WJEC CH1 6

energetics

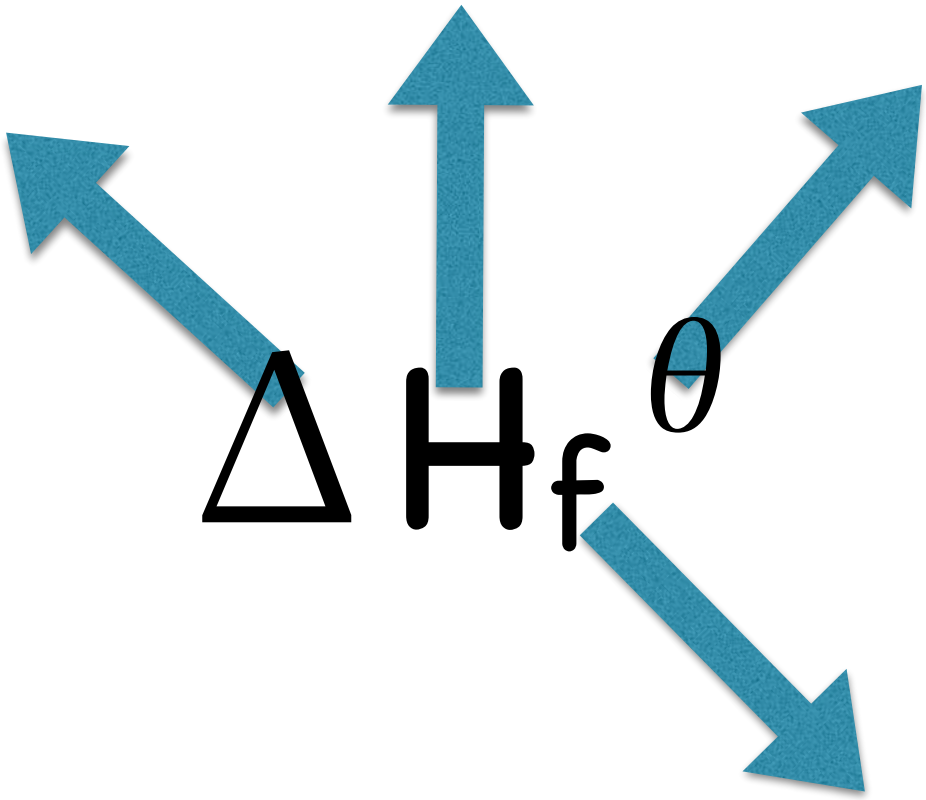
In this lesson you will learn:

- Be able to describe the terms:
  - enthalpy
  - activation energy
  - enthalpy of reaction
  - bond enthalpies
  - enthalpy of formation
- to be able to draw on energy time curve for both exothermic and endothermic reactions
- to be able to reciteHess' law
- to be able to calculate and enthalpy of formation of a substance using enthalpies of combustion

Key words

- Standard temperature and pressure (for energetics)temperature 298 K (25 oC) and a pressure 101 kPa (1 atm).
- The standard molar enthalpy change of formation, ΔH_f^{θ},represents the enthalpy change when one mole of the substance (at 298 K and 1 atm) is formed from its constituent elements in their most stable form at 298 K and 1 atm.
- The standard molar enthalpy change of combustion, ΔH_c^{θ}, represents the enthalpy change .when one mole of the substance (at 298 K and 1 atm) is completely combusted to form products (at 298 K and 1 atm).

Enthalpy is _____



the process of bond breaking is _ _ _ _ _ _ _ _ _ _ _ this means

_____

the process of bond making is _ _ _ _ _ _ _ _ _ _ _ _ this means

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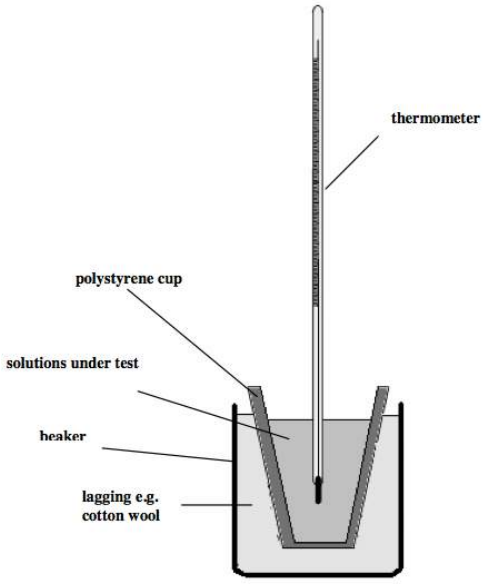


Enthalpy change of neutralisation and of solution can be measured using this toe of apparatus.

