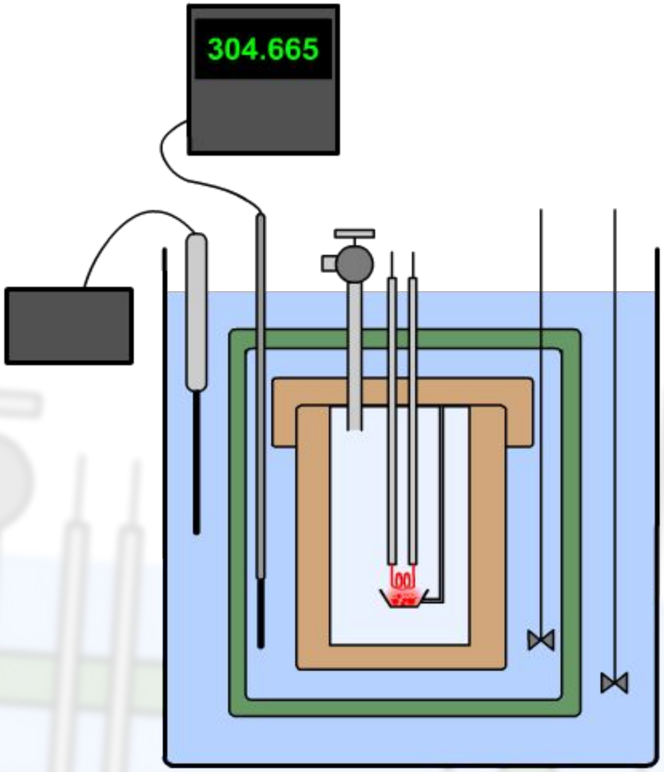
AS Chemistry

Energetics



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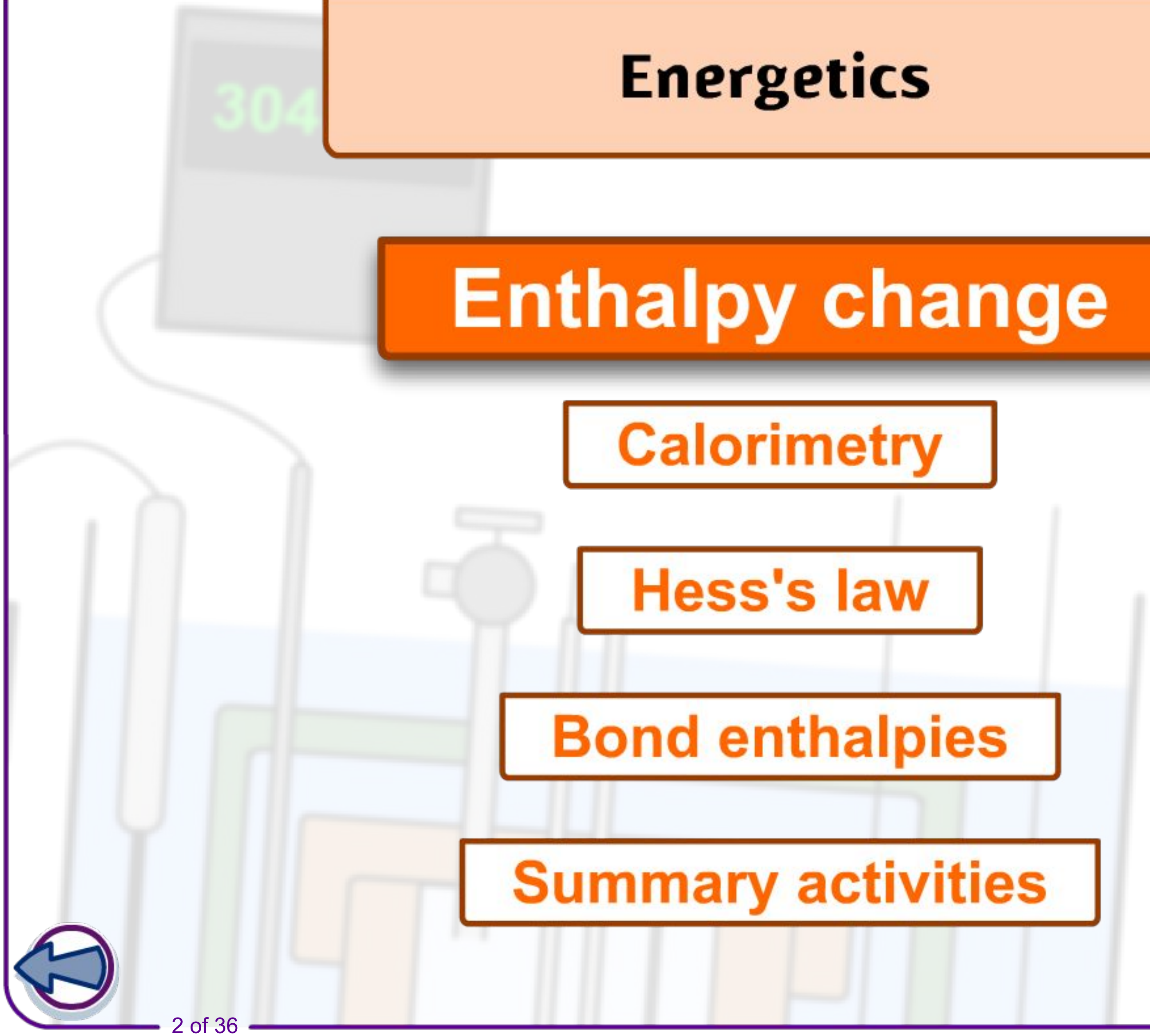

