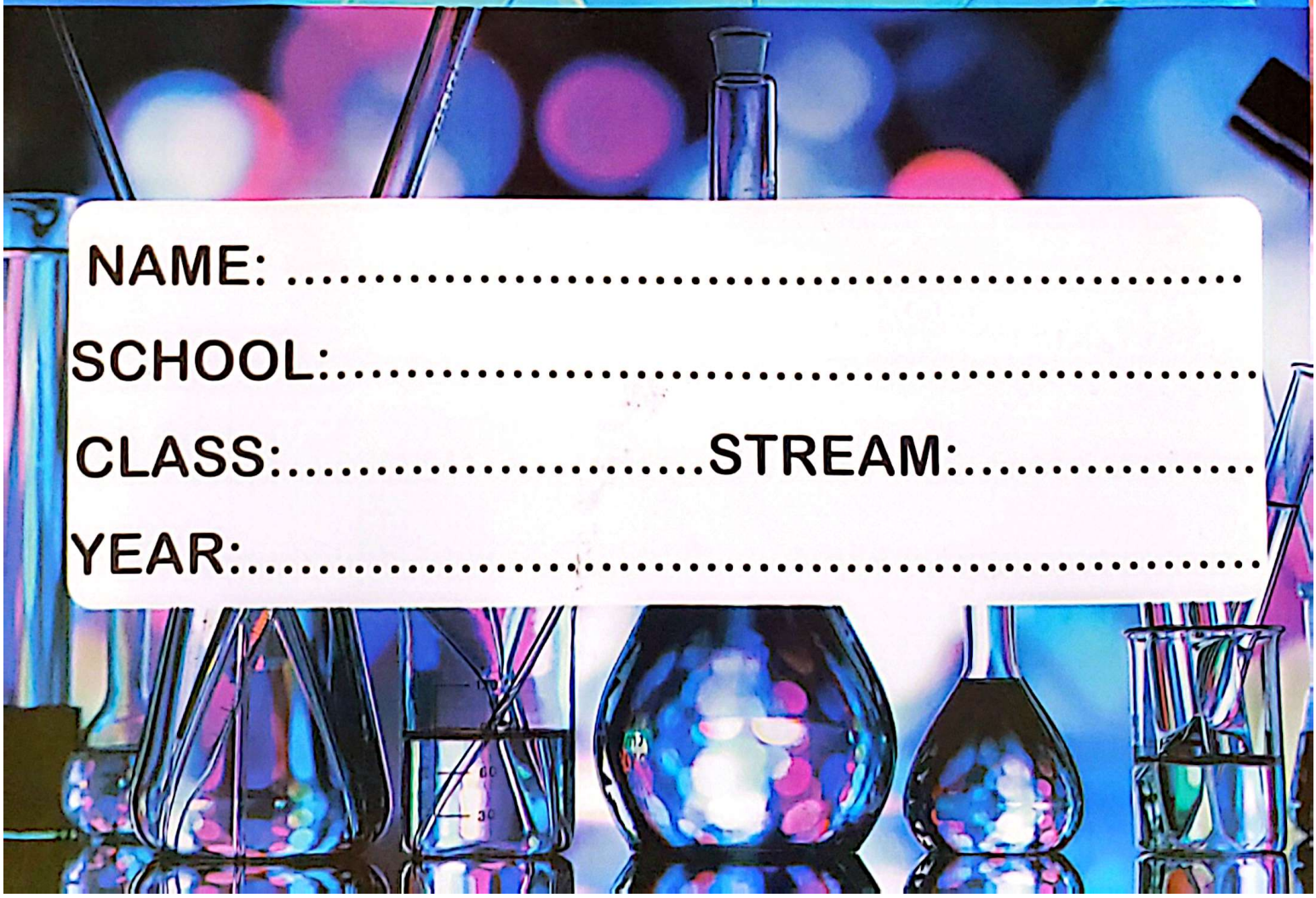
LOWER SECONDARY CHEMISTRY

PRACTICAL WORK BOOK

SECOND EDITION
2025



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NAME:.....

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CLASS.....STREAM.....

YEAR.....TEACHER.....

