

Potential Energy Diagrams: Exothermic Reactions and Catalysts

This worksheet develops your ability to analyze and label energy diagrams, including reactants, products, enthalpy change and activation energy ([Outcome](#)), and to explain how a catalyst alters the energy pathway of a reaction without changing the net energy released ([Outcome](#)). Complete each exercise using the potential energy diagram described in this sheet.

Exercises

1. Reading the diagram

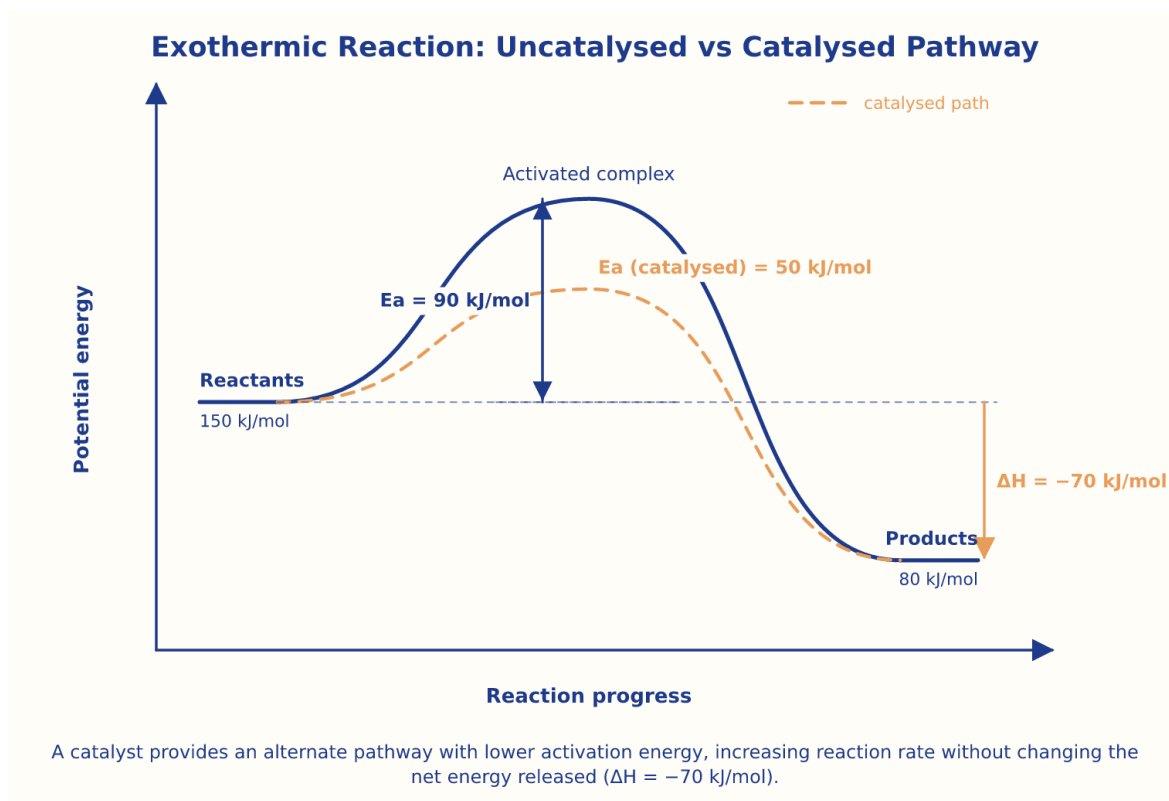


Figure 1: Potential energy diagram of an exothermic reaction: Reactants at 150 kJ/mol, Products at 80 kJ/mol, $E_a = 90 \text{ kJ/mol}$, $E_a (\text{catalysed}) = 50 \text{ kJ/mol}$, $\Delta H = -70 \text{ kJ/mol}$.

