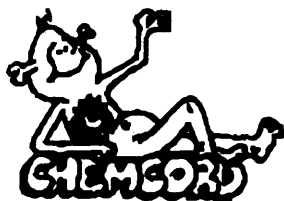


**Revision Notes
for
Higher
Chemistry**



**D A Buchanan
J R Melrose**

Study Planner

UNIT 1 Energy Matters

1. Reaction Rates
2. Enthalpy
3. Patterns in the Periodic Table
4. Bonding, Structure and Properties
5. The Mole

Revision \checkmark			
1	2	3	4

UNIT 2 The World of Carbon

1. Fuels
2. Nomenclature and Structural Formulae
3. Reactions of Carbon Compounds
4. Uses of Carbon Compounds
5. Polymers
6. Natural Products

UNIT 3 Chemical Reactions

1. The Chemical Industry
2. Hess's Law
3. Equilibrium
4. Acids and Bases
5. Redox Reactions
6. Nuclear Chemistry

PPAs

--	--	--	--

2. NOMENCLATURE AND STRUCTURAL FORMULAE

Alkanes, alkenes and cycloalkanes - revision

- the **alkanes** are a subset of the set of hydrocarbons
- each member of the alkane series has a name which ends in **-ane** and a prefix which indicates the number of carbon atoms in the molecule

Prefix	Number of C atoms
meth-	1
eth-	2
prop-	3
but-	4

Prefix	Number of C atoms
pent-	5
hex-	6
hept-	7
oct-	8

- the general formula for the alkanes is C_nH_{2n+2} where n is the number of carbon atoms
- the **full structural formula** can be used to show the arrangement of atoms; a **shortened structural formula** can be used to show the grouping of hydrogen atoms round each carbon,

e.g.

Number of carbon atoms in each molecule	Name of alkane	Formula
4	butane	C_4H_{10}

Full structural formula	Shortened structural formula
$\begin{array}{cccc} \text{H} & \text{H} & \text{H} & \text{H} \\ & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array}$	$\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_3$ <p style="text-align: center;">or</p> $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$

- all alkanes are **saturated** hydrocarbons, i.e. all the carbon to carbon bonds are single covalent bonds
- the **alkenes** are also a subset of the set of hydrocarbons
- each member of the alkene series has a name which ends in **-ene** and a prefix which indicates the number of carbon atoms in the molecule

- the general formula for the alkenes is C_nH_{2n} (each alkene has two hydrogens less than the corresponding alkane due to the double bond),

e.g.

Number of carbon atoms in each molecule	Name of alkene	Formula
3	propene	C_3H_6

Full structural formula	Shortened structural formula
	$CH_2=CH-CH_3$ or CH_2CHCH_3

- all alkenes are **unsaturated** hydrocarbons, i.e. there is at least one carbon to carbon double bond
- the carbon to carbon double bond is an example of a **functional group**, i.e. a group of atoms with characteristic properties
- alkanes with a ring of carbon atoms are called **cycloalkanes**
- the general formula for the cycloalkanes is also C_nH_{2n} (each cycloalkane has two hydrogens less than the corresponding alkane due to the closing of the chain),
e.g.

Number of carbon atoms in each molecule	Name of cycloalkane	Formula
6	cyclohexane	C_6H_{12}

Full structural formula	Shortened structural formula

- all cycloalkanes are also **saturated** hydrocarbons
- a **homologous series** is a family of compounds which can be represented by a general formula,
e.g. the alkanes (C_nH_{2n+2}) and the alkenes (C_nH_{2n})
- successive members in a series differ in formula by a CH_2 group and hence relative molecular masses differ by 14

- there is a gradual change from one member of a homologous series to the next in physical properties, *e.g. boiling point*
- chemical properties of compounds in a homologous series are very similar due to all members having the same functional group, *e.g. the reaction of the alkenes with bromine*

Alkynes

- the **alkynes** are another subset of the set of hydrocarbons
- the functional group in an alkyne is the carbon to carbon triple bond
- each member of the alkyne series has a name which ends in **-yne** and a prefix which indicates the number of carbon atoms in the molecule
- the general formula for the alkynes is C_nH_{2n-2} (each alkyne has four hydrogen atoms less than the corresponding alkane due to the triple bond), *e.g.*

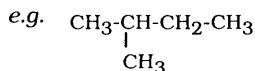
Number of carbon atoms in each molecule	Name of alkyne	Formula
2	ethyne	C_2H_2

Full structural formula	Shortened structural formula
$H-C\equiv C-H$	$HC\equiv CH$ or $CHCH$

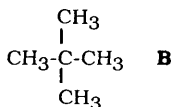
- all alkynes are also **unsaturated** hydrocarbons

Straight and branched chains

- in a **straight** chain all the carbon atoms are joined to one (at end) or two neighbouring carbon atoms, *e.g.* $CH_3-CH_2-CH_2-CH_2-CH_3$
- in a **branched** chain one or more of the carbon atoms may be joined to three or four neighbouring carbon atoms,



A

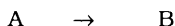


B

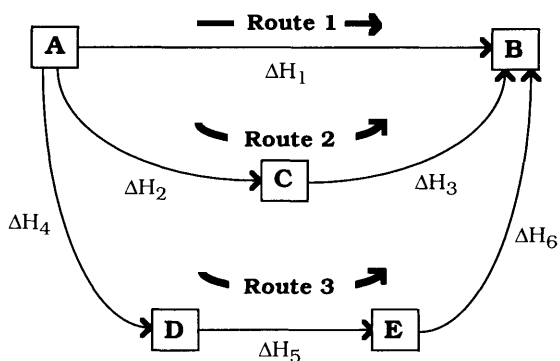
2. HESS' S LAW

Conservation of energy

- the law of conservation of energy states that energy can neither be created nor destroyed
- the application of the law of conservation of energy to chemical reactions is known as Hess's Law
- Hess's Law states that the enthalpy change in converting reactants into products is the same regardless of the route by which the reaction takes place,
e.g. the reaction



may proceed by the three different routes



$$\text{Total enthalpy change for Route 1} = \Delta H_1$$

$$\text{Total enthalpy change for Route 2} = \Delta H_2 + \Delta H_3$$

$$\text{Total enthalpy change for Route 3} = \Delta H_4 + \Delta H_5 + \Delta H_6$$