ENERGY CHANGES DURING CHEMICAL REACTIONS

INTRODUCTION

Chemistry is concerned with the physical and chemical properties of subst and the interaction of energy and matter. The study of chemistry in investigation into chemical reactions and processes. This makes the subj practical subject in which learners are expected to apply investigative problem-solving skills.

Under this sub-construct of chemistry which is the practical part, learner understand that chemistry is a process of evidence-based enquiry invol collection of evidence and the development of theories that help us explain evidence.

To acquire meaningful appreciation of chemistry as a practical subject, lear will need to have mastery and application of.:

(a) Scientific attitudes and values in investigating matter

(b) Scientific method/process of carrying out investigations and the importa of risk assessment to keep self and others safe

(c) Science process skills

Scientific attitudes and values in investigating matter

Scientific attitudes are a mixture of the willingness to know and apply a scienti approach to face any task of problem-solving with respect for logic and critic thinking. These are the features that characterise scientific thinking. The attitudes are manifested through behaviour

These attitudes include: Validity, Honesty, Flexibility, Integrity, Persistenc Responsibility, Objectivity, Accountability, Reproducibility, Collaboration, Oper mindedness, Empiricism (Evidence based)

Science process skills

These are skills defined as a set of broadly transferable abilities, appropriate t many science disciplines and reflective of the behaviours of scientists. Thes include:

a) Observing -using the senses to gather information about an object or event for example describing a pencil as yellow
b) communicating- Using words or graphical symbols to describe an action, object or event for example, describing the change in height of a plant over time in writing or through a graph

c) Classifying- grouping or ordering objects or events into categories based on properties or criteria for example placing all rocks with a certain grain size or hardness into one group

d) Measuring- Using both standard and non-standard measures or estimates to describe the dimensions of an object or event for example using a metre rule to measure the length of a table in centimetres

e) Inferring - Making an educated guess about an object or happening based on previously gathered data or information.

f) Predicting- Stating the outcome of a future event based on a pattern of evidence for example, predicting the height of a plant in two weeks' time based on a graph of its growth during the previous four weeks.

The scientific method/process

The Scientific Method is a dynamic and open-ended process that scientists use when they investigate a question they have. It is not a series of prescribed steps that scientists follow to prove a hypothesis. Rather, it's a general plan that helps guide their investigation. And while all scientists use the Scientific Method, they might not use all the steps, or they may complete the steps in a different order. For example, a scientist might make observations and collect data about a subject that interests him or her for years before formulating a hypothesis.

(a) Defining a question to investigate

As scientists conduct their research, they make observations and collect data. The observations and data often lead them to ask why something is the way it is. Scientists pursue answers to these questions in order to continue with their research. Once scientists have a good question to investigate, they begin to think of ways to answer it.

(b) Making predictions

Based on their research and observations, scientists will often come up with a hypothesis.

A **hypothesis** is a possible answer to a question. It is based on: their own observations, existing theories, and information they gather from other sources. Scientists use their hypothesis to make a prediction, a testable statement that describes what they think the outcome of an investigation will be.

(c) Collecting data

Evidence is needed to test the prediction. There are several strategies for collecting evidence, or data. Scientists can gather their data by observing the natural world, performing an experiment in a laboratory, or by running a model. Scientists decide what strategy to use, often combining strategies. Then they plan a procedure and gather their data. They make sure the procedure can be repeated, so that other scientists can evaluate their findings.

ALL practical should follow the methods of scientific investigation by stating the following under different stages which involve planning, manipulation, measurement and observation, presentation of data, and lastly Analysis, conclusion and evaluation/recommendation

(I) PLANNING

In planning the following should be stated:

(a)Aim of the experiment

Aim of the experiment is the specific objective or purpose which must be achieved through your investigation

It should be brief and describes the main point of the experiment/investigation and this is not normally got from the scenario or task given it is like the title of the experiment

(b) Stating the hypothesis

A hypothesis states your prediction about your investigation. As an investigator, you guess the results through stating the hypothesis (a good guess is usually advised). for example, in an experiment to investigate the effect of concentration of sodium thiosulphate solution on the rate of reaction between sodium thiosulphate solution and hydrochloric acid, the hypothesis can be "Increase in concentration of sodium thiosulphate increases the rate of reaction between sodium thiosulphate and hydrochloric acid."

