NATIONAL OPEN UNIVERSITY OF NIGERIA

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SCHOOL OF EDUCATION

SCIENCE LABORATORY MANUAL

For use of SCIENCE EDUCATION Students in the School of Education

AGRICULTURAL SCIENCE PRACTICAL METHODS

1. FARM TOOLS AND MACHINERY

Contents:

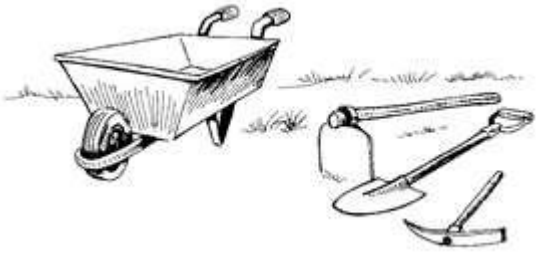
Identification and classification, labeling of parts, uses and maintenance and f tools, implements and machinery.

PRACTICAL ACTIVITIES 1:

a. Collect various simple tools, implements and machinery or download samples from the internet . Examples are given below.
b. Identify each of them, their parts and their uses.
c. Check the parts and mention list two maintenance operations that can be carried out on each tools, implements and machinery.

Sickles

Harrow



Simple Farm Tools

2. FARM SURVEYING AND PLANNING OF FARMSTEAD

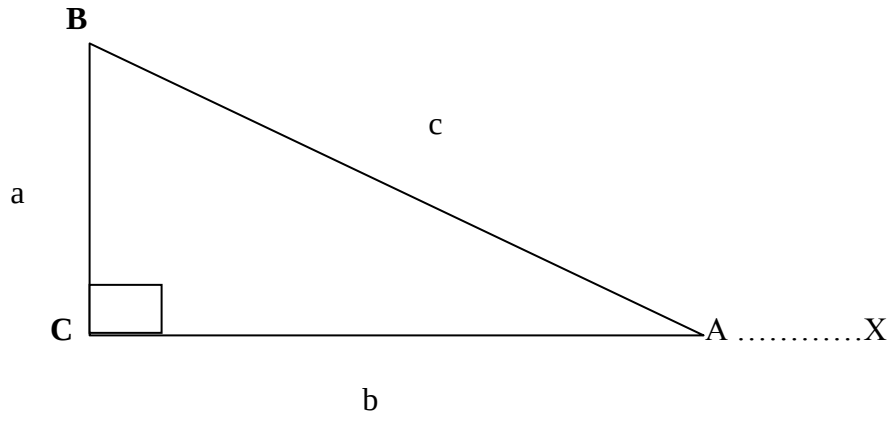
Contents:

Definition, Importance, farm survey tools and equipment, farmstead and planning of farmstead, factors considered in planning a farmstead, principles of farmstead layout / factors considered in the arrangement of buildings and structures within the farm, the 3-4-5 method in farm surveying,

PRACTICAL ACTIVITIES 2:

A. THE 3-4-5 METHOD IN FARM SURVEYING

This is the use of Pythagoras theorem in the construction of right angle triangle for a farm layout through which rectangle or square plots can be constructed.

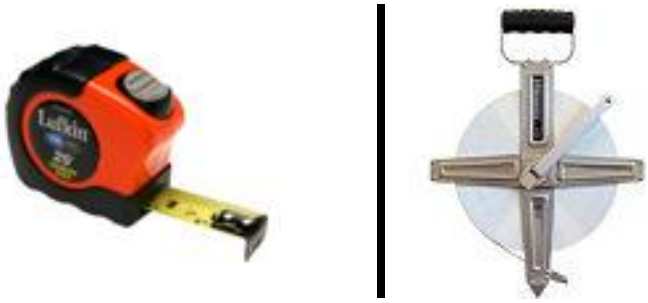


The formulae is $a^2 + b^2 = c^2$ where a=3, b= 4and c=5.

