

Reaction profiles

4.5.1.2 · Energy changes · revision notes

A reaction profile is a simple energy diagram showing how energy changes as reactants turn into products. You need to draw and label profiles for exothermic and endothermic reactions, use them to decide which type a reaction is, and explain what the activation energy is.

Key facts

- Activation energy = minimum energy particles must have to react (when they collide)
- Exothermic profile: products below reactants
- Activation energy = energy at the peak – energy of the reactants
- Both arrows start at the reactants line
- Axes: energy (vertical), progress of reaction (horizontal)
- Endothermic profile: products above reactants
- Overall energy change = energy of products – energy of reactants (negative for exothermic)

Notes

Activation energy

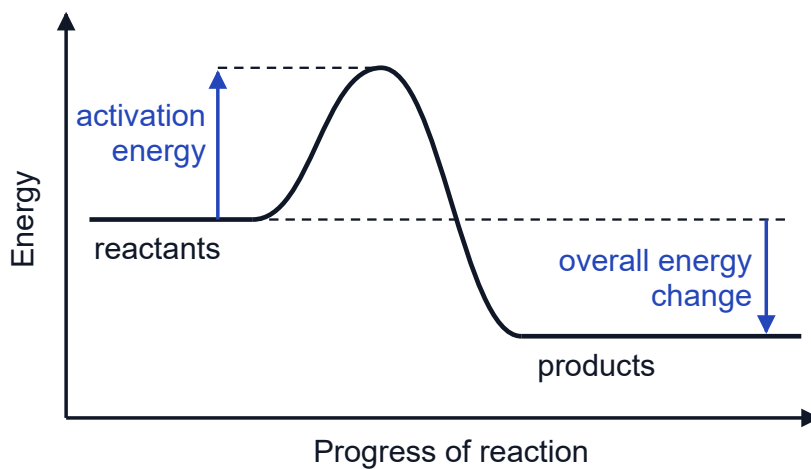
- Chemical reactions can only happen when reacting particles **collide** with enough energy.
- The **activation energy** is the minimum amount of energy that particles must have to react.
- Reactions with a high activation energy need energy to be supplied before they start, e.g. a spark or a flame to light a fuel.

Drawing a reaction profile

- Label the axes: energy (vertical) and progress of reaction (horizontal).
- Draw a short horizontal line for the reactants on the left and one for the products on the right, at the correct relative heights. Label each line with the names or formulae.
- Join the two lines with a smooth curve that rises to a peak above both, then falls to the products.
- **Activation energy**: an arrow from the reactants line up to the top of the curve.
- **Overall energy change**: an arrow from the reactants line to the products line (down for exothermic, up for endothermic).

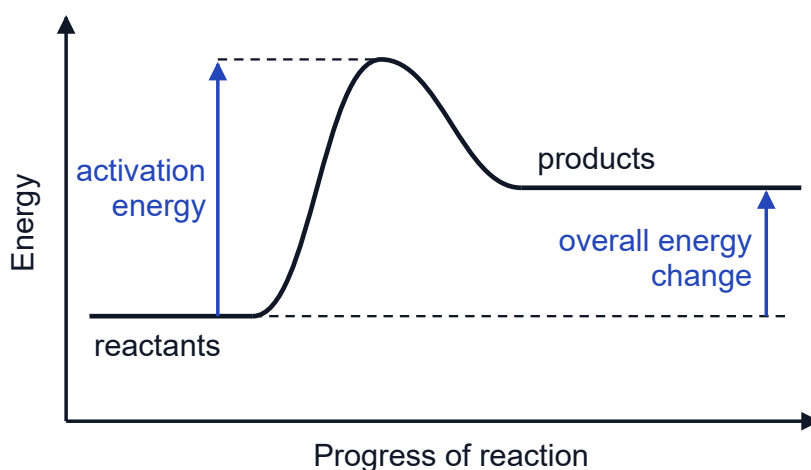
Exothermic or endothermic?

- **Exothermic:** the products are **lower** in energy than the reactants. The difference is the energy released to the surroundings.



Exothermic: products lower than reactants; the overall energy change arrow points down.

- **Endothermic:** the products are **higher** in energy than the reactants. The difference is the energy taken in from the surroundings.



Endothermic: products higher than reactants; the overall energy change arrow points up.

- Both types have a peak: every reaction has an activation energy, even an exothermic one.