The potential energy diagram shows an exothermic reaction with reactants at 150 kJ/mol and products at 80 kJ/mol. The uncatalyzed pathway has an activation energy (E_a) of 90 kJ/mol, and a catalyzed pathway is also shown with $E_a = 50 \text{ kJ/mol}$.

Use the diagram to fill in the blanks.

- Potential energy of the reactants: _____ kJ/mol
- Potential energy of the products: _____ kJ/mol
- Enthalpy change (ΔH) for the forward reaction: _____ kJ/mol
- Activation energy (E_a) for the uncatalyzed forward reaction: _____ kJ/mol
- Activation energy (E_a) for the catalyzed forward reaction: _____ kJ/mol

f) Is this reaction endothermic or exothermic? Explain your answer using the relative positions of reactants and products on the diagram.

2. Bonds and energy

Explain, in terms of bond breaking, bond forming, and changes in potential and kinetic energy, why this reaction releases energy overall ([Outcome](#)).

3. Calculations from the diagram

Using the values given for this reaction, calculate each of the following. Show your work.

- a) The potential energy of the activated complex (the peak of the curve) for the uncatalyzed pathway.
 - b) The potential energy of the activated complex for the catalyzed pathway.
 - c) The activation energy of the reverse reaction along the uncatalyzed pathway.
 - d) The activation energy of the reverse reaction along the catalyzed pathway.
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4. The role of the catalyst

A classmate claims that adding a catalyst makes this reaction release more energy. Explain why this claim is incorrect, referring to the definition of a catalyst and its effect on the reaction pathway ([Outcome](#)).

5. Multiple choice

Circle the letter of the best answer for each question.

- i) Compared to the uncatalyzed pathway, the catalyzed pathway in this diagram has:
 - A) a lower activation energy and a lower ΔH
 - B) a lower activation energy and the same ΔH
 - C) the same activation energy and a lower ΔH
 - D) a higher activation energy and the same ΔH
- ii) Activation energy is best described as:
 - A) the total energy released during a reaction
 - B) the energy barrier that must be overcome for a reaction to occur ([Outcome](#))
 - C) the difference in potential energy between reactants and products
 - D) the kinetic energy of the products
- iii) A catalyst increases the rate of a reaction by:
 - A) increasing the potential energy of the reactants
 - B) decreasing the potential energy of the products
 - C) providing an alternate pathway with a lower activation energy, without changing the net energy of the reaction ([Outcome](#))
 - D) increasing the enthalpy change of the reaction

6. Matching

Match each term on the left with its correct description on the right by writing the matching letter in the blank.

Term	Blank	Description
Activation energy	_____	A) The overall energy change between reactants and products
Enthalpy change (ΔH)	_____	B) The energy barrier that must be overcome for a reaction to occur
Catalyst	_____	C) The highest-energy point on the reaction pathway
Activated complex	_____	D) A substance that provides an alternate pathway with a lower activation energy, without affecting the net energy of the reaction

Answer key

- a) 150 kJ/mol b) 80 kJ/mol c) 70 kJ/mol d) 90 kJ/mol e) 50 kJ/mol f) Exothermic, because the products (80 kJ/mol) have lower potential energy than the reactants (150 kJ/mol), so energy is released overall ([Outcome](#)).

