

Potential Energy Diagrams: Exothermic Reactions and Catalysts

This worksheet asks you to analyze and label a potential energy diagram for an exothermic reaction, calculate enthalpy and activation energy values, and explain how a catalyst changes the reaction pathway without changing the net energy change ([Outcome](#), [Outcome](#), [Outcome](#)). You will also connect the diagram to bond breaking, bond forming, and changes in potential and kinetic energy ([Outcome](#)).

Exercises

1. Label the diagram

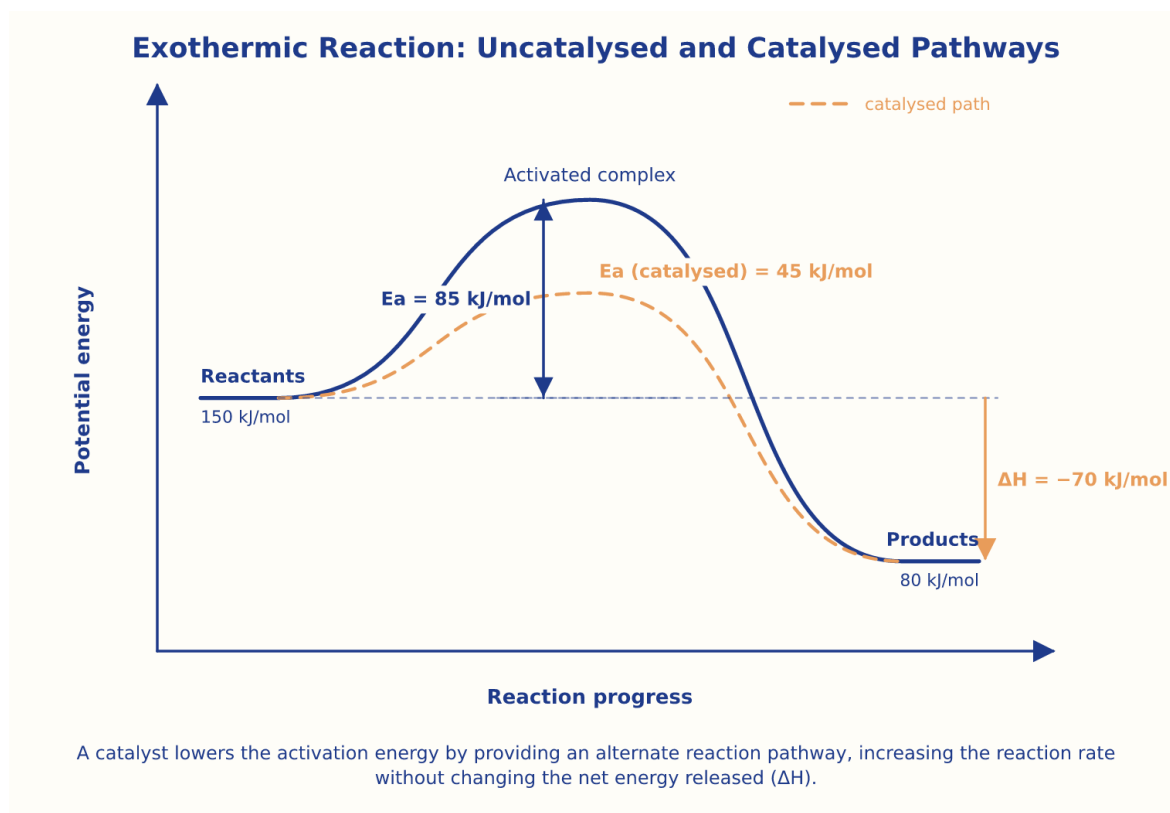


Figure 1: Potential energy diagram of an exothermic reaction: Reactants at 150 kJ/mol, Products at 80 kJ/mol, E_a = 85 kJ/mol, ΔH = -70 kJ/mol

Using the potential energy diagram described above, fill in the missing values on the lines below.

Potential energy of reactants: _____ kJ/mol

Potential energy of products: _____ kJ/mol

Activation energy (uncatalyzed forward reaction), E_a : _____ kJ/mol

Enthalpy change, ΔH : _____ kJ/mol

Activation energy (catalyzed forward reaction): _____ kJ/mol

2. Calculations

Using the values from the diagram, show your work for each calculation.