How to answer each type of question

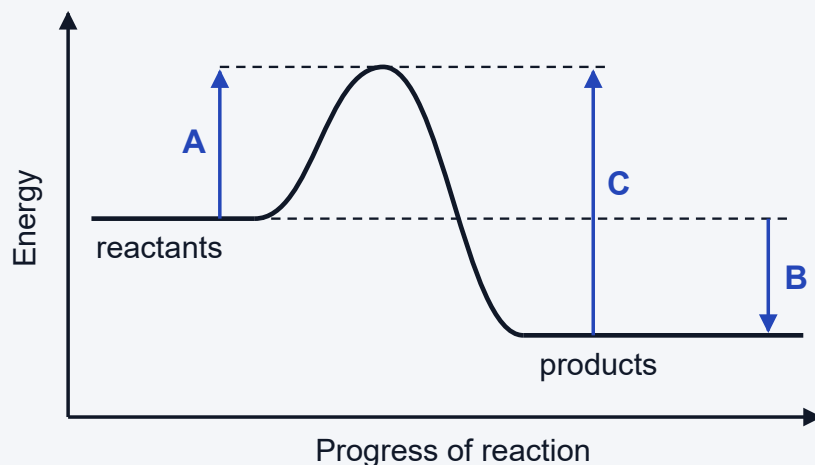
Identify the parts of a given profile

1 to 4 marks

Grade 4

1. Find the reactants (left line) and the products (right line).
2. The arrow from the reactants up to the peak is the activation energy.
3. The arrow between the reactants line and the products line is the overall energy change.
4. Products lower means exothermic; products higher means endothermic.

Example. The diagram shows a reaction profile with three labelled arrows, A, B and C.



- (a) Which arrow shows the activation energy? (1)
- (b) Which arrow shows the overall energy change? (1)
- (c) Is the reaction exothermic or endothermic? Give a reason for your answer. (2)

Model answer. (a) A (1)

(b) B (1)

(c) Exothermic (1) because the products have less energy than the reactants / arrow B points down (1)

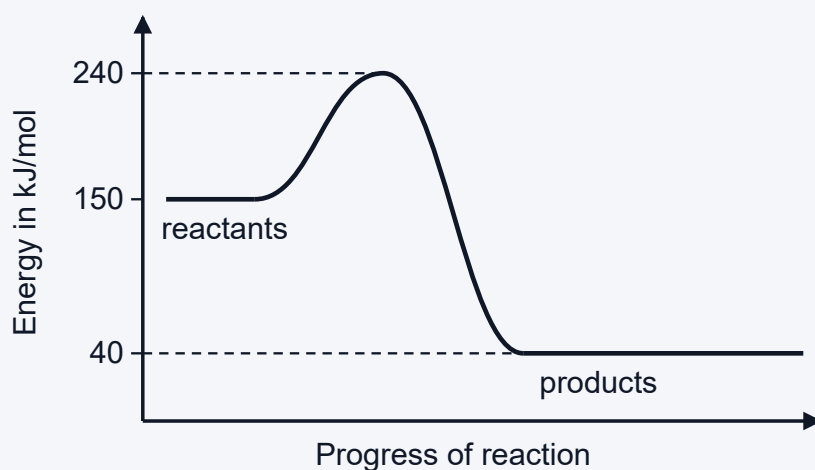
Calculate values from a reaction profile

2 to 3 marks

Grade 5

1. Read the energy of the reactants, the peak and the products from the axis.
2. Activation energy = peak – reactants.
3. Overall energy change = products – reactants. A negative answer means energy is released (exothermic).

Example. On a reaction profile, the reactants are at 150 kJ/mol, the top of the curve is at 240 kJ/mol and the products are at 40 kJ/mol.



- (a) Calculate the activation energy. (1)
- (b) Calculate the overall energy change and state whether the reaction is exothermic or endothermic. (2)

Model answer. (a) $240 - 150 = 90$ kJ/mol (1)

(b) $40 - 150 = -110$ kJ/mol (1); exothermic, because the products have less energy than the reactants (1)

Don't lose marks

- ✗ Drawing the activation energy arrow from the products line or from the axis, instead of from the reactants line up to the peak.
- ✗ Drawing the overall energy change arrow from the peak down to the products. It goes from the reactants line to the products line.
- ✗ Leaving out the hump on an exothermic profile. Every reaction has an activation energy.
- ✗ Drawing the peak lower than the products line on an endothermic profile.
- ✗ Writing that activation energy is 'the energy given out' or 'the energy of the products'. It is the minimum energy the particles need to react.

More tips

Memory tricks

- Exothermic profiles go downhill overall (energy exits); endothermic profiles go uphill overall.
- Every arrow starts at the reactants line.
- The hump is the activation energy; the step between the two lines is the overall energy change.
- Sense check an endothermic profile: the peak must be higher than the products line, so the activation energy arrow is always longer than the energy change arrow.

Exam technique

- Use a ruler for the arrows and make them start and finish exactly on the levels they measure.
- Label with the exact words the question uses: reactants, products, activation energy and overall energy change.
- If a question adds a catalyst, draw a second, lower peak between the same reactants and products lines: a catalyst lowers the activation energy but does not change the overall energy change (see the rates of reaction notes).
- In 'explain' questions about activation energy, mention both collisions and energy: particles must collide with at least the activation energy to react.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

State what activation energy is

The minimum amount of energy that particles must have to react when they collide.

Grade 4

Label the parts of a reaction profile

Identify the reactants, products, activation energy and overall energy change on a given profile.

Grade 4

Identify exothermic or endothermic from a profile

Products lower than reactants means exothermic; products higher than reactants means endothermic.

Grade 5

Read energy values from a profile

Activation energy = peak – reactants; overall energy change = products – reactants.

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