Enthalpy change

- Calorimetry
- Hess's law
- Bond enthalpies
- Summary activities

What is enthalpy?

The **enthalpy**, ***H***, of a system is a measure of the energy stored in (or heat content of) a system. It cannot be measured directly.

During reactions, the enthalpy of the reactants and the products is not the same. This results in energy being either given out or taken in during the reaction. This energy is the **enthalpy change**, ΔH ('delta H').

The enthalpy change for a reaction is usually observed as a change in temperature, which can be measured or calculated.

Enthalpy changes

The **enthalpy change** of a reaction is the heat energy exchange with its surroundings at constant pressure.

Enthalpy is the energy content of the reactants and is given the symbol ***H***.

In science, change is represented by the upper case Greek letter delta, Δ.

Therefore, enthalpy change is represented by ΔH. It has the units kilojoules per mole (kJ mol^{-1}).

Standard enthalpy changes are measured at a standard pressure of **100 kPa** and temperature of **298 K**. Standard enthalpy changes are represented by $\Delta H^{\ominus}_{298}$ but this is usually shortened to $\Delta H^{\ominus}$.

Exothermic reactions

Endothermic reactions

Exothermic and endothermic reactions

Types of enthalpy change

Standard enthalpies: examples

The **standard enthalpy of formation** of methane can be represented by:

$$\mathbf{C_{(s,\ graphite)} + 2H_{2(g)} \rightarrow CH_{4(g)}}$$

$\Delta H_f^{\ominus} = -74.9\ \text{kJ mol}^{-1}$

By definition, the standard enthalpy of formation of an element, in its standard state, must be zero.

The **standard enthalpy of combustion** of methane can be represented by:

$$\mathbf{CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(l)}}$$

$\Delta H_c^{\ominus} = -890\ \text{kJ mol}^{-1}$

Enthalpy change summary

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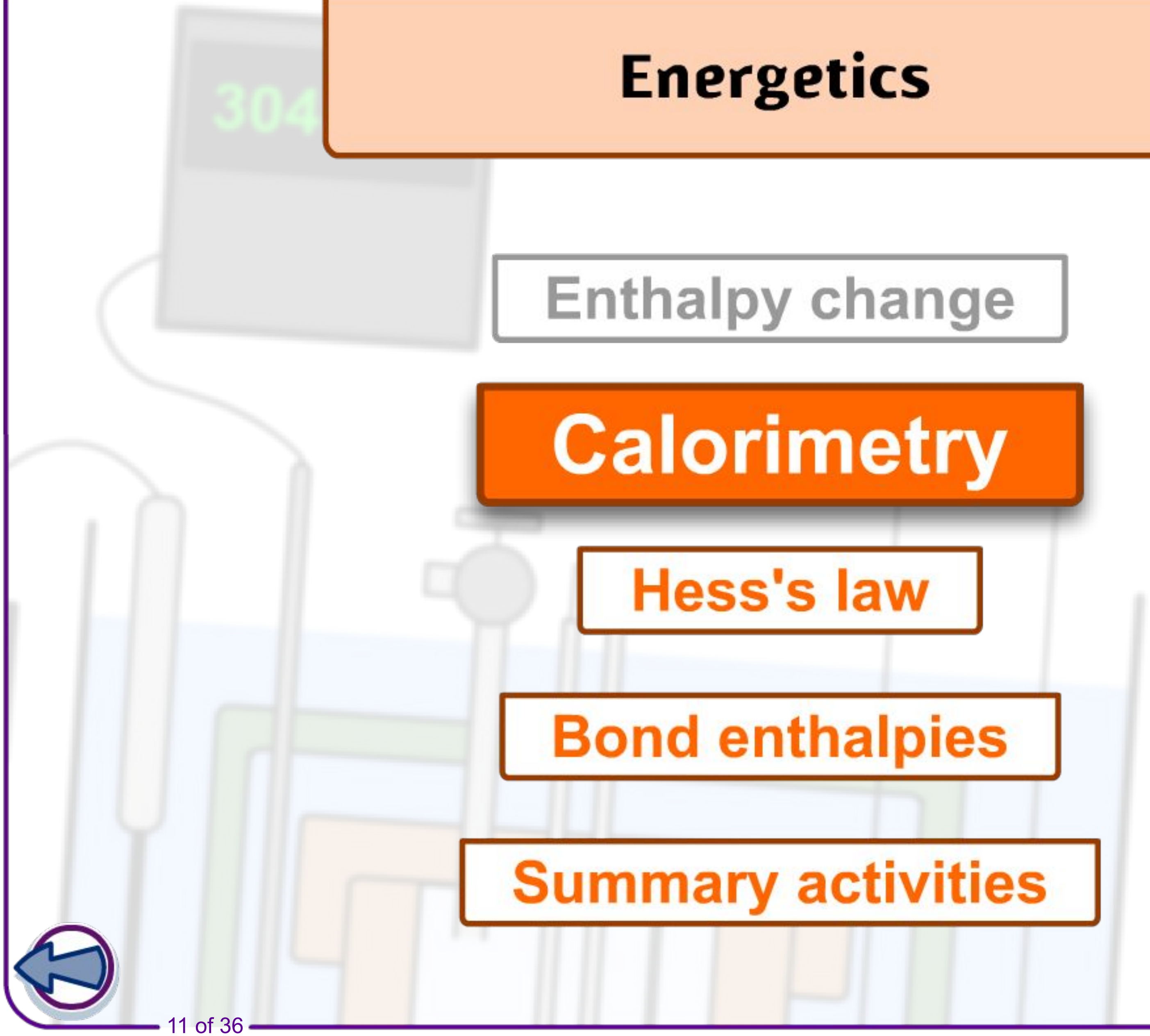

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Enthalpy of combustion experiment

Enthalpy of neutralization experiment

Using experimental results

Calorimetry calculations

Enthalpy change can be calculated using the following equation:

$$\boxed{q = mc\Delta T}$$

q = enthalpy change in joules

m = mass of substance being heated (often water) in grams

c = specific heat capacity in joules per Kelvin per gram ($4.18\ JK^{-1}g^{-1}$ for water)

ΔT = change of temperature in Kelvin.

To work out the enthalpy of neutralization, the density and specific heat capacities of the acid and base used are taken to be the same as for pure water.