- a) Calculate the potential energy of the transition state (activated complex) for the uncatalyzed pathway.
- b) Calculate the activation energy for the reverse reaction (products $\rightarrow$ reactants) along the uncatalyzed pathway.
- c) By how many kJ/mol does the catalyst lower the activation energy of the forward reaction?

3. Multiple choice

Circle the best answer.

Adding a catalyst to this reaction changes:

- A) ΔH , ΔE_a
- B) E_a only
- C) both ΔH , ΔE_a
- D) neither ΔH , ΔE_a

4. Matching

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

Term	Blank	Description
1. Activation energy	_____	A) The energy barrier that must be overcome for a reaction to occur
2. Catalyst	_____	B) The difference in potential energy between products and reactants
3. Enthalpy change (ΔH)	_____	C) A substance that provides an alternate pathway with lower E_a
4. Exothermic reaction	_____	D) A reaction in which the products have lower potential energy than the reactants

5. True or False

Write True or False on each line. If a statement is false, correct it.

- a) In this reaction, breaking bonds in the reactants releases more energy than forming bonds in the products absorbs. _____
- b) The catalyzed pathway has a lower activation energy but the same ΔH , ΔE_a pathway. _____
- c) A catalyst increases the amount of energy released by the reaction. _____

6. Short answer

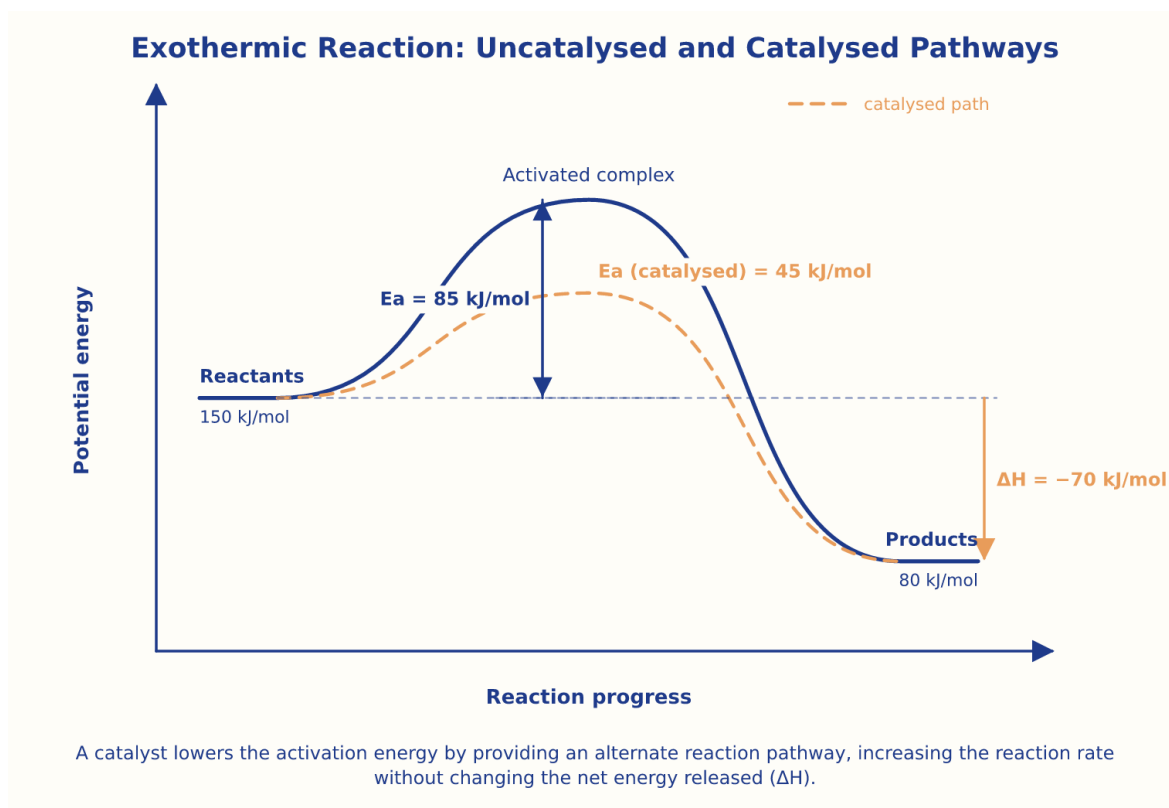


Figure 1: Potential energy diagram of an exothermic reaction: Reactants at 150 kJ/mol, Products at 80 kJ/mol, $E_a = 85$ kJ/mol, E_a (catalysed) = 45 kJ/mol, $\Delta H = -70$ kJ/mol.