USING THE 3-4-5 METHOD

1. Attach two ropes of lengths 3m and 4m respectively to a ranging pole erected at the centre of the farmland.
2. Stretch the ropes and set one of them as a baseline.
3. Extend the two free ends of the ropes, while maintaining one as a baseline, until the distance between them is 5m.
4. Mark out the two arms, any of which can be extended to a desired length through sighting.
5. To extend the line **CA** to point **X** by sighting, another ranging pole is erected on point **A** and, a third one is held around point **X**. Somebody then stands behind the pole on point **C**, closes one of his eyes and sights the pole on point **A.** He then directs the person holding the third pole to move behind the pole on point **A** until he can no longer see the pole on points **A** and **X** while still holding one eye closed**.** The third pole is then erected on this point**.** This indicates that points **C**, **A** and **X** are on the same straight line. You would not be able to see the poles on points A and X because pole **C** is perfectly covering pole **A** and pole **A** is perfectly covering pole **X.** Arm CB can also be extended this way. A square or rectangular layout can therefore be construct day this way.

B. Identify 10 other survey tools and equipment apart from those shown below stating their uses and mentioning three maintenance operations that can be carried out regularly on the tools and equipment.



Measuring Tapes

Ranging / Surveying Pole

3. MANAGEMENT OF FARM ANIMAL : Management systems, milking process, process of egg production, process of incubation and castration.

Contents:

Extensive, semi-intensive and extensive management systems of ruminants and non-ruminants, milking process, process of egg production, candling, process of incubation and castration**.**

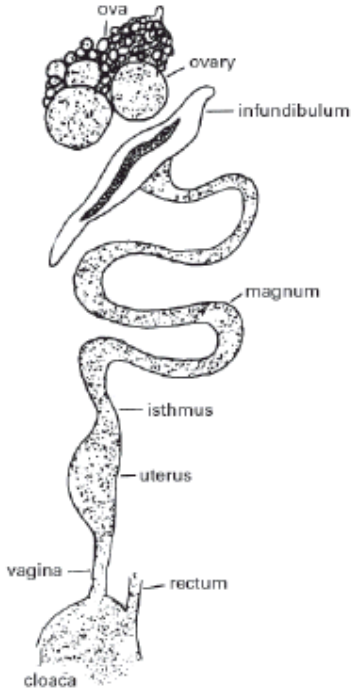
PRACTICAL ACTIVITIES 3:

Process of Egg Formation

1. Visit a poultry farm operating an extensive system of management, list the tools and equipment being used. And identify six differences between the system and the traditional free range system.
2. Major stages of egg formation are:
   a. Ovulation

b. Fertilization (If mating occurs)
c. Formation and depositing of albumen
d. Formation and depositing of shell membranes
e. Formation and depositing of shell
f. Oviposition

You are to examine, draw the reproductive system of an hen and identify where each of the stages listed above takes place. How long does it take for an egg to be formed and released?



Reproductive system of an Hen

PRACTICAL ACTIVITIES 4:

Construction of Egg Candler and Candling:

Stages of constructing an Egg Candler :

a. Make six square cuts of plywood of equal dimensions (20cm)
b. Drill a hole big enough for a cable to pass through in one.
c. Fix a lamp holder with a bulb to the plywood.
d. Take a second plywood and cut a round hole in it slightly less than the size of an egg.
e. Fix the six cuts together to form a box.
f. Link the cable to a source of power.
g. Place a freshly laid egg on the round hole in the candler in a dark room and put on the light in the candler.
h. If the egg is clear (translucent), it is not fertilized and will serve as table egg not to hatching.
i. If it shows a dark spot, it is most likely fertilized and should be put in an incubator.

PRACTICAL ACTIVITIES 5:

Process of carrying out bloodless castration:

a. Hold the calf of about 4-10weeks hold down with an assistant tying down the legs.
b. Hold the scrotum in one hand, work the spermatic cord within the scrotal sac to the side of the scrotum
c. Clamp the instrument for castration (Burdizzo) about 1 inch above the testicle.
d. Hold the instrument for about 3-5 seconds.
e. Repeat the same procedure for the other cord ensuring that the instrument is clamped about one inch below the first point.

A BURDIZZO

3. FISH FARMING- TOOLS AND METHODS

Contents: Definitions, importance, construction and maintenance of a fish pond, fishing tools and equipment, methods of fishing and methods of preserving fish.

PRACTICAL ACTIVITIES 6:

Fish ponds:

a. Visit a fish pond and learn about the different types of ponds that are use.
b. Identify eight other tools and equipment used in the pond apart from those shown below:

Fish Pond Fountain


Pond Aerator

c. List eight common species of fish reared in your environment.

