Checkpoint Task

Enthalpy changes

Instructions and answers for teachers

These instructions cover the learner activity section which can be found on page 6. This Checkpoint Task should be used in conjunction with the KS4–5 A Level Chemistry Transition Guide Amount of Substance, which supports OCR A Level Chemistry A and Chemistry B (Salters).

When distributing the activity section to the learners either as a printed copy or as a Word file you will need to remove the teacher instructions section.

Overview

This activity tests learners' understanding of energy profile diagrams, exothermic and endothermic reactions, finally leading on bond enthalpy calculations. Activation energy could also be included here, depending on what you know about learners' prior knowledge.

The activity allows teachers to gauge how well the learners understand the main ideas, enabling them to focus on any misconceptions before embarking on the A Level content.

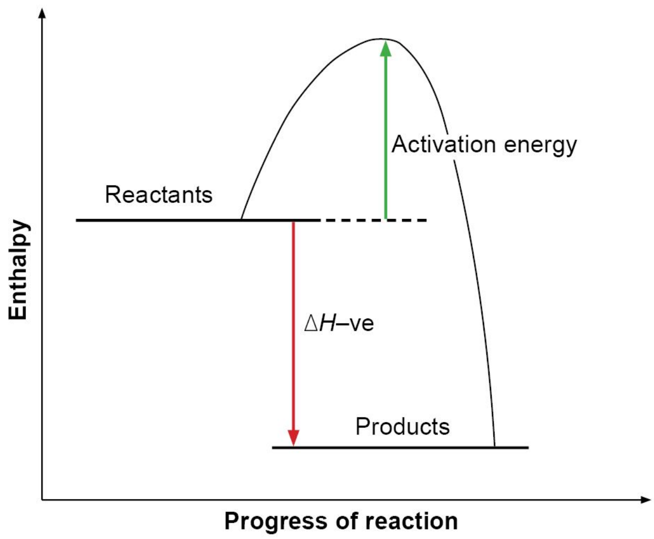
Exothermic reactions

1. Write a definition of an exothermic reaction.

An exothermic reaction is one in which energy is given out to the surroundings.

2. Draw an enthalpy profile diagram for an exothermic reaction.

   Label the axes, ΔH and the activation energy.



3. Give an example of an exothermic reaction.

E.g. combustion, lots of oxidation reactions (including rusting), neutralisation.

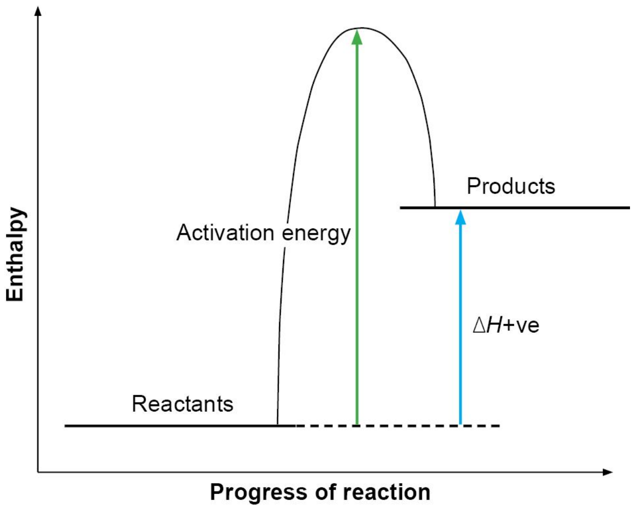
Endothermic reactions

4. Write a definition of an endothermic reaction.

An endothermic reaction is one in which energy is taken in from the surroundings.

5. Draw an enthalpy profile diagram for an endothermic reaction.

Label the axes, Δ*H* and the activation energy.



6. Give an example of an endothermic reaction.

E.g. decomposition of metal carbonates, electrolysis, reaction between ethanoic acid and sodium carbonate, cracking, photosynthesis.

