

Potential Energy Diagrams: Exothermic Reactions and Catalysts

This worksheet addresses the labelling and analysis of energy diagrams, including reactants, products, enthalpy change and activation energy ([Outcome](#), [Outcome](#)). It also covers activation energy as an energy barrier and the role of catalysts in providing alternate reaction pathways ([Outcome](#), [Outcome](#)).

Exercises

1. Reading the diagram

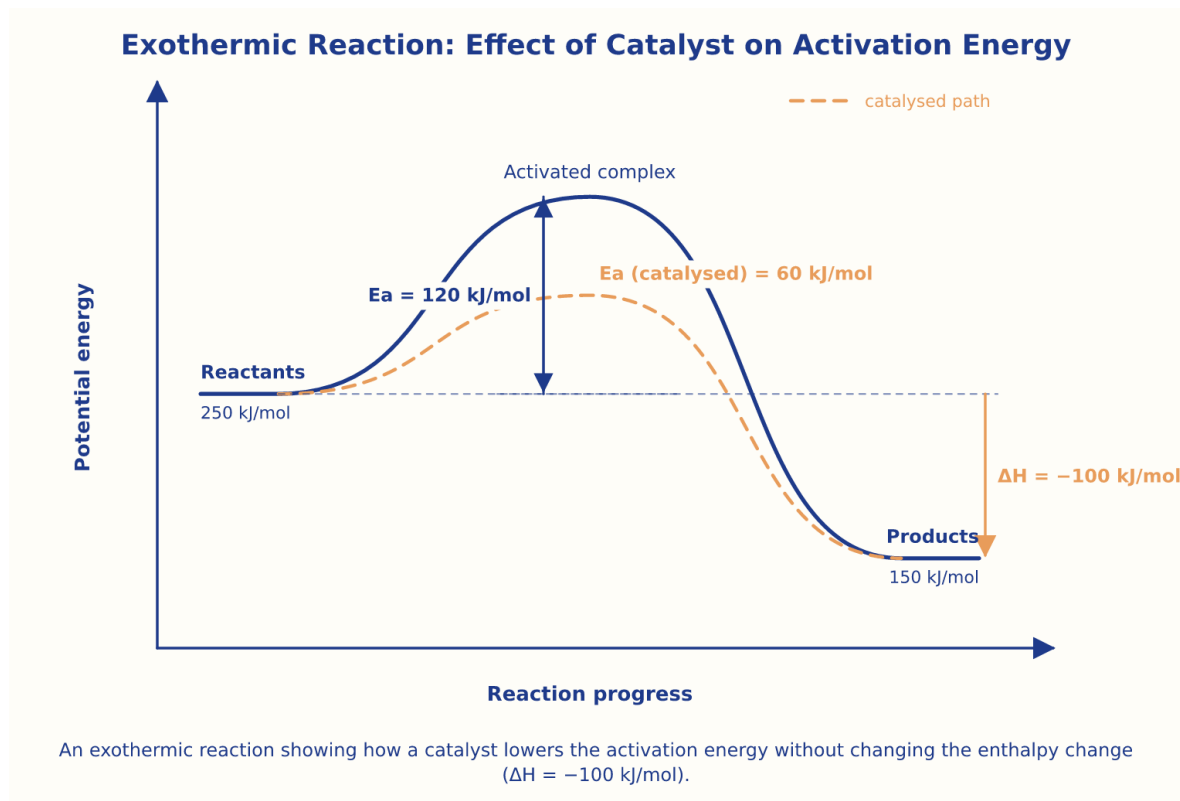


Figure 1: Potential energy diagram of an exothermic reaction: Reactants at 250 kJ/mol, Products at 150 kJ/mol, $E_a = 120 \text{ kJ/mol}$, E_a (catalysed) = 60 kJ/mol, $\Delta H = -100 \text{ kJ/mol}$.

Use the potential energy diagram above to answer the following.

- What is the potential energy of the reactants, in kJ/mol? _____
- What is the potential energy of the products, in kJ/mol? _____
- What is the value of the activation energy, E_a , for the uncatalysed reaction? _____
- What is the value of ΔH for this reaction? _____

2. Classifying the reaction

Based on the sign of ΔH , found in Exercise 1, classify the reaction and justify your answer in one sentence.