4. SOIL AND SOIL EXPERIMENTS

Contents: Definitions, formation, soil experiments such as Sedimentation Experiment/ Mechanical or Soil Analysis, Soil Capillarity or Capillary action, Demonstration of the presence of particles, air, water, organic materials and living organisms etc.

PRACTICAL ACTIVITIES 7:

Sedimentation Experiment

Aim: To demonstrate that soil is made of particles of different sizes.

Materials Used: Measuring cylinder (500 ml), soil sample, water, Beakers, stirrer, and Sodium Hydroxide or Hydrogen Peroxide.

Procedure:

a. Half fill the measuring cylinder with soil.
b. Pour water into the cylinder up to the top level.
c. Stir the content properly.
d. Add a few drops of Sodium Hydroxide or Hydrogen Peroxide
e. Allow the content to settle undisturbed for bout 12-24 hours

Observation:

The particles separated into different soil particles. With the bigger particles at the bottom.in this order : Gravel., Coarse Sand, Fine Sand, Silt and Clay with clear water and floating Organic Materials.

Conclusion:

Soil is made up of particles of different sizes.

Note: Sodium Hydroxide or Hydrogen Peroxide hastens the separation and settling down of soil.

PRACTICAL ACTIVITIES 8:

Experiment To Demonstrate The Presence Of Water In Soil:

AIM: To show that water is present in soils

MATERIALS USED: Fresh soil sample (Collected from 10cm -15cm below the soil surface), a weighing machine, an oven, an evaporating dish and a stirrer.

PROCEDURE:

a. Put 100g or any other convenient known quantity of the soil sample into an evaporating dish of known weight
b. Place the dish in the oven maintained at 100^0C for about 5 minutes
c. Remove the dish, stir it gently and allow it to cool down for about 5 minutes and reweigh.
d. Return the dish back into the oven and repeat the same previous process until a constant weight is achieved.

OBSERVATION:

A gradual reduction in weight will be observed initially followed by a constant weight.

CONCLUSION:

Since the oven was maintained at 100^0C which is the boiling point of water and a point at which liquid water becomes vapour, the reduction in weight can be explained by the loss of the water content in form of vapour at the maintained temperature.

To calculate the percent (%) water content in the soil sample, use the following formula:

$$\frac{\text{Initial weight of soil sample} - \text{Final weight of soil sample}}{\text{Initial weight of soil sample}} \times 100$$

PRACTICAL ACTIVITIES 9:

Experiment To Demonstrate The Presence Of Organic Matter In Soil:

AIM: To show that organic matter is present in soils

MATERIALS USED: Dry soil sample (the type produced from the previous experiment on water content), a weighing machine, bursen burner, a crucible and a stirrer.

PROCEDURE:

a. Put 100g or any other convenient known quantity of the dry soil sample into an a crucible of known weight
b. Place the crucible over a hot flame from the burner for about 5 minutes
c. Remove the crucible, stir it gently and allow it to cool down for about 5 minutes and reweigh.
d. Return the crucible back to the hot flame and repeat the same previous process until a constant weight is achieved.

OBSERVATION:

A gradual reduction in weight will be observed initially followed by a constant weight.

CONCLUSION:

Since dry soil sample was used and the content of the crucible was placed on hot flame until it became red hot, the reduction in weight can be explained by the loss of the organic matter content by oxidization and loss of gases (mainly Carbon Dioxide).

To calculate the percent (%) organic matter content in the soil sample, use the following formula:

$$\frac{\text{Initial weight of soil sample} - \text{Final weight of soil sample}}{\text{Initial weight of soil sample}} \times 100$$

PRACTICAL ACTIVITIES 10:

Experiment To Demonstrate The Presence Of Air In Soil (Soil porosity):

AIM: To show that air is present in soils

MATERIALS USED: A dry soil sample, two measuring cylinders ($100cm^3$), water and a stirrer.

PROCEDURE:

a. Put $50cm^3$ of water in one measuring cylinder and $50cm^3$ in the other measuring cylinder
b. Pour the soil from the first cylinder into the second cylinder and stir gentle.
c. Note the final total volume

OBSERVATION:

The expected total volume is higher than the actual final volume and bubbles were seen coming out of the cylinder when soil was been poured into it.

CONCLUSION:

The difference in weight between the expected total volume and the actual total volume can be explained by the loss of air content of the soil sample to the atmosphere as it mixed with water and evidenced by bubbles released.

