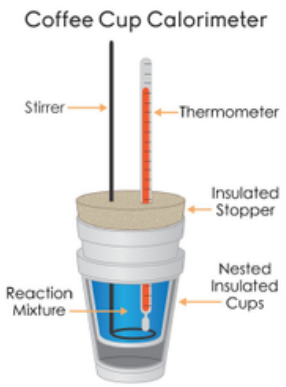
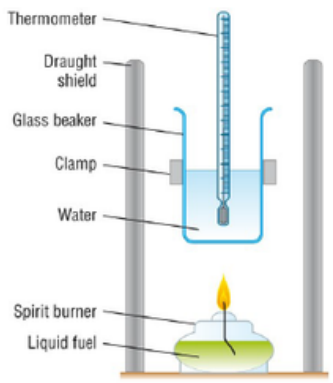
STUDY PACK 3 A

Pearson Edexcel

CHEMICAL ENERGETICS





Since 2005
Chembase
School of Chemistry

First Edition Jan 2006
Second Edition Jun 2009
Third Edition Jun 2011
Fourth Edition Jun 2021 (Revised New Syllabus)

All Rights Reserved.
Unauthorized duplication contravenes applicable laws.

No part of this publication may be reproduced or utilized in any form or by electronic, mechanical or other means, now known or hereafter invented including photocopying & recording, without the prior permission in writing from the copyright owner.

PUBLISHED BY :

Since 2005 Chembase School of Chemistry

PRODUCER OF WORLD PRIZE & ISLAND TOP AWARD WINNERS SINCE 2005

Pearson Edexcel

UNIVERSITY OF CAMBRIDGE

COPYRIGHT OWNER :

Prof. IMRAN RAZEEK I.Chem.C(P1), M.Ed, Ph.D (Reading)

Honorary Professor | Founder, Chairman & Head of Department of Chembase School of Chemistry | Chief Chemistry Educator

CHEMBASE SCHOOL OF CHEMISTRY

34, 1/2, Galle Road, Dehiwela. SRI LANKA.

+94 754 456 456 | +94 776 534 233

info@chembase.lk

22 YEARS LEGACY OF EXCELLENCE Chembase School of Chemistry 2005-2026

ASIA PACIFIC EXCELLENCE AWARD 2025

JOIN LIVE CLASSES @ WWW.CHEMBASE.LK

ONLINE COURSES @ WWW.CHEMBASEACADEMY.COM

CHEMBASE.LK

CHEMBASE SCHOOL OF CHEMISTRY

CHEMBASE.LK

CHEMBASE SCHOOL OF CHEMISTRY

ACCREDITED & APPROVED BY :

UKIQ | UK International Qualifications

R·S·D·C·A Regional Skill Development & Certification Authority

AN ACCREDITED TEACHING INSTITUTE OF UK INTERNATIONAL QUALIFICATIONS.

ENERGETICS

01.

i. Define the term 'enthalpy' & write its symbol & units

Enthalpy is the scientific term which denotes the system's internal energy. In a chemical reaction the reactants and products are defined as the system and the energy is stored in form of bond energy.

Symbol = 'H' units: $kJmol^{-1}$

ii. Explain the term enthalpy change & write its symbols

The energy change associated in a system. Symbol $\triangle H$

iii. Write an equation in words to show the enthalpy change

Enthalpy Change = Enthalpy of products – Enthalpy of reactants

$\triangle H = H_P - H_R$

02.

i. Define the term 'exothermic reactions'

Chemical reaction, which liberates heat energy to the surroundings

ii. What can you say about the energies of reactants and products in an exothermic reaction?

Energy of the reactants is greater than the products

iii. Therefore, what can you say about $\triangle H$, is it negative or positive?

$\triangle H = H_P - H_R$

$H_R > H_P$

$\triangle H$ - ve (negative)

iv. Give some examples for an exothermic reaction.

03.

i. In what ways the enthalpy change can be represented?

By drawing energy level diagram which is also referred to as energy profile or enthalpy level diagram.

ii. Draw an energy level diagram for an exothermic reaction.