(c)Stating variables.

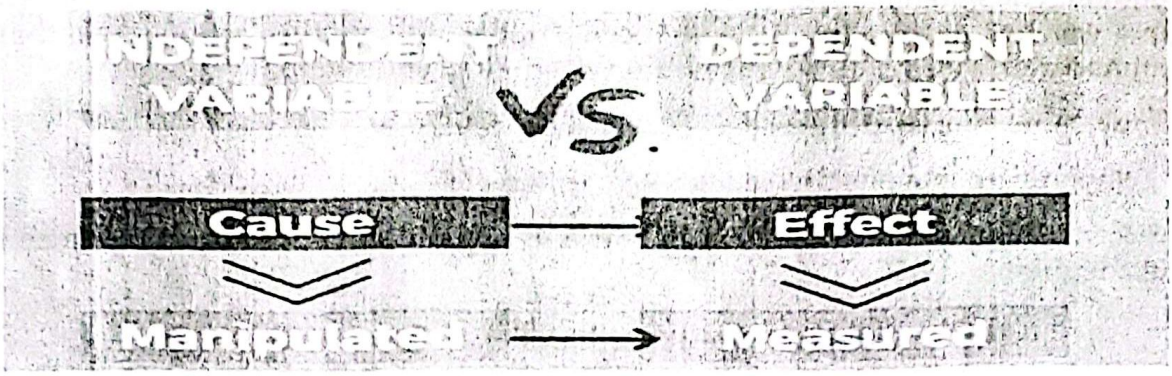
A variable is anything that can change and be measured. A scientific investigation usually has three variables;

- **Independent variables** Is the variable that you intentionally change or manipulate to observe its effect on the dependent variable. It is also called the "manipulated variable" or "cause variable" because it causes a change in the dependent variable. For example, in the experiment to investigate the effect of temperature on the solubility of a salt, the temperature is the independent variable, that means it's the factor that is intentionally changed or manipulated by the experimenter. By varying the temperature, the goal is to observe how this change affects the solubility of the salt.

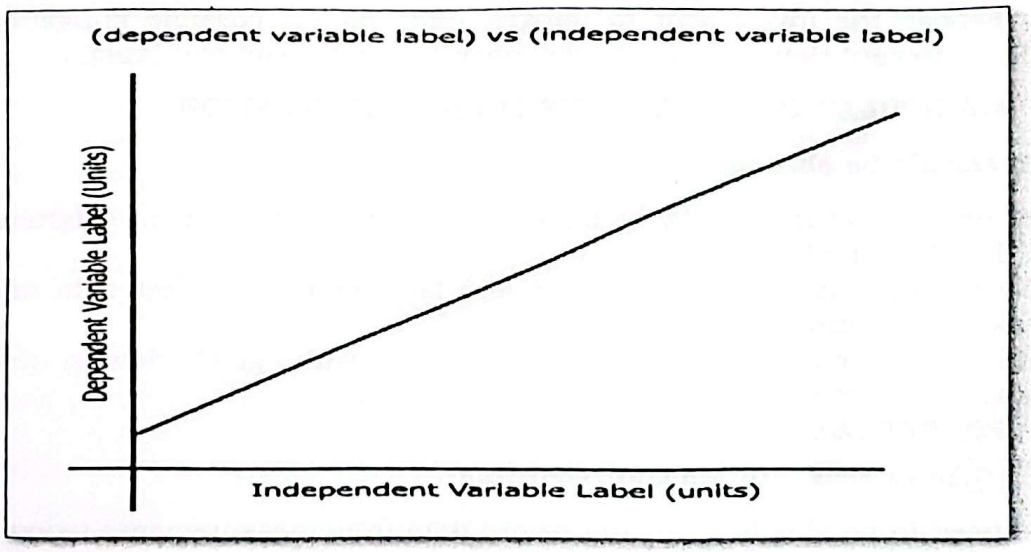
- **Dependent variable**. Is the variable that is measured to observe the effect of the independent variable in an experiment Or, it is the factor that changes in response to the independent variable. For that case, it is known as the "Responding variable ". For example, in the experiment to investigate the *effect of temperature* on the solubility of the salt, the *solubility of the salt* is the *dependent variable* because it is the factor that is measured and observed in response to the change in the temperature.