To calculate the percent porosity(% porosity) of soil sample, use the following formula:

$$\frac{\text{Expected total vol. of water and soil sample} - \text{Actual total vol. of water and soil sample}}{\text{Initial weight of soil sample}} \times 100$$

PRACTICAL ACTIVITIES 11:

Experiment to Demonstrate the Presence Living Organisms in Soil (Soil porosity):

AIM: To show that there are living organisms in soils

MATERIALS USED: Fresh soil sample, two test tubes, two rubber bungs, glass wool or cotton wool and Calcium Hydroxide [$Ca(OH)_2$] or Bromothymol blue

PROCEDURE:

a. Fill one third of each of the test tubes labelled **A** and **B** respectively with Calcium Hydroxide or Bromothymol blue.
b. Gently put glass wool into the test tube just above the level of the chemical.
c. Put a small quantity of the soil sample into test tube **A** only and cover each of the two test tubes with a rubber bung.
d. Keep the test tubes in place for twenty four hours or more. (A week if Bromothymol blue is used)

OBSERVATION:

The Calcium Hydroxide in test tube **A** will change from colourless to white (or Bromothymol blue from blue-green to green, light green or yellow depending on the volume of gas released). There will be no change in colour in test tube **B** which serves as the control.

CONCLUSION:

When living organisms breathe, they release carbon dioxide gas as a waste product while taking in oxygen. Carbon dioxide gas can be detected using a carbon dioxide indicator solutions such as Calcium Hydroxide or Bromothymol blue. The colour change confirms the presence of living organisms in soil.

PRACTICAL ACTIVITIES 12:

Experiment to Demonstrate Water Retention Capacity of Soils:

AIM: To demonstrate and compare the capacity of different soils to retain water.

MATERIALS USED: Sandy soil, loamy soil, clayey soil, three measuring cylinders, three funnels and three filter papers or cotton wool.

PROCEDURE:

a. Fold one filter paper each to fill each of the funnels labelled **A**, **B**, and **C**.
b. Place each of the funnels on a measuring cylinder.
c. Fill funnels **A, B** and **C** with equal quantities of sandy, loamy and clayey soils respectively.
d. Slowly and simultaneously pour equal volumes of water into the three funnels.
e. Note the volume of water that finally drains into each of the measuring cylinders after about one hour.

OBSERVATION:

Experimental set-up with funnel **A** which contains sandy soil will have the highest volume of drained water followed by the one with funnel **B** which contains loamy soil and lastly by the one with funnel **C** which contains clayey soil.

CONCLUSION:

Since the highest amount of water that drains is observed in experimental set-up with funnel **A** which contains sandy soil, it implies that sandy soils have lowest degree of water retention capacity while experimental set-up with funnel **C** which contains clayey soil has the highest volume of water retained. Experimental set-up with funnel **B** which contains loamy soil retains an average volume of water.

NOTE: A filter paper is folded by holding two opposite edges and folding them smoothly to form a half cycle. The two edges of the base of the half cycle are then folded to form a cone. Three of the folds are pressed together neatly before being put in the funnel.

PRACTICAL ACTIVITIES 13:

Experiment to Determine Soil Reaction or Level of Soil Acidity or Alkalinity (P^H).

AIM: To determine acidity and alkalinity of soils.

MATERIALS USED: Soil samples, water, white dishes and a universal indicator

PROCEDURE:

a. Collect samples of soil from different parts of your area.
b. Moisten a sample with water and then pour a few drops of the soil water into a white dish.
c. Use a universal soil indicator to produce a colour reaction in the sample of soil water.
d. March the colour produced against a colour key card to determine the p^H of the soil.
e. Repeat the procedure for other samples.

The following colour change may apply:

Red – An acid soil with p^H less than 6.5 ($p^H < 6.5$)

Blue / Purple - An alkaline soil with p^H more than 6.5 ($p^H > 6.5$)

Green - A neutral soil with a p^H around 6.5.

Note: Most soils are slightly acidic to neutral in nature. A universal indicator is typically composed of water, propan-1-ol, phenolphthalein sodium salt, sodium hydroxide, methyl red, bromothymol blue monosodium salt, and thymol blue monosodium salt.

A roll of Universal Soil Indicator paper

OBSERVATION:

Soils show different colour change in the experiment.

CONCLUSION:

Soils have different levels of soil reaction or soil acidity and alkalinity.