Calorimetry calculation examples

Calorimetry calculation problems

The bomb calorimeter

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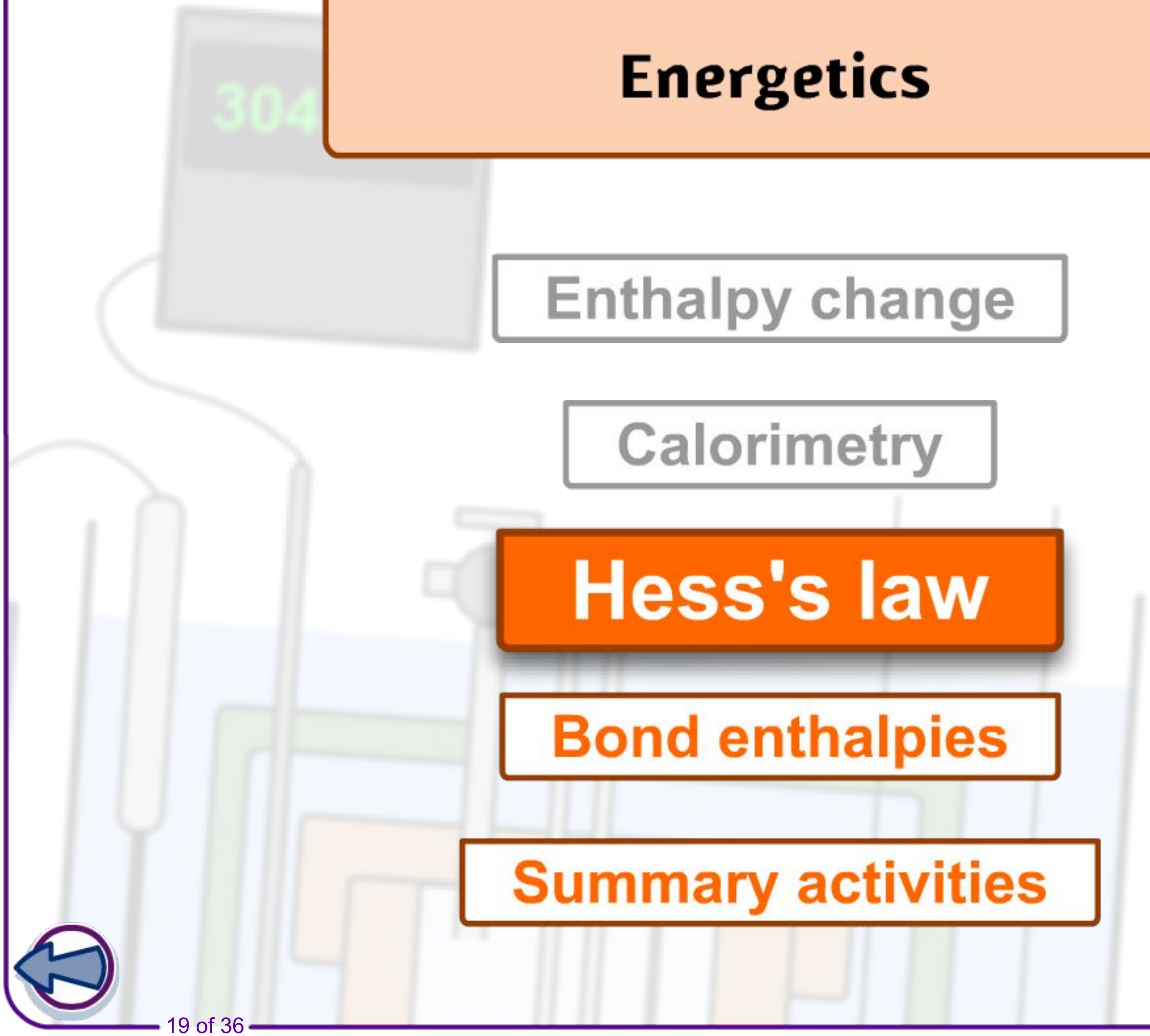

Enthalpy change

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Hess's law and thermodynamics

In 1840, the Russian chemist Germain Hess formulated a law which went on to be known as **Hess's Law**.

Hess's law states that the overall enthalpy change for a reaction is independent of the route the reaction takes.