2. The size of the ball is kept constant

3. The surface the ball is dropped on to is kept constant



Graphically the *independent variable* is plotted on the *X -axis* whereas the *dependent variable* is plotted on the *Y-axis* as shown below. The *acronym* which can enable you to always remember which variable is plotted on X -axis and y-axis is *"DRY " meaning, Dependent is the Responding variable on Y-axis* and *"MIX " meaning Manipulated variable is the Independent variable on X-axis.*



(d) List of requirements (reagents/ solutions/ apparatus etc.) used.

Learners should show competence in use of appropriate apparatus to record a range of quantitative measurements (to include mass, time, volume, temperature, length and pH).

Volumes might be directly measured using a measuring cylinder

The table should include the dependent and independent variables with the controlled variable outside the table.

Data should be recorded to the right number of decimal places as show in the table below

Apparatus	Number of decimal places
Measuring cylinder	1
Thermometer	1 ends with .0 or .5
Burette	2 i.e. X.00 or X.50
Stop clock	1 or 2
Weighing balance	At least 1
Pipette	1 i.e. 20.0 or 25.0

Learners need to be careful while performing investigations to avoid data which falls outside error margin.

Learners need to take care about the number of sets of data to record in an investigation since conclusion cannot be made using one data value because of experimental errors.

Commonly when an investigation does not require analyzing using a graph a minimum of three sets of data is required and then average of the consistent values but when analysis requires a graph, a minimum of five sets of data is required though in energy changes a learner is usually required to carry out the investigation until the results change trend i.e. increases and then decreases or becomes constant. Therefore, in this case five sets of data will not be Accepted if no change of trend. But sometimes number of sets of required data is specified in the task.

(IV) ANALYSIS, CONCLUSION AND EVALUATION

(h) Data analysis.

Data analysis/processing requires use of appropriate method of processing data and accurately used. Most data generated form chemistry investigations should be processed in graphical(which must be clearly drawn following the acronym **SPASHE i.e. Scale, Plotting, Axes, Shape extrapolation**) but for some investigations like determining hardness of water a learner may just get average of the consistent values

(i) Data interpretation.

Conclusion.

Investigator/ learner indicates the significance of his/ her results and it is here that the investigator provides logical explanations/ interpretations for the results data from the investigation.

ata analysis and terpretation	Method used is: ➢ Appropriate and accurate ➢ Appropriate and partially accurate ➢ Appropriate and inaccurate ➢ Inappropriate and inaccurate	 03 02 01 00
onclusion	➢ Conclusion based on data interpretation ➢ No conclusion based on data interpretation	01 00

EXPERIMENTAL CHEMISTRY

Worked example on experimental chemistry

During one of the field trips to an ice cream manufacturing factory, students of Kikwitą seed school learnt that freezing point is a constant temperature at which a liquid substance turns to solid state. Through their interaction with the factory workers, they also learnt that many substances especially solids are melted first and cooled in order for this constant temperature to be determined. Suitable solid raw materials in this factory must have a freezing point below 60 °C for a good product to be obtained. The students have been given solid Y which is a potential raw material in the industry but its suitability is yet to be determined.

Task

(a) As a chemistry learner,

Design an experiment you will carry out

Carryout the experiment and record your findings

Obtain the freezing point of solid Y

What can students deduce about the suitability of solid Y for use

Aim: Determining the freezing point of Y

Variables of the experiment.

Independent variable: Time

Dependent variable: Temperature

Controlled variable: Mass of Y used and experiment was done under ordinary laboratoy conditions (Room temperature and pressure)

Hypothesis: Y has a freezing point above 60 °C and therefore not suitable for use as raw material

Apparatus and materials.

Solid Y Tripod stand

Another trial item: Peter and John are two brothers living in Gwafu cell Mukono municipality and use different sources of water P and Q respectively for washing. John always uses all his soap while Peter remains with a balance of some soap after washing. Their mother is worried about how John uses his soap and she thinks that he washes while leaving the soap in water which John says it's not true. Peter advised that it could be as a result of different types of water they which their mother couldn't believe.