Classification: _____

Justification: _____

3. Multiple choice

Select the best answer for each question.

i) Activation energy is best defined as ([Outcome](#)):

- A) the total energy released by a reaction
- B) the energy barrier that must be overcome for a reaction to occur
- C) the difference between reactant and product potential energy
- D) the energy absorbed when bonds form

ii) Compared to the uncatalysed pathway, the catalysed pathway in the diagram shows:

- A) a higher E_a and a higher ΔH
- B) a lower E_a and the same ΔH
- C) a lower E_a and a lower ΔH
- D) the same E_a and a lower ΔH

iii) A catalyst increases the rate of a reaction by ([Outcome](#)):

- A) increasing the potential energy of the products
- B) decreasing the potential energy of the reactants
- C) providing an alternate pathway with a different activation energy, without changing the net energy involved
- D) increasing the enthalpy change of the reaction

4. Calculations using the figure

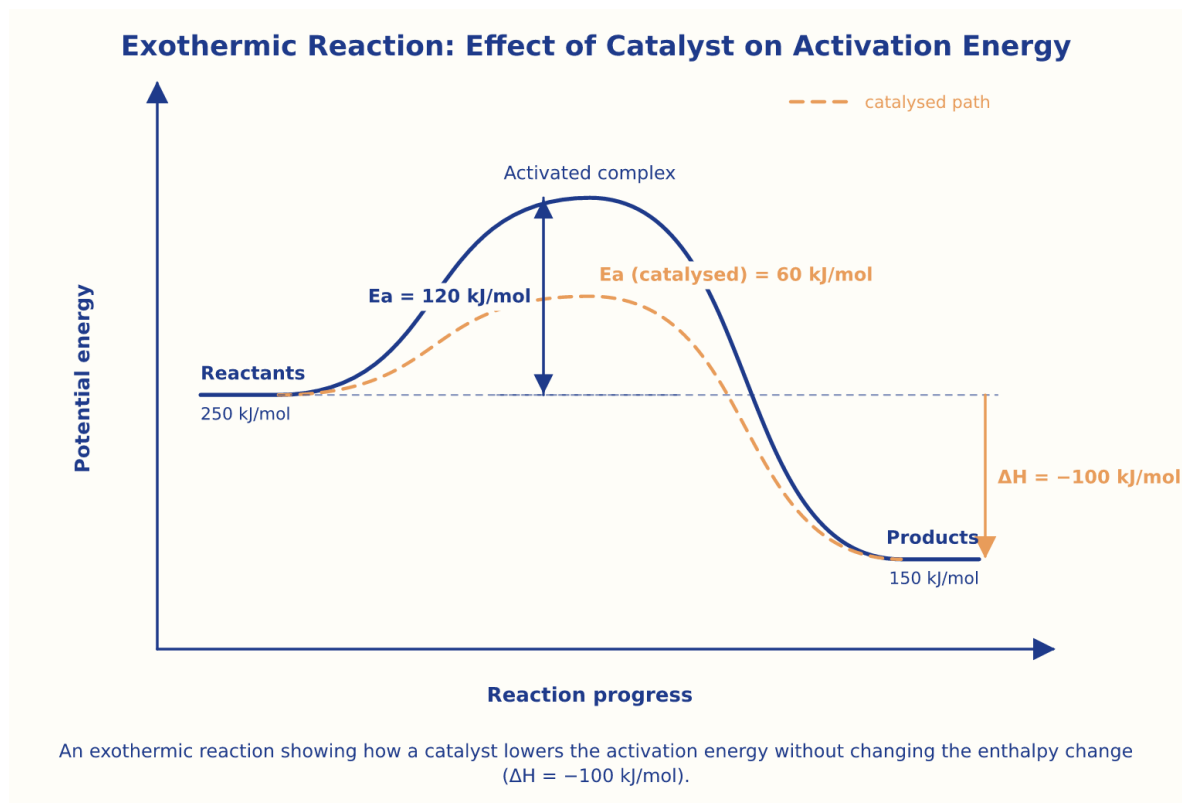


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Using the values given in the figure, calculate the following. Show your work.

a) Calculate ΔH , $\Delta H = \text{potential energy of products} - \text{potential energy of reactants}$.