This went on to form the basis of one of the laws of **thermodynamics**:

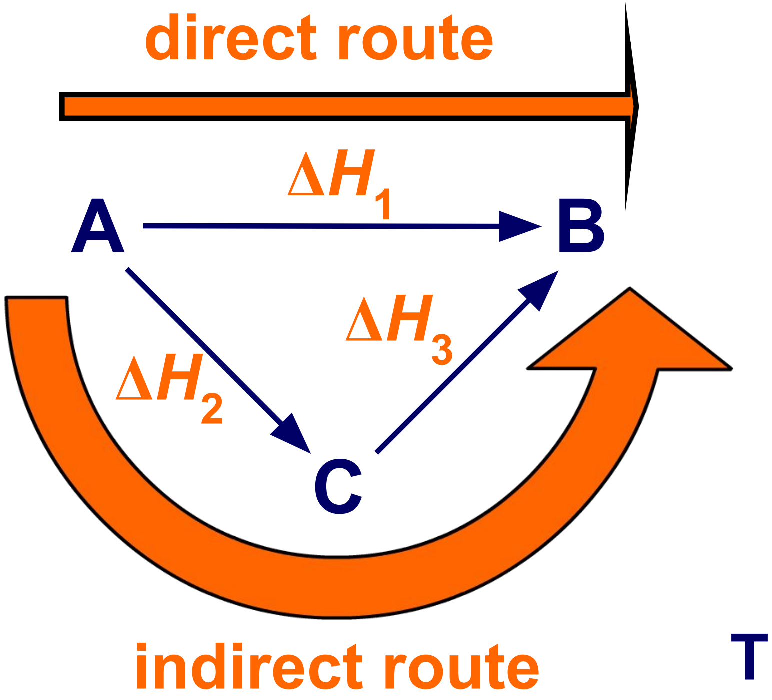
The **first law of thermodynamics** relates to the conservation of energy. It is sometimes expressed in the following form: *Energy cannot be created or destroyed, it can only change form.*

This means that in a closed system, the total amount of energy present is always constant.

Hess's Law and chemical reactions

Hess's law can be used to calculate the standard enthalpy change of a reaction from known standard enthalpy changes.

For example, the enthalpy change for A forming B directly, ΔH_1, is the same as the enthalpy change for the indirect route, $\Delta H_2 + \Delta H_3$.