You are provided with the following; Samples of water P and Q, Soap solution X other apparatus. Plan a scientific investigation for the experiment you will use to verify Peter's advice to the mother on why John uses more soap, carry out the investigation, record your finding and give advice to John

CHEMICAL REACTION RATES

1.1 Introduction.

At home, meat and other perishable foods can be kept in the refrigerator at lower temperatures to slow down rate of spoilage (decay of food by microorganisms) thus preserving food (food spoilage).

At home, when you are preparing a charcoal stove to cook food, you always break large charcoal pieces to smaller pieces. When smaller pieces of charcoal are used, food can be cooked faster. This is because smaller pieces of charcoal have surface area, which will burn faster to produce more heat.

At industrial level. the rate of reaction in chemical production determines the

efficiency and yield of industrial processes, for example in the production of ammonia

Chemical kinetics deals with rates (speeds) of chemical reactions and factors alters, chemical reactions

By definition, rate of chemical reaction is the change in the amount of reactants used up or products formed per unit time.

Rate of reaction is a measure of the progress of the reaction in unit time

Mathematically rate of reaction can be given by

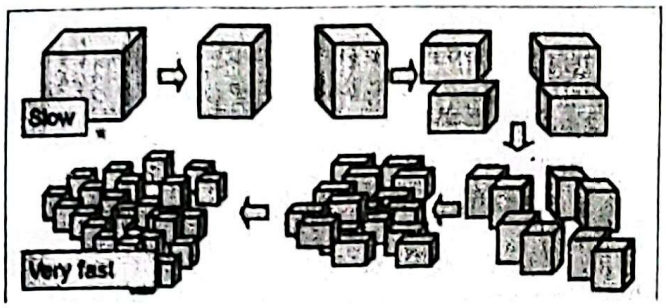
$$\text{Rate of reaction} = \frac{\text{change in concentration of reactants}}{\text{Time taken}}$$

Factors that affect the rate of chemical reaction

1. Temperature.
2. Concentration.
3. Particle size of the solid reactant.
4. Catalyst.

(The higher concentration of solution, the faster the rate of reaction). This is because at higher concentration, the number of reactant particles are many and so close to one another, which causes higher frequency of collision between the reactant particles, leading to faster rate of reaction as shown by the graph above.

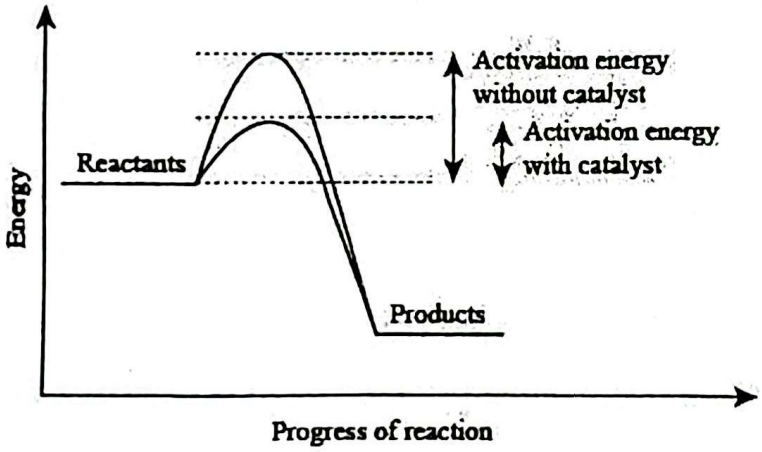
(C) **Effect of particle size on the rate of reaction**



As the surface area of the solid reactant is increased by either cutting the bigger sized solid into smaller pieces of particles or grinding bigger sized particles into powdery form, the faster the rate of reaction.