04.

i. Define the term 'Endothermic Reactions'

Chemical reaction, which absorbs heat energy from the surroundings.

ii. What can you say about the energies of the reactants and products in an endothermic reaction?

Energy of the products are greater than the reactants

iii. Therefore, what can you say about $\triangle H$, is it negative or positive?

$\triangle H = H_P - H_R$

$H_P > H_R$

$\triangle H$ +ve (positive)

iv. Give some examples for endothermic reactions.

v. Draw an energy level diagram for endothermic reactions.

05

i. What does an enthalpy diagram or energy level diagram clearly state?

It states whether the reactants are more stable or less stable than the products. If the energy of substance is greater then it is less stable & if the energy is lesser its more stable.

ii. Draw energy profiles for the reactions below.

(a) $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$ $\triangle H = -890kJmol^{-1}$

(b) $2NH_3 \longrightarrow N_2 + 3H_2$ $\triangle H = +92.8kJmol$

c) $HCl + NaOH \longrightarrow NaCl + H_2O$ $\triangle H = -57kJmol^{-1}$

(d) $N_2 + O_2 \longrightarrow 2NO$ $\quad \triangle H = +184 kJmol^{-1}$

06. Explain what "Activation energy" means

The minimum energy required to initiate a chemical reaction.

Write equations for the statements below & show it in an energy profile including Activation energies

i. When 1 mol of H_2 gas is completely burnt in oxygen, it forms 1 mol of liquid water with the liberation of 286 kJ of heat.

ii. When 1 mol of solid carbon reacts with two moles of solid sulphur to produce 1 mole of liquid CS_2. 117 $kJmol^{-1}$ of heat is absorbed from the surrounding.

07.

i. What is meant by 'Heat of Reaction'?

The heat energy evolved or absorbed during a chemical reaction.
$\triangle$H (symbol) $kJmol^{-1}$ (units)

ii. Explain how heats of reactions are produced.

Heats of reaction are the result of energy changes when bonds are broken & formed. When a chemical reaction takes place atoms rearrange. Energy is required to break the bonds & energy is evolved when bonds are made.

12.

i. Write the formula, which is used for calculating the total amount of heat absorbed or given out.

ii. What is the specific heat capacity (SHC) of H_2O?

iii. State the factors to be considered when interconverting units in the equation for heat energy change.

iv. Explain how to calculate molar enthalpy change $\triangle$ H, From the heat change, Q

13. Suggest a method that we can use in order to measure the heats of reaction

- **Combustion Reactions:**

Heats of combustion reactions can be measured by using the heat produced by the reaction to warm up a vessel of water. The rise or fall in temperature is recorded & by the formula $Q = m.c.\theta$ The total amount of heat absorbed or evolved can be calculated, thus the molar enthalpy change.

- **Neutralization reactions:**

The reaction is carried out in a calorimeter. A thermoflask / an insulated cup / polystyrene cup can be used as a calorimeter. (Unlike a beaker, calorimeter minimizes the heat loss to the surroundings) Record the initial temperature of acid & alkali before the reaction and the final temperature after addition of the two into the calorimeter. Molar enthalpy change can be found by the equation.

- **Displacement reactions:**

Add a concentration, volume known salt solution into the calorimeter and record the initial temperature, add excess of the solid metal and record the final (highest / lowest) temperature. Molar enthalpy change can be found by the equation.

- **Dissolving of a salt:**

Add a known mass of a salt in to the calorimeter. Record the temperature of a known volume of water and add it into the salt container, stir till the salt dissolves and record the final (highest / lowest) temperature. Molar enthalpy change can be found by the equation.

14. Describe in detail the experiment to estimate the heat of combustion of ethanol.

Take a known mass of ethanol to a specimen bottle. Clamp 100g of water in a thin-walled tin can above the specimen bottle as shown below. Record the initial temperature of water. Start the reaction by igniting ethanol & when the temperature is raised by 20^0C, put off the flame & weigh the mass of ethanol. Make sure the apparatus is well insulated to minimize the heat loss to the surroundings. Thin-walled tin can is used to minimize the heat absorbed by the can.