A → B	ΔH_1
A → C → B	$\Delta H_2 + \Delta H_3$

Therefore: $\Delta H_1 = \Delta H_2 + \Delta H_3$

Using enthalpies of formation

Enthalpies of formation calculations

Using enthalpies of combustion

Enthalpies of combustion calculations

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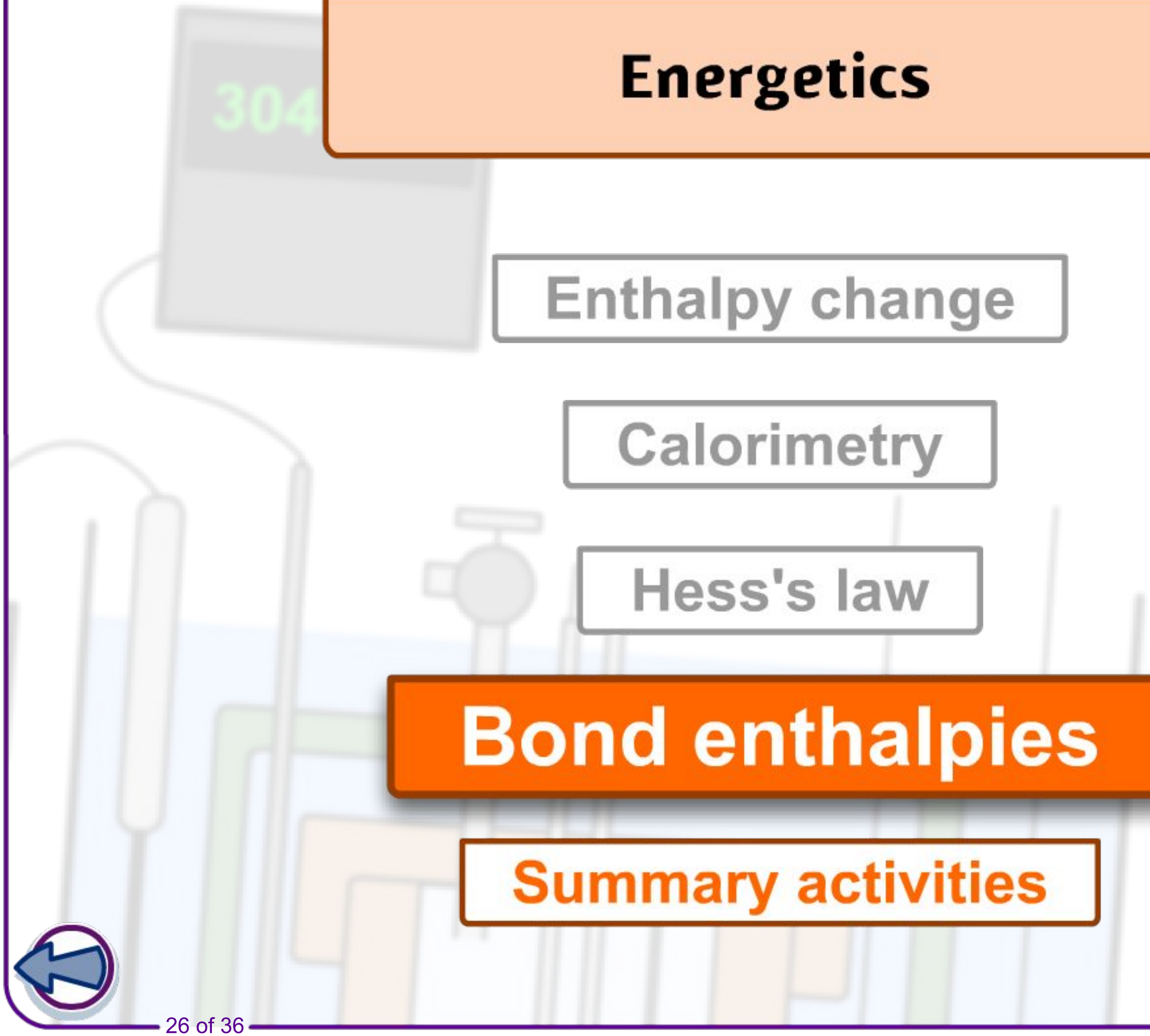

Enthalpy change

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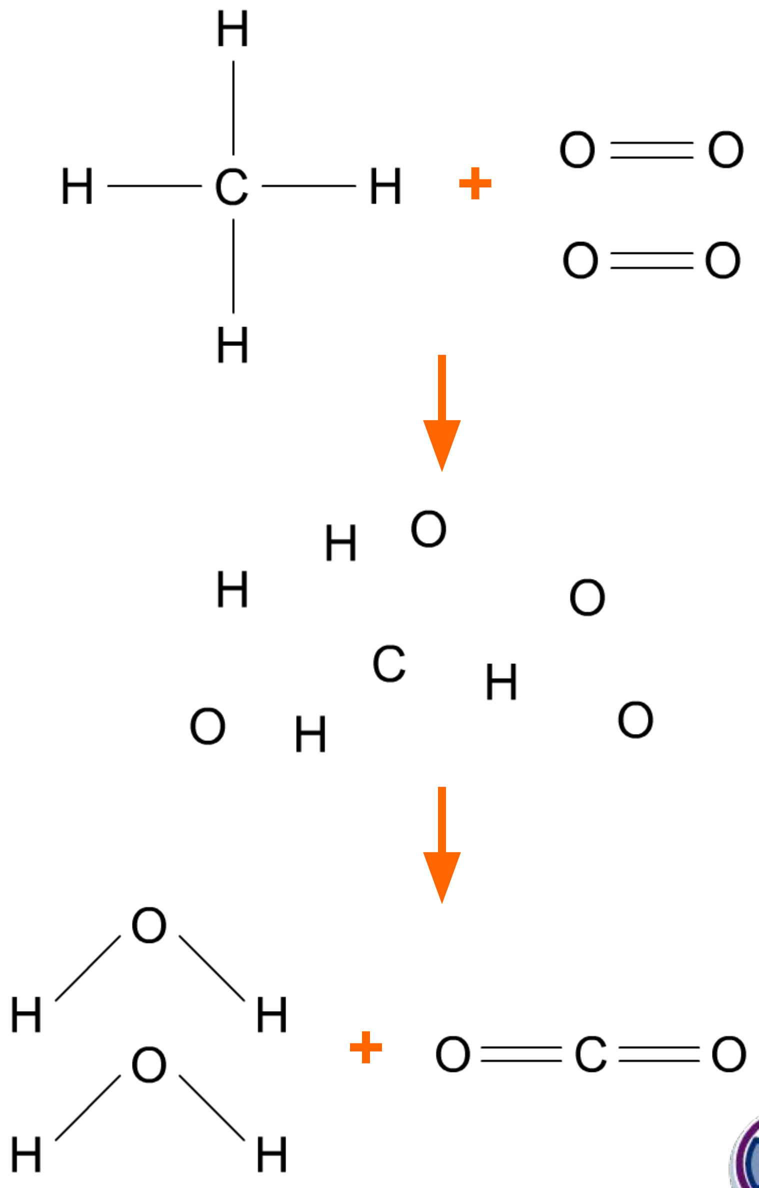
Breaking and forming bonds