According to Hess's Law the total enthalpy change for Routes 1, 2 and 3 will be identical,

$$\begin{aligned} \text{i.e. } \Delta H_1 &= \Delta H_2 + \Delta H_3 \\ &= \Delta H_4 + \Delta H_5 + \Delta H_6 \end{aligned}$$

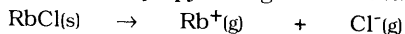
Applications of Hess's Law

- Hess's Law can be used to calculate enthalpy changes which are difficult or impossible to determine by experiment

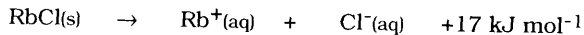
See
UNIT 3 PPA 1

Example 1

Calculate the enthalpy change for the reaction:



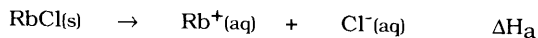
Use the following enthalpy changes.



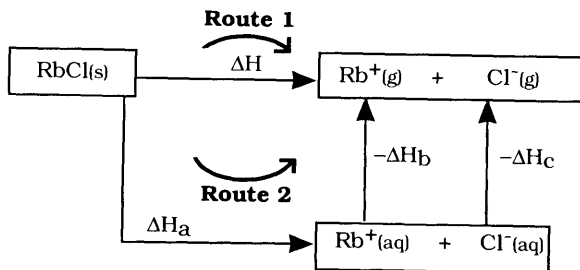
Step 1 Write a balanced equation for the reaction the enthalpy change of which is to be found.



Step 2 Write a balanced equation for the reactions the enthalpy changes of which have been given and label them ΔH_A , ΔH_B , etc.

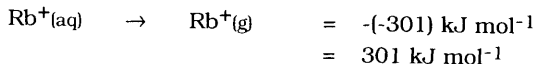


Step 3 Identify a second route for the reaction and label each step with the appropriate ΔH value, taking into account the number of moles involved and the direction of the reaction.



Note:

ΔH_B takes a negative sign since the reaction is reversed.



Similarly for ΔH_C .

Step 4 Apply Hess's Law.

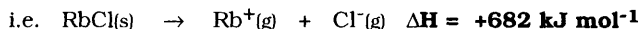
The enthalpy change for the direct route, i.e. Route 1, will equal the total enthalpy change for Route 2.

$$\Delta H = \Delta H_A + (-\Delta H_B) + (-\Delta H_C)$$

Step 5 Substitute numerical values in the above equation and solve for ΔH .

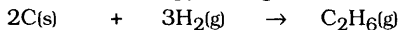
$$\Delta H = +17 + (+301) + (+364)$$

$$\Delta H = +682 \text{ kJ mol}^{-1}$$



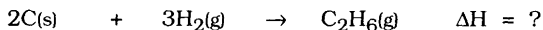
Example 2

Calculate the enthalpy change for the reaction:

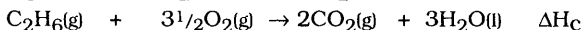
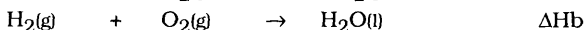
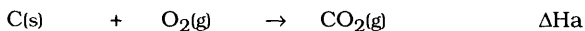


Take the enthalpies of combustion of carbon, hydrogen and ethane to be -394 kJ mol^{-1} , -286 kJ mol^{-1} and $-1560 \text{ kJ mol}^{-1}$ respectively.

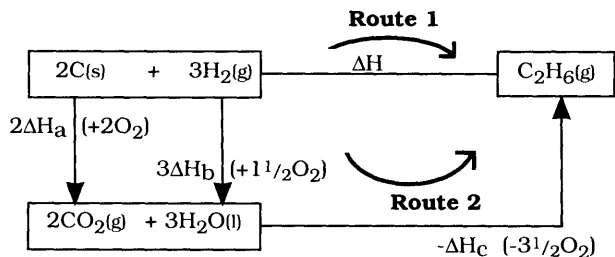
Step 1 Write a balanced equation for the reaction the enthalpy change of which is to be found.



Step 2 Write a balanced equation for the reactions the enthalpy changes of which have been given and label them ΔH_A , ΔH_B , etc.



Step 3 Identify a second route for the reaction and label each step with the appropriate ΔH value, taking into account the number of moles involved and the direction of the reaction.

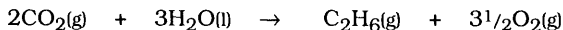


Note:

ΔH_A is multiplied by 2 since 2 mol of C(s) are involved.

Likewise, ΔH_B is multiplied by 3.

ΔH_C takes a negative sign since the reaction



is the reverse of that for the enthalpy of combustion of ethane.

Step 4 Apply Hess's Law.

The enthalpy change for the direct route, i.e. Route 1, will equal the total enthalpy change for Route 2.

$$\Delta H = 2\Delta H_a + 3\Delta H_b + (-\Delta H_c)$$

Step 5 Substitute numerical values in the above equation and solve for ΔH .

$$\Delta H = 2(-394) + 3(-286) + (+1560)$$

$$\Delta H = \mathbf{-86 \text{ kJ mol}^{-1}}$$