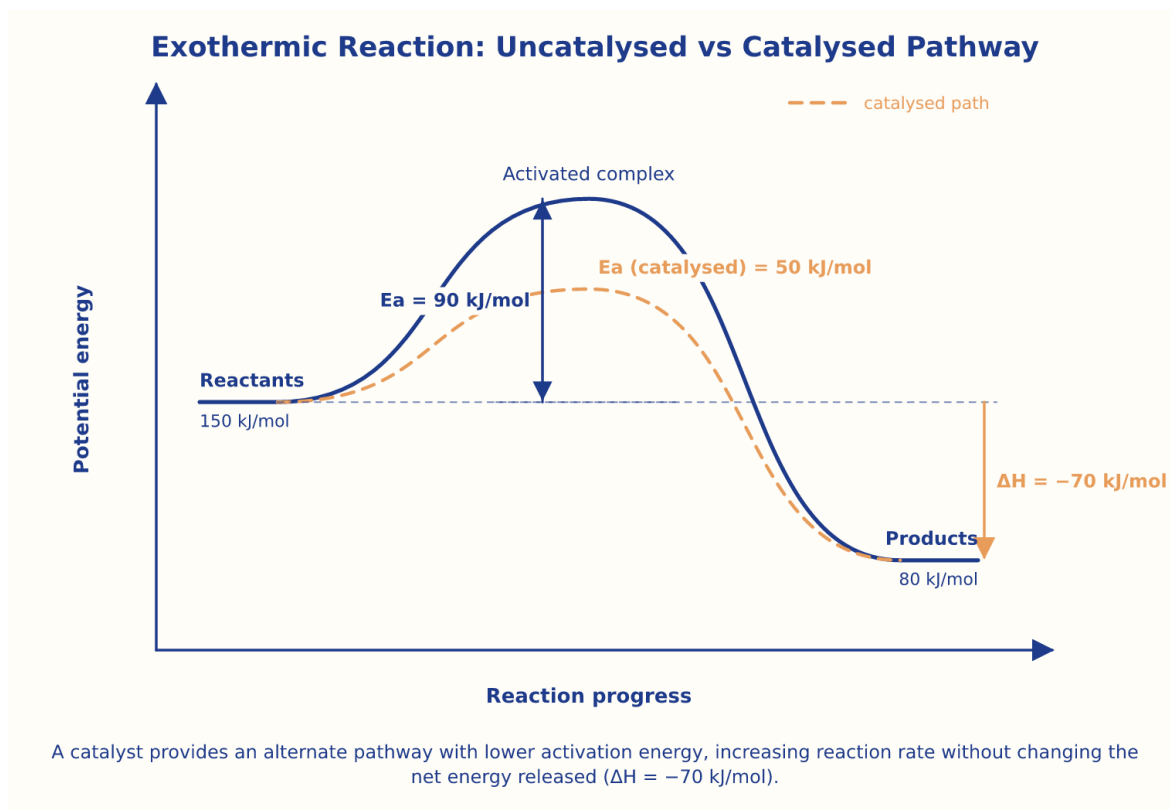


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- During the reaction, existing bonds in the reactants break (requiring an input of energy) and new bonds form in the products (releasing energy). Because more energy is released forming the new bonds than was needed to break the old ones, the potential energy of the system decreases and this energy is released, largely as kinetic energy of the surroundings ([Outcome](#)).

3. a) $150 + 90 = 240$ kJ/mol b) $150 + 50 = 200$ kJ/mol c) $240 - 80 = 160$ kJ/mol d) $200 - 80 = 120$ kJ/mol
4. The catalyst lowers the activation energy from 90 kJ/mol to 50 kJ/mol, making it easier for reactant molecules to reach the activated complex, but it does not change the potential energy of the reactants or products. 9D, &VÖ –ç2 !#s ´ ¢öÖöÂ öâ &÷F, F‡pays, so the catalyst changes the rate of the reaction, not the net energy released ([Outcome](#)).
5. i) B ii) B iii) C
6. Activation energy: B. Enthalpy change (9D,“ A. Catalyst: D. Activated complex: C.

I can

- I can label a potential energy diagram with reactants, products, activation energy and enthalpy change ([Outcome](#)).
- I can explain energy changes during a reaction in terms of bond breaking, bond forming, and potential and kinetic energy ([Outcome](#)).
- I can define activation energy as the energy barrier a reaction must overcome ([Outcome](#)).
- I can explain that a catalyst lowers activation energy by providing an alternate pathway, without changing the net energy of the reaction ([Outcome](#)).
- I can analyze and label energy diagrams of a chemical reaction, including reactants, products, enthalpy change and activation energy.