Work: _____

ΔH , $\Delta H = \text{potential energy of products} - \text{potential energy of reactants}$

b) Calculate the activation energy of the reverse reaction (products $\rightarrow$ reactants) for the uncatalysed pathway.

Work: _____

$E_a(\text{reverse}) = \text{_____ kJ/mol}$

c) Calculate how much lower the catalysed E_a is compared to the uncatalysed E_a .

Work: _____

Difference = _____ kJ/mol

5. Bonds, energy, and the catalyst's effect on ΔH

Answer in complete sentences.

a) Explain, referring to bond breaking and bond forming, why this reaction releases energy overall ([Outcome](#)). _____

b) Explain why the value of ΔH , -2 kJ/mol for both the catalysed and uncatalysed pathways, even though the catalysed pathway has a lower activation energy ([Outcome](#)). _____

6. Matching

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

Term	Match	Description
1. Activation energy (E_a)	_____	A) The energy difference between products and reactants
2. Enthalpy change (ΔH)	_____	B) A substance that lowers E_a without being consumed
3. Catalyst	_____	C) The energy barrier that must be overcome for reactants to convert to products
4. Exothermic reaction	_____	D) A reaction in which the products have lower potential energy than the reactants

Answer key

1. a) 250 kJ/mol b) 150 kJ/mol c) 120 kJ/mol d) 100 kJ/mol

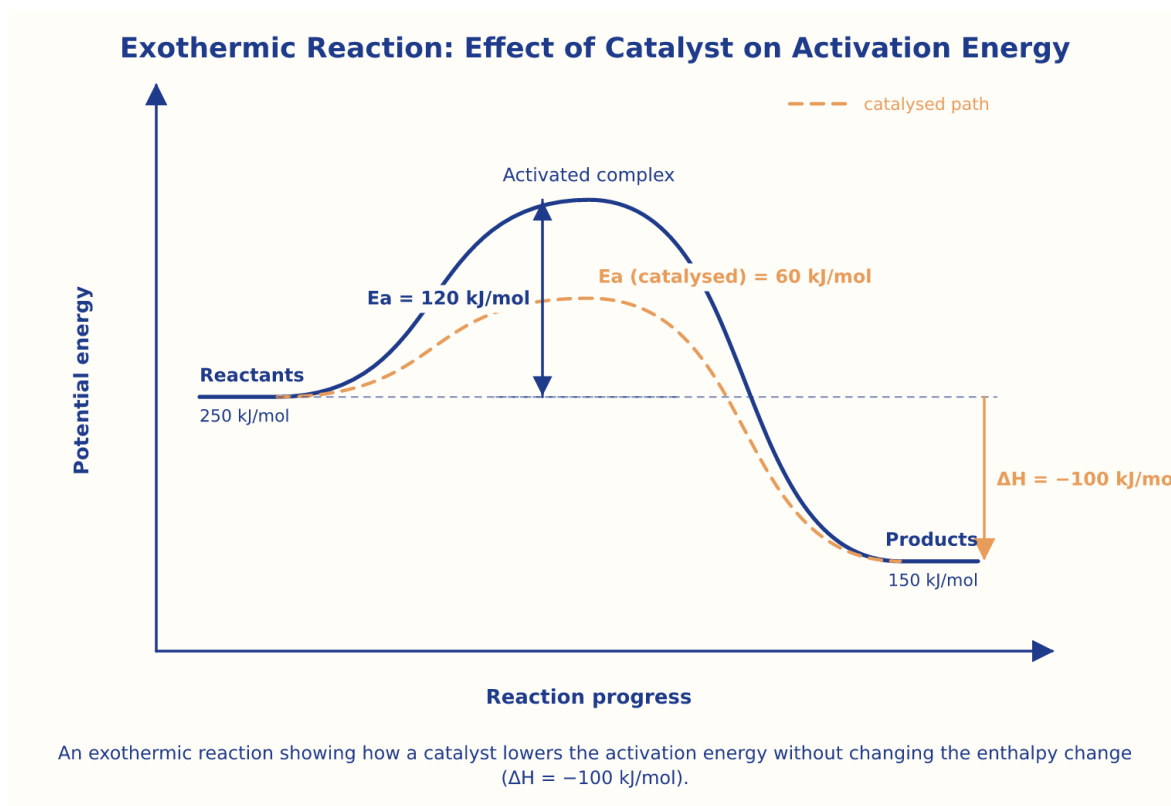


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2. Exothermic, because $\Delta H = -100 \text{ kJ/mol}$, meaning the products have lower potential energy than the reactants and energy is released to the surroundings ([Outcome](#)).
3. i) B ii) B iii) C
4. Figure 1