The reaction is faster because increase in surface area of the solid reactant exposes more particles for reaction with other reactant particles which leads to increased number of effective collision between reactant particles hence faster rate of reaction.

d)**The effect of catalyst in the rate of reaction.**



acid. Copper (II) Sulphate, $CuSO_4$ Catalyst is used

$Zn(s)+H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + H_2(g)$

3.Conversion of Sulphur dioxide to Sulphur trioxide during contact process (industrial manufacture of Sulphuric acid). Vanadium(V) oxide catalyst is Used:

$2SO_2(g) + O_2(g) \longrightarrow 2SO_2(g)$

4.Conversion of sulphur dioxide to sulphur trioxide during contact process (industrial manufacture of Sulphuric acid). Finely divided iron catalyst is used

$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$

Effect of pressure on rate of chemical reaction

For reactions involving gaseous reactants, increase in pressure increases the rate of reaction. When the reactant gaseous molecules are confined in a cylinder fitted with a movable piston, the gas pressure can be on molecules, thus there is increased frequency of collision between molecules hence Increased by pushing the piston, and this reduces the volume available for gaseous increased reaction rate.

Practicals based on rate of chemical reaction

Practicals under rates of chemical reaction are carried out to investigate the effect of changing the above factors ie investigatigating effect of changing temperature, concentration or surface area

Worked example on of changing temperature on rate of reaction

An agrochemical industry deals in the production of pesticides and uses sulphur as one of the main ingredients. Of recent, they decided to start preparing sulphur on small scale at the production facility to add on the sulphur supplied by one company and also reduce cost of production. Sulphur is prepared from sodium thiosulphate and hydrochloric acid as equation below.

$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + S(s) + H_2O(l) + SO_2(g)$

The workers in the sulphur production unit need to investigate through experimenting how to promote the effectiveness of sulphur production which is slow, by elevating the temperature. One group doubted the experimentation to yield expected results. You have been consulted for guidance on the experiment.

You are provided with the following.

BA1 which is sodium thiosulphate solution.

BA2 which is hydrochloric acid.

Other materials and apparatus required.

Task.

As a Chemistry student,

(a) design an experiment you will carry out to guide the workers.

Aim;

To investigate the effect of temperature on the rate of reaction between sod thiosulphate solution and hydrochloric acid.

Hypothesis: Increase in temperature increases the rate of reaction bet sodium thiosulphate solution and hydrochloric acid.

Variables

Dependent variable: Time taken for the reaction to reach completion (OR of reaction)

Independent variable: Temperature

Controlled variables:

I. Concentration of sodium thiosulphate solution, controlled by using the s volume of solution.

II. Volume of the acid controlled using the same volume of acid.

Procedure with relevant apparatus

I.A small cross was marked on a white piece of paper using a pen and con flask (or glass beaker) was placed on the piece of paper over the marked cro

II. 50cm^3 of sodium thiosulphate solution was measured using measur Cylinder, then transferred into a glass beaker (or conical flask) and temperature noted and recorded.

III. 10cm^3 of hydrochloric acid was added into the conical flask using anot measuring cylinder or from the burette, and stop clock was Immediately start Time taken for the cross to be invisible was noted and recorded.

IV. Reaction mixture is poured away and the conical flask was wash thoroughly well.

V. The procedure from (I) to (IV) was repeated other four times, but heat sodium thiosulphate solution to T+5°C, T+10°C, T+15°C and T+20°C where T the starting temperature(room temperature).

ENERGY CHANGES DURING CHEMICAL REACTIONS

2.1 Introduction.

Thermochemistry mainly deals with the study of heat changes that occur during chemical reactions.

When you light up a match, burn a piece of paper or wood, cook, sit near a campfire, put ice in a refrigerator or melt ice, you witness the interplay of heat loss and heat gain taking place. All matter possess energy in one form or another. Some substances have energy as a result of the fact that particles of those substances are moving, such energy is known as kinetic energy.

Other substances have energy stored within themselves, and this energy is as a result of the positions of the particles contained in the substances relative to one another. The stored energy is known potential energy. It is an easier task to determine the energy change which takes place when one substance reacts with another.

The commonest form of energy change in chemical reactions is heat change.

There are two types of reactions: exothermic reactions and endothermic

An exothermic reaction is the one during which heat is liberated(released) to the

Surrounding (exhibited by an increase in temperature of the reaction mixture) whereas an endothermic is the one during which heat is absorbed from the surrounding. (exhibited by decrease in temperature of the reaction mixture)

Understanding exothermic reaction and endothermic reactions.