Explain, using the values from the diagram, why the catalyzed pathway allows the reaction to proceed faster while the enthalpy change of the reaction stays at -70 kJ/mol. Refer to the activation energy of both pathways in your answer ([Outcome](#)).

Answer key

- Reactants: 150 kJ/mol; Products: 80 kJ/mol; E_a (uncatalyzed): 85 kJ/mol; $\Delta H = -70$ kJ/mol; E_a (catalyzed): 45 kJ/mol.

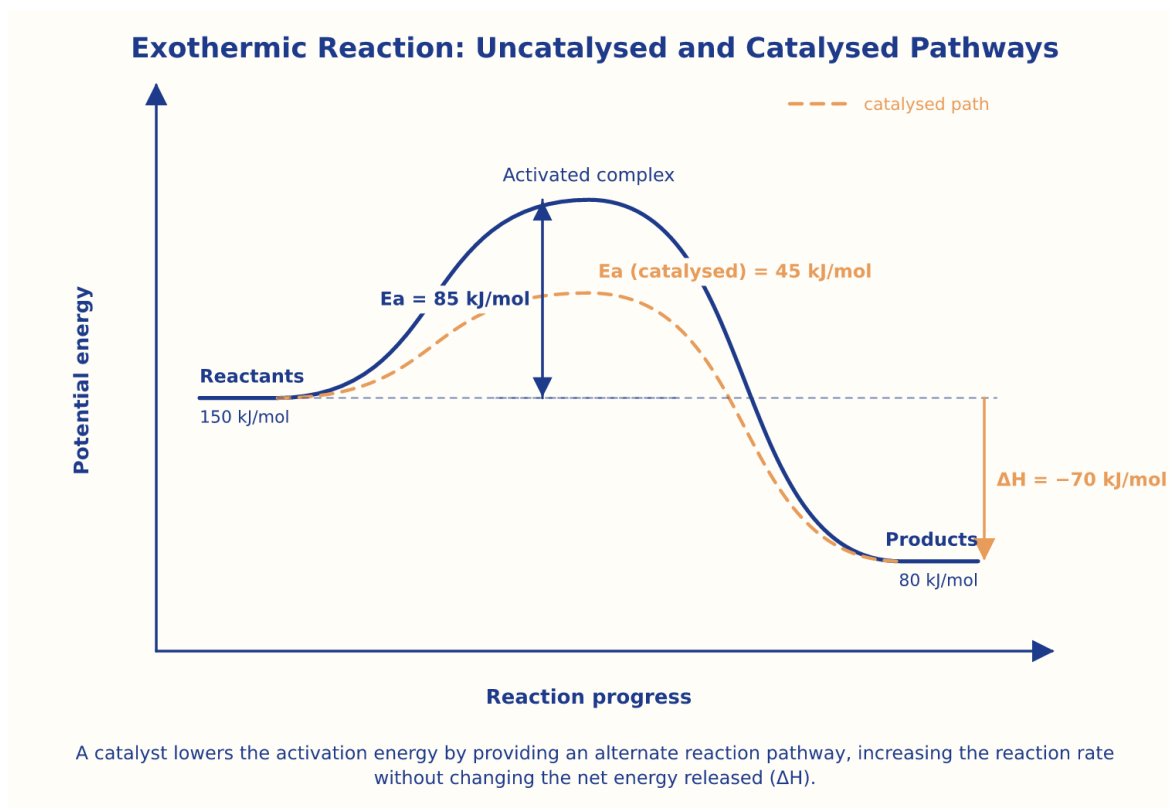


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2. a) $150 \text{ kJ/mol} + 85 \text{ kJ/mol} = 235 \text{ kJ/mol}$; b) $235 \text{ kJ/mol} - 80 \text{ kJ/mol} = 155 \text{ kJ/mol}$; c) $85 \text{ kJ/mol} - 45 \text{ kJ/mol} = 40 \text{ kJ/mol}$.
3. B) E_a only, since a catalyst provides an alternate pathway with a lower activation energy but does not change the net energy of the reaction ([Outcome](#)).
4. 1, A, 2, C, 3, B, 4, D ([Outcome](#), [Outcome](#)).