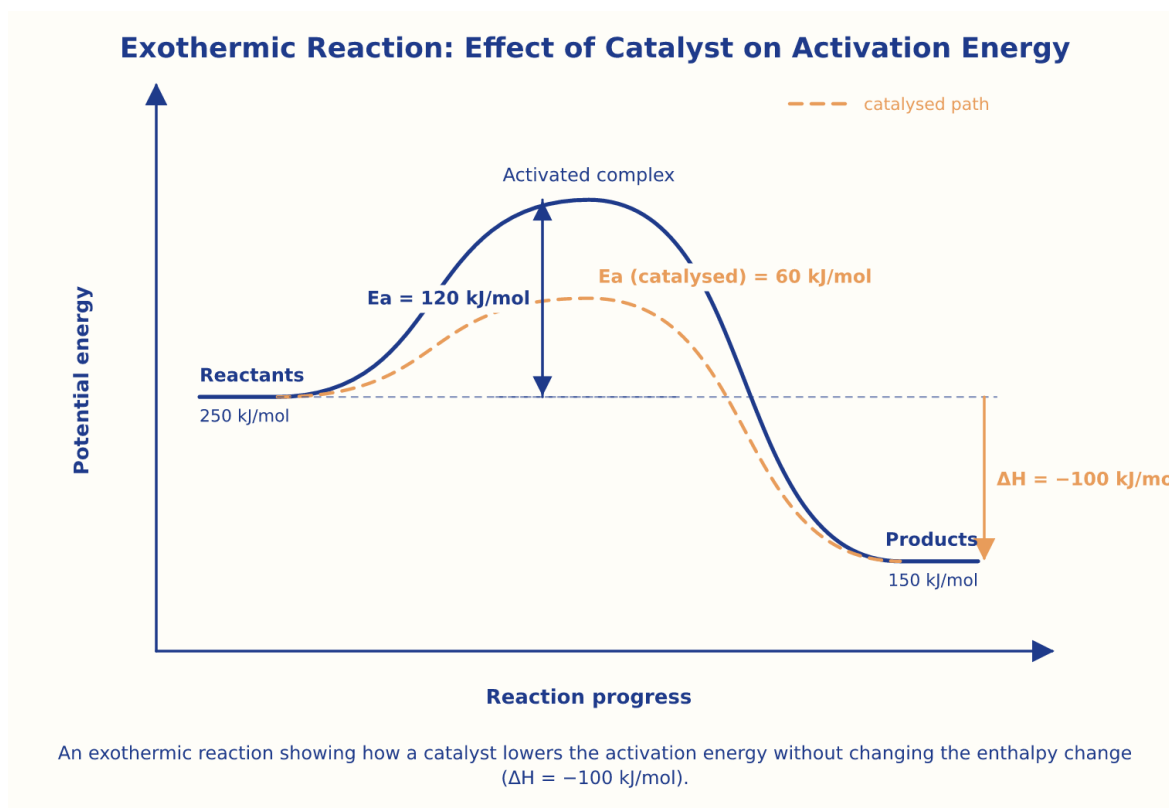


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a) $E_a = 120 \text{ kJ/mol}$

b) $E_a(\text{reverse}) = 250 - 150 = 100 \text{ kJ/mol}$ (the reverse E_a is measured from products, 150 kJ/mol, up to the peak, 270 kJ/mol, giving 120 kJ/mol; accept either method provided the work shown is consistent, since the peak height above reactants is 120 kJ/mol and above products is 220 kJ/mol)

c) $120 - 60 = 60 \text{ kJ/mol}$

5. a) Sample answer: Energy is required to break bonds in the reactants and energy is released when new bonds form in the products; since more energy is released forming product bonds than is absorbed breaking reactant bonds, the reaction releases energy overall (**Outcome**).

b) Sample answer: A catalyst provides an alternate pathway with a lower activation energy, but it does not change the potential energy of the reactants or products, so the net amount of energy released, ΔH , is the same (**Outcome**).

6. 1-C, 2-A, 3-B, 4-D