ***activation energy*** would be *166.1kJ/mol*

Coordinate Diagrams:

Example:

Sketch a reaction coordinate diagram for a reaction with Ea = 45 kJ/mol and ΔH = - 40 kJ/mol.



Coordinate Diagrams:

Try This One…

Sometimes chemical reactions are reversible. Draw a potential energy diagram for a reaction whose Ea forward is 60 kJ/mol and ΔH is + 45 kJ/mol. What is the reverse reaction's activation energy?