Exothermic reactions and bonds

During an **exothermic** reaction, heat energy is **released** to the surroundings.

This happens because more energy is released making new bonds in the products than is taken in breaking bonds in the reactants.

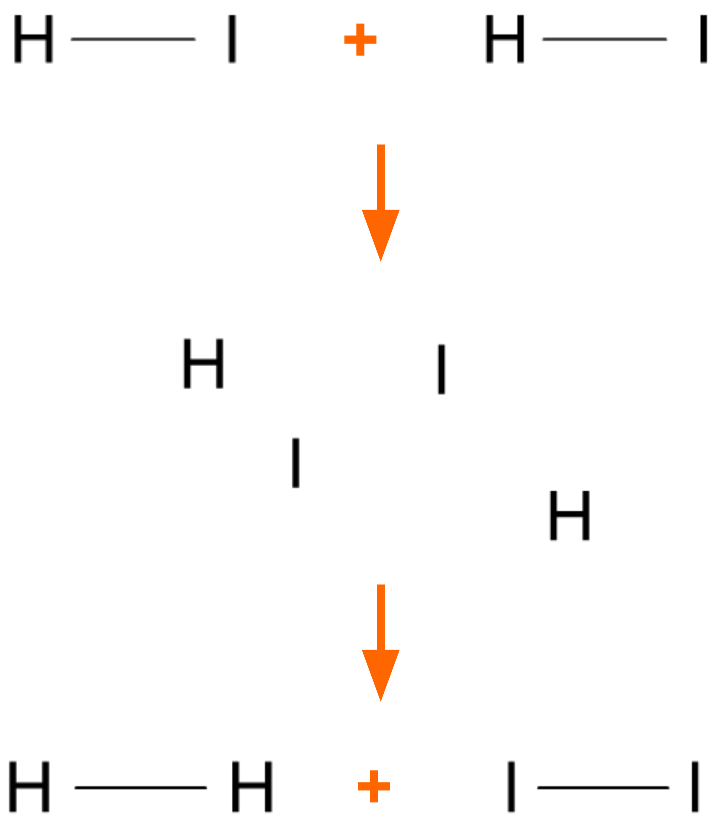
There is therefore a net release of energy, which is measured as an increase in temperature.



Endothermic reactions and bonds

During an **endothermic** reaction, heat energy is **taken in** from the surroundings.

This happens because more energy is used in breaking bonds in the reactants than is released when bonds are formed in the products.



There is therefore a net intake of energy, which is measured as a decrease in temperature.

Mean bond enthalpy

The H–H bond is only found in H_2 and its bond dissociation energy is +436 kJ mol^{-1}. However, bonds such as C–H exist in different compounds and have a slightly different bond dissociation enthalpy in each case.

The **mean bond enthalpy** is the average (mean) **bond dissociation enthalpy** for a particular bond in a range of different compounds.

Precisely, it is the average enthalpy change for breaking 1 mole of a particular bond in a range of different compounds in the gas phase.