15. Calculate the enthalpy of combustion of ethanol in $kJmol^{-1}$ using below data:-

Initial temperature of water	= 17.7 ^0C
Final temperature of water	= 41.2 ^0C
Mass of water in the can	= 101g
Mass of lamp + ethanol before burning	= 29.97g
Mass of lamp + ethanol after burning	= 29.59g

16. Describe in detail the experimental procedure to find out the heat of neutralization between NaOH & HCl

Pipette out 25 cm^3 of 0.1mol dm^{-3} HCl acid to a calorimeter. (pipette is more accurate than using a measuring cylinder) Record the initial temperature. Pipette out 25 cm^3 of 0.1 mol dm^{-3} NaOH to a beaker & record the initial temperature. Transfer the NaOH solution into the thermo flask, which contains HCl. Stir the reactants & record the maximum temperature.

Assumption:

The total mass is taken as 50g assuming the solutions are very dilute & almost equal to water. Density of solution is taken as the density of water which is 1 g cm^{-3}
(mass of 1 cm^3 of water is 1g)

Apparatus setup:

17. An experiment was carried out to calculate the heat of neutralization between NaOH & HCl. Below results was obtained. Calculate the heat of neutralization in $kJmol^{-1}$

Volume of 2M $HCl_{(aq)}$ solution	= 20.0 cm^3
Volume of 2M M $NaOH_{(aq)}$ solution	= 20.0 cm^3
Initial temperature of NaOH	= 15.4 ^0C
Initial temperature of HCl	= 15.0 ^0C
Final temperature of the mixure	= 28.2^0C

Assumption :

The actual value of heat of neutralization of above experiment is -57kJmol^{-1}, what is the reason for this difference?

18. The change in below dilute aqueous solution of the exothermic reaction is given.

$$NaOH + HCl \longrightarrow NaCl + H_2O \quad \triangle H\ -57.3\ kJmol^{-1}$$

State the heat changes for the following reactions in dilute aqueous solutions & give reasons for your answer

i. $KOH + HNO_3 \longrightarrow KNO_3 + H_2O$

ii. $2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O$

The heat of neutralisation focuses on the formation of 1 mol of water. In the (i) question as 1 mol of water is produced the enthalpy of neutralisation is -57.3 kJmol^{-1}, in the (ii) question as 2 mols of water is produced the enthalpy of neutralisation is twice of -57.3 kJmol^{-1} which is –114.6 kJmol^{-1}

19. Describe in detail the experimental procedure to find out the molar enthalpy change for a displacement reaction between Zinc solid and copper (II) sulfate solution.

Pipette out 25cm^3 of 1M $CuSO_4$ solution in to a polystyrene cup. Support the cup in a glass Record the initial temperature.
Using a balance, weigh out a known mass of excess zinc. (Can use any metal higher than Copper in the reactivity series) Add the solid to the $CuSO_4$ solution, Stir the mixture and record the final temperature.
Excess solid added ensures that all $CuSO_4$ reacts. Volume of the solution is taken as the mass in the calculation of heat energy, whereas the reacted mass of zinc (not the excess mass) is used to find the moles hence calculate the molar enthalpy change.

20. An experiment was carried out to calculate the heat of the displacement reaction between Fe and $CuSO_4$. Below results was obtained. Calculate the molar enthalpy change.

Concentration of $CuSO_4$ solution	= 2moldm^{-3}
Volume of $CuSO_4$ solution	= 25.0 cm^3
Initial temperature of $CuSO_4$	= 28.5 ^{0}C
Final temperature of $CuSO_4$	= 42.0 ^{0}C
Mass of Iron filings	= 3g

21. Describe in detail the experimental procedure to find out the molar enthalpy change for dissolving of solid ammonium chloride in water.