One important practical technique is to allow for heat losses to the atmosphere. To do this temperatures of solutions are taken for a short time before mixing and then again for some time after mixing. This allows for a corrected temperature rise (or loss) to be measured.

Enthalpy can be calculated using the following equation

$$\Delta H = -\frac{mc\Delta T}{n}$$

100 cm^3 of water were placed in a polystyrene cup as shown above. 10.0 g of finely ground potassium nitrate was weighed out. The temperature of the water was recorded every thirty seconds for 2 minutes. Then potassium nitrate was quickly added to the water and the mixture vigorously stirred with the thermometer until the solid had dissolved and the temperature recording continued for some time after mixing. Calculate the enthalpy change of solution of potassium nitrate in kJ mol^{-1}.

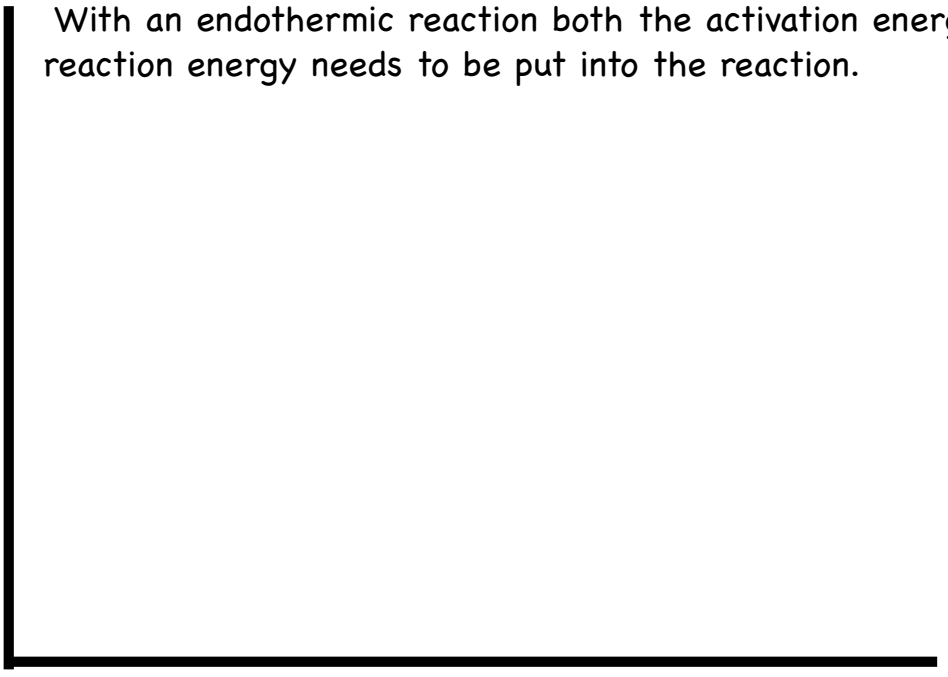
Time s	0	30	60	90	120	150	180	210	240	270	300	330
Temp °T	18.1	18.3	18.5	18.7	18.9	11.7	10.5	10.7	10.9	11.1	11.3	11.5

specific heat capacity of water = 4.18 J per g per °C

the majority of reactions need some energy input before they will start. This is known as activation energy Ea.

within exothermic reaction once this activation energy has been achieved the reaction generates its own energy therefore heat is given off.

With an endothermic reaction both the activation energy and reaction energy needs to be put into the reaction.



Hess' Law

Essentially, this means regardless which chemical reactions you use to get from one set of reactants to another set of products the enthalpy change will be the same.

Combustion

Formation

Born in Geneva, Switzerland, his father was an artist and in 1805 moved the family to Russia to find work. Beginning in 1822, Hess studied medicine at the University of Tartu. He qualified as a physician in 1825. Hess turned to chemistry after a meeting with Jöns Jakob Berzelius, the famous Swedish chemist, and went to Stockholm University to study under him. On his return to Russia, Hess joined an expedition to study the geology of the Urals before setting up a medical practice in Irkutsk.

In 1830, Hess took up chemistry full-time, researching and teaching, and later became a professor at the Saint Petersburg Technological Institute. His most famous paper, outlining his law on thermochemistry, was published there in 1840. His principle, a progenitor for the first law of thermodynamics, came to be called Hess's Law. It states that in a series of chemical reactions, the total energy gained or lost depends only on the initial and final states, regardless of the number or path of the steps. This is also known as the law of constant heat summation.

Hess's other work concerned the investigation of minerals, including analysis of silver telluride (Ag2Te), which was named Hessite in his honour. He also discovered that the oxidation of sugars yielded saccharic acid.
Hess was the author of a textbook on chemistry that was the standard Russian work for several decades. He died in St. Petersburg.