Bond enthalpy

7. Write a definition of bond enthalpy. (You might know this term as 'bond energy'.)

The energy needed to break one mole of a given bond in a gaseous molecule. The units are kJ mol^{-1} (kilojoules per mole).

8. In a chemical reaction, bonds in the reactants are broken, and new bonds are formed to make the products. Complete the following sentences.

Energy is **required** to break bonds.

Energy is **released** when bonds are formed.

The overall energy change of a reaction is the

energy required minus energy released

Calculations

9. Use bond enthalpies to calculate the enthalpy change for the following reaction.

$H_2(g) + Br_2(g) \rightarrow 2HBr(g)$

Bond	H–H	Br–Br	H–Br
Bond enthalpy / kJ mol^{-1}	438	193	366

Energy required to break bonds:

(H–H) + (Br–Br) = 631 kJ mol^{-1}

Energy released in forming new bonds:

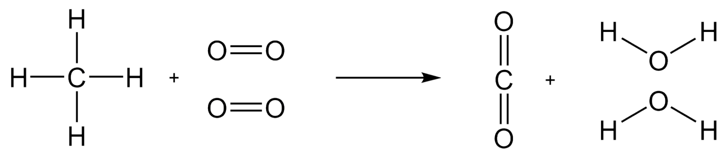
2 × (H–Br) = 732 kJ mol^{-1}

Enthalpy change:

631 – 732 = –101 kJ mol^{-1}

10. Use bond enthalpies to calculate the enthalpy change for the combustion of methane.

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$



Bond	C–H	C–C	O–H	C=O	O=O
Bond enthalpy / kJ mol^{-1}	413	347	464	805	498

Energy required to break bonds:

4 × (C–H) + 2 × (O=O) = 2648 kJ mol^{-1}

Energy released in forming new bonds:

2 × (C=O) + 4 × (O–H) = 3466 kJ mol^{-1}

Enthalpy change:

2648 – 3466 = –818 kJ mol^{-1}

11.

Bond	C–H	C–C	H–H	C=C
Bond enthalpy / kJ mol^{-1}	413	347	436	612

Use the bond energies above to calculate

a) the enthalpy change for the hydrogenation of ethene

CH_2=CH_2(g) + H_2(g) → CH_3CH_3(g)

Energy required to break bonds: 4 × (C–H) + (C=C) + (H–H) = 2700 kJ mol^{-1}
Energy released in forming new bonds: 6 × (C–H) + 1 × (C–C) = 2825 kJ mol^{-1}
Enthalpy change: 2700 – 2825 = –125 kJ mol^{-1}

b) the enthalpy change for the cracking of decane

$C_{10}H_{22}$(g) → CH_2=CH_2(g) + C_8H_{18}(g)

Energy required to break bonds: 22 × (C–H) + 9 × (C–C) = 12 209 kJ mol^{-1}

Energy released in forming new bonds: 22 × (C–H) + (C=C) + 7 × (C–C) = 12 127 kJ mol^{-1}

Enthalpy change: 12 127 – 12 209 = +82 kJ mol^{-1}

N.B. This can be more easily calculated by realising that the overall reaction involves breaking of 2 C–C bonds and formation of 1 new C=C bond. The calculation is then

Energy required to break bonds: 2 × (C–C) = 694 kJ mol^{-1}

Energy released in forming new bonds: 1 × (C=C) = 612 kJ mol^{-1}

Enthalpy change: 694 – 612 = +82 kJ mol^{-1}

12. Explain in terms of bond breaking and bond formation why combustion reactions are exothermic but cracking reactions are endothermic.

In combustion reactions, the bond enthalpies in the products are greater than those in the reactants. Therefore, more energy is released in making the bonds in the products than is required to break the bonds in the reactants.

In cracking reactions, the bond enthalpies in the products are smaller than those in the reactants. Therefore, less energy is released in making the bonds in the products than is required to break the bonds in the reactants.