5. a) True, since the reaction is exothermic (9D, 0!#s '¢öÖöÂ'Â ÖV æ-ær VæW&w' &VÆV 6VB -â `orming product bonds exceeds energy absorbed in breaking reactant bonds ([Outcome](#)). b) True, the catalyst lowers E_a from 85 kJ/mol to 45 kJ/mol but 9D, &VÖ -ç2 !#s '¢öÖöÂöâ &÷F, F†paystc ([Outcome](#)). c) False; a catalyst does not change the amount of energy released, only the rate at which the reaction reaches that energy change ([Outcome](#)).
6. The uncatalyzed pathway requires 85 kJ/mol of activation energy, while the catalyzed pathway requires only 45 kJ/mol, so more reactant particles have enough energy to reach the lower energy barrier, increasing reaction rate. The reactants (150 kJ/mol) and products (80 kJ/mol) are unchanged, so 9D, &VÖ -ç2 !#s '¢öÖöÂ öâ &÷F, F†paystc ([Outcome](#), [Outcome](#)).

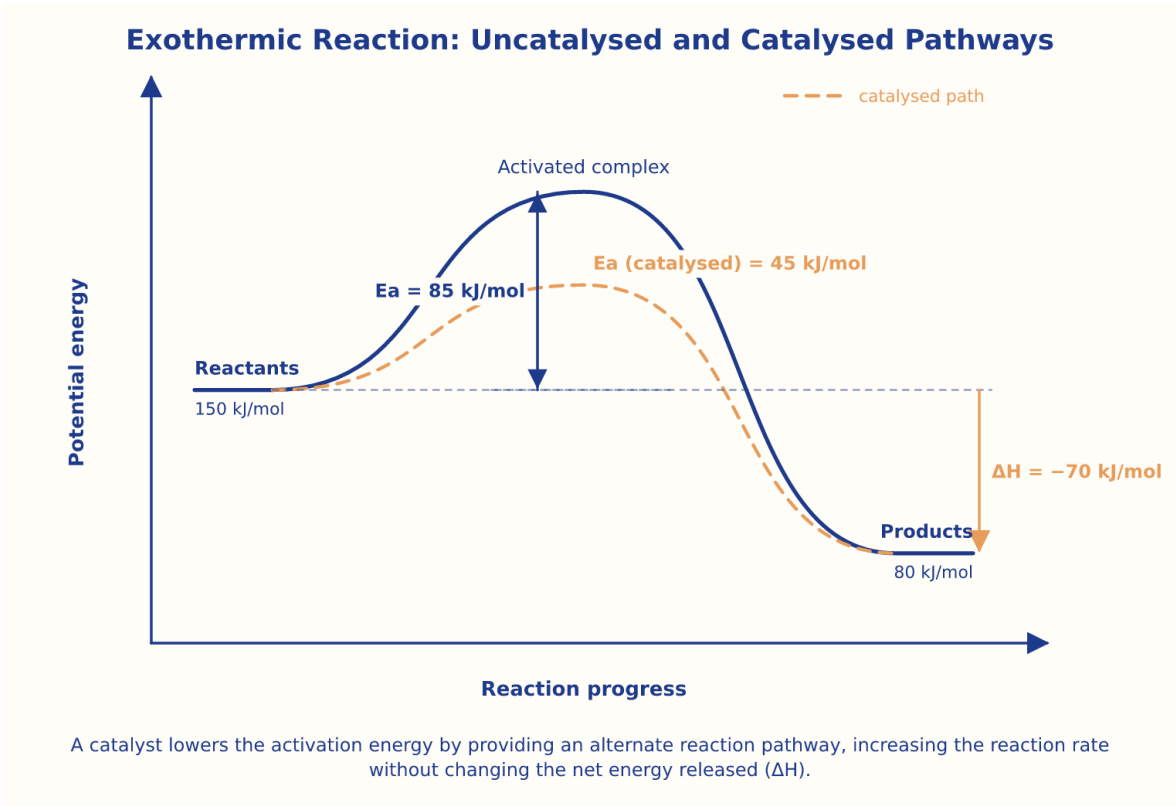


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