When chemicals react to form products, changes in energy content of reactants and products occur. This causes heat to be released or absorbed in the reaction.

The amount of heat energy released or absorbed during chemical reaction is called heat of reaction, given by ΔH where Δ means "change in " and H means heat of reaction measured in Joules (J) or Kilojoule(KJ)

Heat of reaction, $\Delta H = Hp - Hr$ Where,

Hp, is the Energy content of the products

Hr, is the Energy content of the reactants.

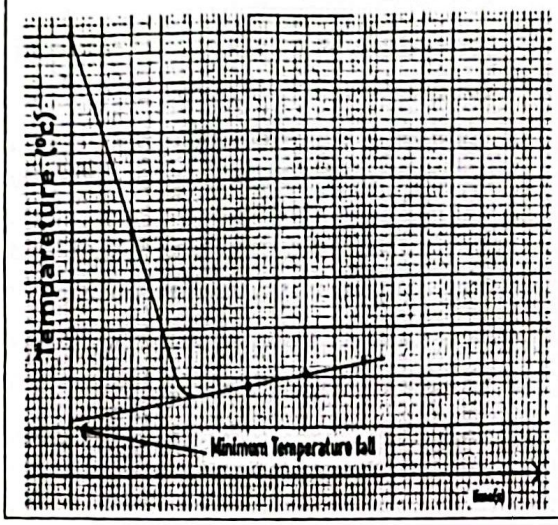
In an exothermic reaction, the reactants lose heat energy to form products, thus

the products formed have less energy than the reactants that is,

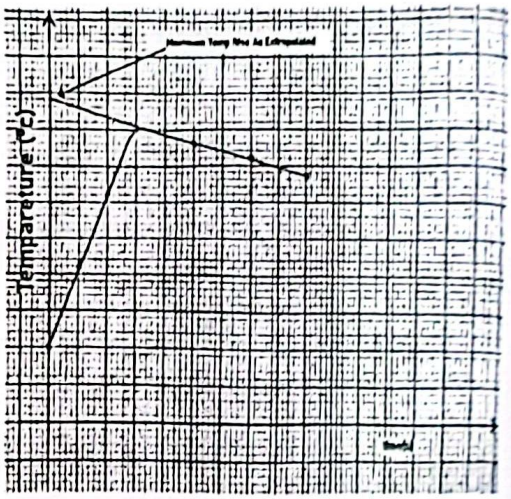
$Hp < Hr$, hence ΔH = -ve Joules (or -ve Kilo joules).

In an endothermic reaction, the reactants absorb heat energy from the surrounding to form products, thus the products formed have more energy than the reactants, that is, $Hp > Hr$, hence ΔH= +ve Joules(or +Kilo joules)