ENERGETICS HOMEWORK 1

Examiner only

9. *(a)* (i) Given the bond enthalpy values

Bond	*Bond enthalpy value* / kJ mol^{-1}
Cl – Cl	243
H – Cl	432
H – H	436

calculate the standard enthalpy change, $\Delta H^{\ominus}$, for the gaseous reaction

$$H_2(g) + Cl_2(g) \longrightarrow 2HCl(g)$$ [2]

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(ii) Using your answer to *(a)*(i) calculate the standard enthalpy change of formation, $\Delta H_f^{\ominus}$, for gaseous hydrogen chloride, HCl(g). [1]

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(iii) State the standard conditions which apply to *standard* enthalpy changes. [2]

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(iv) By reference to the bond enthalpy values in *(a)*(i), state which bond will break first in the reaction. [1]

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(v) Typical energies associated with visible light are

Colour of light	*Typical energy* / kJ mol^{-1}
red	171
yellow	200
green	226
blue	254
violet	285

State and explain which colours of light will cause a mixture of hydrogen and chlorine to react. [3]

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(vi) Explain why shining visible light has very little effect on the reverse reaction

$$2HCl(g) \longrightarrow H_2(g) + Cl_2(g)$$ [1]

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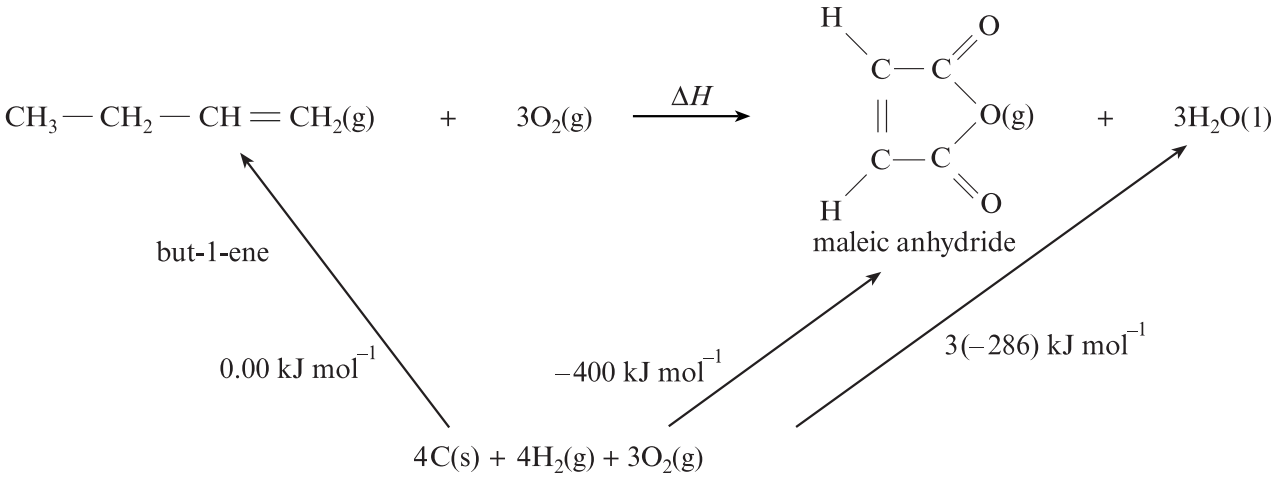
Examiner only

(ii) One method of preparation of maleic anhydride is the oxidation of but-1-ene.

Use the energy cycle to calculate the enthalpy change, ΔH, for the production of maleic anhydride from but-1-ene. [2]



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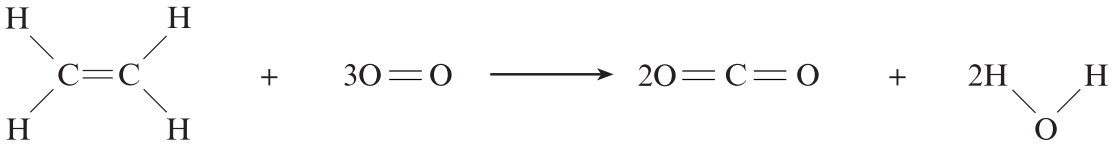
(b) In the complete oxidation of ethene, carbon dioxide and water are formed.

Use the bond energy values in the table to calculate the enthalpy change in the reaction given. [4]

Bond	Average bond energy / kJ mol^{-1}
C — H	412
C = C	612
O = O	496
C = O	743
O — H	463



ethene

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Turn over.