Using the mean bond enthalpy takes into account the different bond dissociation enthalpies of the particular bond in different compounds.

Calculating enthalpy change

Calculating enthalpy change problems

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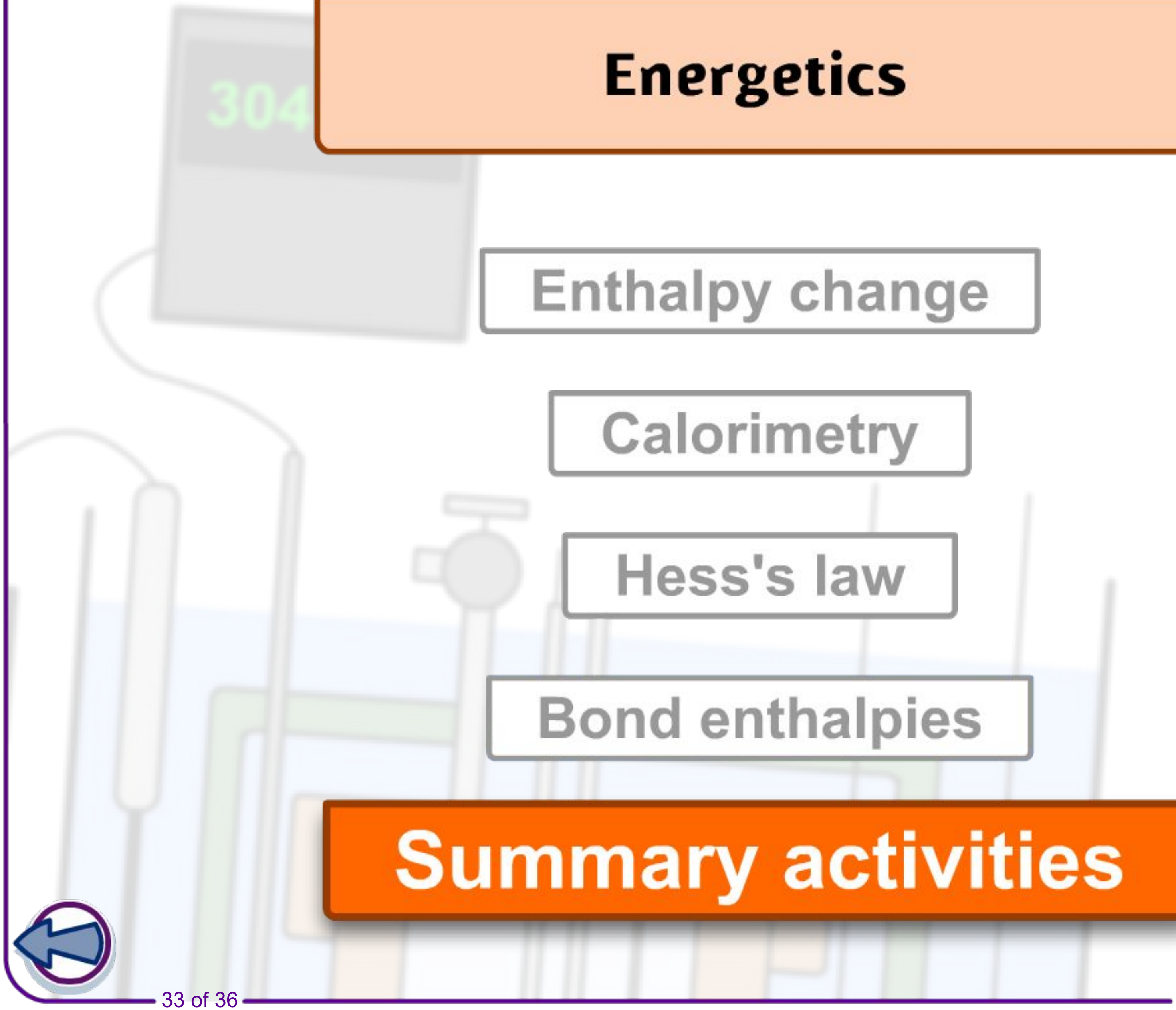

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Glossary

What’s the keyword?

Multiple-choice quiz