Support the polystyrene cup in a beaker. Add a known mass of solid NH_4Cl in to the cup. Pour 25cm^3 of distilled water (excess) in to a measuring cylinder and record the initial temperature. Pour the water into the cup containing NH_4Cl, stir the contents and record the final temperature. Repeat the experiment to minimize the experimental errors.

It is not necessary to use the pipette to measure the volume of water as water in excess. (measuring cylinder is fine) The volume of water is taken as the mass in the calculation of the heat change. The mass of the solid is used to calculate the moles hence the molar enthalpy change.

22. An experiment was carried out to calculate the heat of solution for dissolving NH_4Cl, below results was obtained. Calculate the molar enthalpy change.

Mass of NH_4Cl	= 3.1g
Volume of water	= 25.0 cm^3
Initial temperature of water	= 25.5 ^0C
Final temperature of solution	= 16.0 ^0C

23. A. Explain the energy changes that occurs when a chemical reaction takes place

When a chemical reaction takes place atoms are arranged by breaking bonds & forming new bonds. Energy must be supplied to break the bond between 2 atoms. Likewise, energy is released when a bond is made.

B. Relate bond breaking & bond making whether endothermic or exothermic?

C. Relate the heat of a reaction to bond breaking & bond forming

24.

i. Define the term 'Bond Energy'?

ii. What is Bond Disassociation Energy?

25.

i. Calculate the energy required to break one C-H bond in the below example.

$CH_4 \longrightarrow C + 4H \qquad \triangle H = +1664\ kJmol^{-1}$

ii. Specific bond enthalpies for each C-H bond differs in CH_4. What do we call the above value, which we got for the disassociation of one C-H bond?

26. Explain how enthalpy change can be calculated in terms of bond energies?

27. Some average bond disassociation energies are given in the table below.

Bond	**Average bond disassociation energy kJ/mol^{-1}**
C-H	410
Cl-Cl	240
C-Cl	340
H-Cl	430

The reaction between methane and Chlorine is represented by the equation:

$CH_4 + Cl_2 \longrightarrow CH_3Cl + HCl$

i. Calculate the energy needed to break the bonds in 1 mole of each of the reactants

ii. Calculate the energy released when the bonds are formed in the products.

iii. Hence, calculate the enthalpy change ($\triangle H$) for the above reaction.

28. The bond energies of C-H bonds in methane differ from each other as shown below.

Reaction	Enthalpy Change (kJ mol^{-1})
$CH_4 \longrightarrow CH_3 + H$	+435
$CH_3 \longrightarrow CH_2 + H$	+444
$CH_2 \longrightarrow CH + H$	+440
$CH \longrightarrow C + H$	+343

i. Calculate the $\triangle H$ for the reaction.

ii. Calculate the average bond enthalpy (mean bond enthalpy) in the C-H bond in methane.

29. Various values for bond energies are listed below:

C – I = 218kJmol^{-1} C – H = 413kJmol^{-1}

C – C = 346kJmol^{-1} H – I = 297 kJmol^{-1}

C = C = 611kJmol

Calculate the enthalpy change of the below reaction.

$C_2H_4 + HI \longrightarrow C_2H_5I$

30.

Bond	C - H	C - Br	Br - Br	H – Br
Average bond enthalpy/kJmol^{-1}	413	209	193	366

Use the data to calculate the enthalpy change for the reaction:

$CH_4 + Br_2 \longrightarrow CH_3Br + HBr$

31. Some average bond dissociation energies are given in the table below.

Type of Bond	**Average bond disassociation energy kJ/mol^{-1}**
C—H	435
C = O	745
H—O	460
O = O	495
C – C	360
C=C	612
C-O	315

Calculate the enthalpy change for the below reactions:-

A) Methane burns in a good supply of air according to the following equation

$$CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(g)}$$

B) Ethene burns completely in air according to the following equation

$$C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$$

C) When methanol is burned in air, the reaction according to the following equation occurs:-

$$2\ CH_3OH + 3O_2 \longrightarrow 2CO_2 + 4H_2O$$

Chembase - School of Chemistry I All Rights Reserved I www.chembase.lk