ENERGETICS HOMEWORK 2

Examiner only

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$$2HCl(g) \longrightarrow H_2(g) + Cl_2(g)$$ [1]

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Examiner only

(b) The corresponding reaction between hydrogen, $H_2(g)$, and iodine, $I_2(g)$,

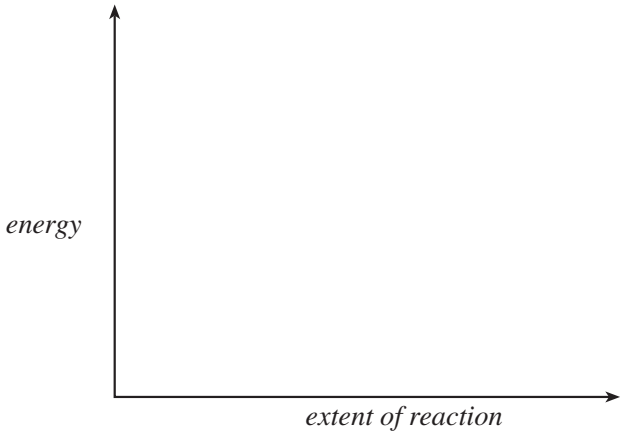
$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

for which the standard enthalpy change of reaction, $\Delta H^{\ominus}$, = –9.6 kJ mol^{-1}, is a system unaffected by light.

Sketch on the axes below the energy profile (*energy* v *extent of reaction*) for the reaction between hydrogen and iodine and use it to explain:

- the concept of *activation energy*;
- the effect of increasing temperature on the rate of reaction;
- the effect of adding a catalyst to a reaction mixture. [6]

QWC [2]



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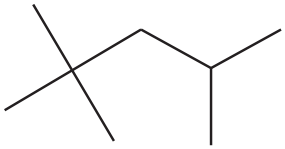
Total [18]

Turn over.

Answer **all** the questions.

1 Octane is a component of petrol and the 'octane number' of a petrol is a measure of the tendency of the petrol to auto-ignite. The structure of an **isomer** of octane is given below.



(a) (i) What **type** of formula is represented by the structure above?

..... **[1]**

(ii) Give the systematic name of this isomer of octane.

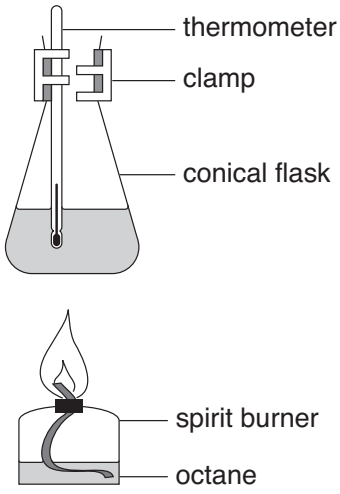
..... **[2]**

(iii) Branched chain hydrocarbons are useful in petrol because they have a low tendency to auto-ignite.

Name another structural feature of hydrocarbon molecules that also results in a lower tendency of the fuel to auto-ignite.

..... **[1]**

(b) A value for the enthalpy change of combustion of octane can be obtained from a simple experiment using the following apparatus.



(i) Describe how you could use this apparatus to obtain data from which you could calculate a value for the enthalpy change of combustion of octane. You should also explain how you would use your experimental results to calculate this value.

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..... **[5]**

(ii) Results obtained using this apparatus give a much less negative value for the enthalpy change of combustion of octane than the data book value.

Suggest **two** limitations in the practical procedure which would result in a less negative value for the enthalpy change of combustion of octane than the data book value.

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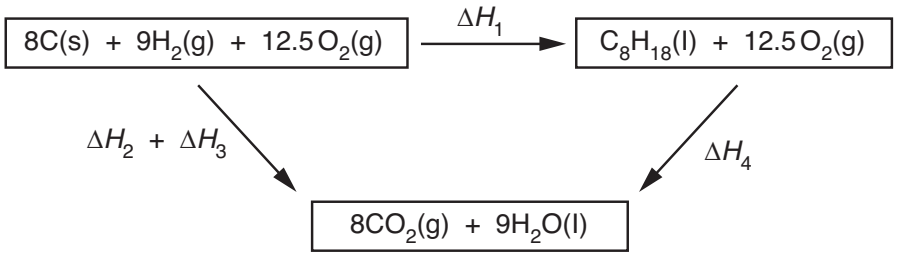
..... **[2]**

(c) ΔH_f values can be calculated for hydrocarbons using enthalpy changes of combustion in an enthalpy cycle.

The enthalpy cycle below can be used to calculate the standard enthalpy change of formation of octane.



(i) State the enthalpy changes represented by ΔH_1, ΔH_2, ΔH_3, and ΔH_4.

ΔH_1 = ...

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ΔH_2 = ...

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ΔH_3 = ...

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ΔH_4 = ...

..... **[4]**

(ii) You are given the following values:

$$\Delta H_2 + \Delta H_3 = -5718\,\text{kJ mol}^{-1};\quad \Delta H_4 = -5470\,\text{kJ mol}^{-1};$$

Calculate a value for ΔH_1.

ΔH_1 = ... kJ mol^{-1} **[1]**

[Total: 16]

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