Graph 1

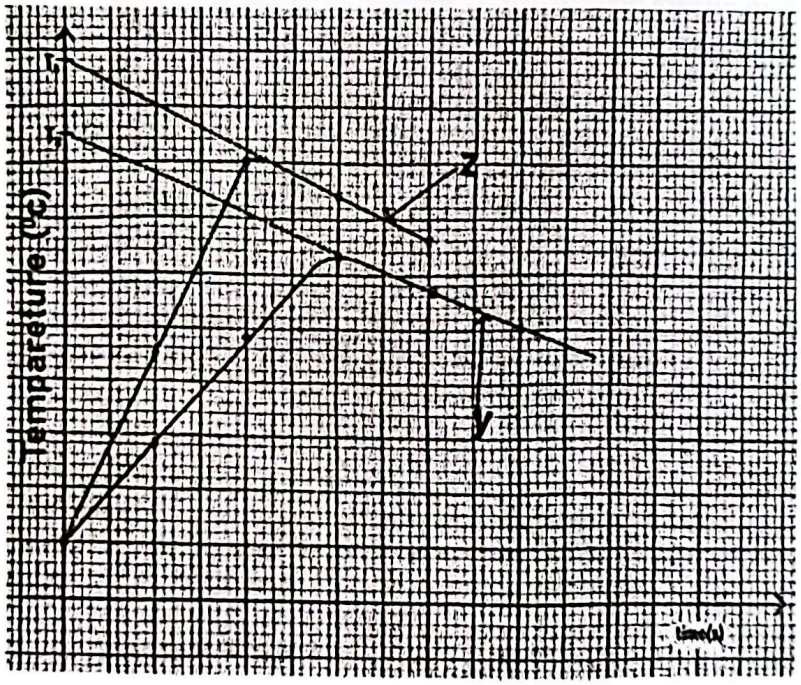


Graph 2



2. In case two solids are given for example solids Z and Y are dissolved in water separately to form solutions with release of heat, given solid Z releases more heat energy faster than solid Y, a temperature-time graph plotted is typical to graph 3 below

Graph 3



measured using a thermometer and recorded, then a piece of zinc rod is put into the solution, it is noted that the temperature of the solution raises and more often, the vessel (plastic beaker or cup) from which the reaction is carried out, may get warmer. This is due to the heat released when iron displaced copper from its solution. This heat change is due displacement reaction

Heat change due to displacement reaction can be determined experimentally using a calorimetry.

Relationship between the heat change due to displacement reaction and the reactivity of metals in the series:

The amount of heat released during a displacement reaction between metals is directly related to the reactivity of the metals involved. More reactive metal displaces a less reactive metal from its solution more readily than a closer metal above the less reactive metal in solution.

This results to a higher temperature increase thus more heat energy released,

for example,

Magnesium releases more heat energy than zinc when equal mass of each metal is separately put in equal volume of copper(II) sulphate solution of the same concentration in the plastic cup/beaker and experiment left to stand for about 10 minutes.

Worked example on reactivity series vs energy changes

A company is planning to use metal X and hydrochloric acid to produce hydrogen gas to be used in fuel cells for generating electricity. Heat generated or absorbed influences both the reaction speed and hydrogen quality. The company wants to determine the heat change for a reaction between the metal (X) and dilute hydrochloric acid to be able to make a decision on whether to use it or not.

Metal X reacts with hydrochloric acid according to the following equation;

$X(s)+2HCl(aq) \rightarrow XCl_2(aq)+H_2(g)$ + Heat

You are provided with:

- Solid P which is sample of metal X
- BA1 which is a dilute solution of hydrochloric acid
- Some apparatus

TASKS

(a) Design an experiment that can be used to determine the amount of heat involved during the reaction

(b) Carry out the experiment and obtain data to determine the amount of heat involved during the reaction.

(c) Analyze the data and draw your conclusion

Aim of the experiment	To determine the heat change of the reaction between metal X and hydrochloric acid
Hypothesis	The reaction between metal X and hydrochloric acid liberates heat energy
Variables	Dependent variable – temperatures Independent variable – time Controlled variable – volume of hydrochloric acid is kept constant
Risk and mitigation	- Breaking of the thermometer hence causing injuries to the body. **Mitigated by** putting the thermometer in its casing immediately after use - Acid pouring on the skin hence causing burns. **Mitigated by** wearing a laboratory coat, gloves and closed shoes
Procedure	(a) Using a measuring cylinder, 30 cm^3 of hydrochloric acid is measured and transferred into a plastic beaker. (b) The initial temperature of the solution is read using a thermometer and recorded (c) 0.5g of metal X is weighed using a digital scale and added at once to the acid in the plastic beaker and the stop watch is simultaneously stated. (d) The mixture is stirred using a thermometer and the temperature of the solution mixture is read and recorded every after 30 seconds for 3 minutes (e) The results are entered in the table.

(b) Volume of BA1 used = 30.0cm^3

Time(s)	0.0	30.0	60.0	90.0	120.0	150.0	180.0
Temperature of mixture of BA1 and metal X(°C)	25.0	40.0	51.0	57.0	60.0	59.0	58.0

(c) From the graph;

Maximum temperature attained by the mixture = 64°C

Temperature change of the mixture = 64 – 25

= 39°C

Heat change of reaction = mcΔt

= 30 × 4.2 × 39

= −4,914J

Or; −4.914KJ

Conclusion;

The reaction between metal X and hydrochloric acid liberates = 4.914KJ of heat energy.