NOTE: Using common litmus papers may not be very accurate. Acids turn blue litmus red, and bases turn red litmus blue.

6. ROCKS AND ROCK FORMATION

Contents: Rocks, Identification and classification of rock samples, and examples.

PRACTICAL ACTIVITIES 14:

a. Collect different types of rock samples
b. Examine each of the specimens carefully noting the following:
i. Texture

ii. Colour

iii. Presence or absence of crystals (You may use hand lens)

c. Scratch the samples to find out if an expression is made.

d. Examine the samples for fossils (If any).

e. Add drops of Hydrochloric acid to see effervescence occurs or not.

7. FLORICULTURE – COMMON AND BOTANICAL NAMES OF ORNAMENTAL PLANTS.

Contents: Definition, importance, common examples and methods of propagation.

PRACTICAL ACTIVITIES 15:

a. Collect different types of ornamental plants such as Hibiscus, Wild rose, Cauliflower, Zinna, Sunflower, Morning glory, Clitoria etc .
b. Find out the planting materials for each of the ornamental plant.
c. State what makes each of the plants attractive?

8. DISEASES AND PESTS OF CROPS

Contents: Definitions, classification of diseases based on causal organisms, effects and control of diseases, classification of pests, effects and control of pests.

PRACTICAL ACTIVITIES 16:

a. Collect diseased plants from the environment.
b. Note the parts that are affected by the disease
c. Identify the observable symptoms on the plant noting whether they are:

   i. **Necrosis** (The death of cell or of tissues)
   ii. **Chlorosis** (Yellowing of green tissues due to chlorophyll destruction)
   iii. **Rosette** (Short, bunchy habit of plant growth)
   iv. **Rot** (Softening, discoloration and disintegration of tissues)
   v. **Wilt** (Loss of rigidity and dropping of plant parts, wholly or partially)
   vi. **Gall/tumor** (Unusual development or transformation)
   vii. **Gummosis** (Excessive gum formation)

d. Determine the causal organism such as Viruses, Bacteria, Fungi or Nematodes

WEEDS:

Contents: Definitions, importance and control.

PRACTICAL ACTIVITIES 17:

Stages of preparing a weed album:

a. Collect a weed from its natural site
b. Mount it on a newsprint or plain sheet showing as much many parts as possible and as you want it mounted on the weed album.
c. Place another sheet on it and mount another weed on it
d. Repeat the procedure above.
e. Place a weight covering the sheets on the last sheet.
f. Leave it in a dry condition for about a week.
g. Remove the weeds one by one and mount each of them on a sheet of a big drawing book with glue or transparent cellotape.
h. Provide the following information on each of the sheets. –Common and botanical names of the weed, and date and place of collection.

CROP HUSBANDRY

Contents: Planting, management, harvesting and storage of selected crops.

PRACTICAL ACTIVITIES 18:

Preparing planting materials and planting yam:

i. Obtain warehouse yam or seed yam or yam sett or minisett which are all planting materials for yam.

ii. Dust the setts with wood ash or a fungicide such as Tectodust^{TM} (thiabendazole) to minimize damage in the soil and plant a day after treatment.

iii. Plant the sett by burying it in the ridge or heap the setts 15–20 cm deep with the cut surface facing up with a spacing of 1.0m x 1.0m for setts weighing 250g-300g.

iv. Provide one stake for two stands of yam or one long strong bamboo stake for 4 adjacent stands. Other staking materials include palm fronds, branches of trees etc.

FARM RECORDS AND ACCOUNT

Contents: Meaning, types, importance and preparation of Profit and Loss Account

PRACTICAL ACTIVITIES 10:

Stages of preparing Profit and Loss Account:

a. Identify all business monetary business transactions carried out by the farm during the year under consideration with the date.
b. Post each of the transactions into Debit and Credit columns in the in the Profit and Loss account based on whether money comes into the business or goes out of the business. Sales and receipts are recorded on the right hand side (Credit side) while purchases and expenses are recorded on the left hand side (Debit side). If the total in the credit side is higher, net profit is made but if the debit side is higher, net loss is made.

PRACTICUM IN BIOLOGY

TITLE OF EXPERIMENT: MICROSCOPY

AIM/OBJECTIVE: Introduction to the use of microscopes and other magnifying lenses, so that at the end of the experiment:

1. Students should be able to use microscopes and other magnifying lenses effectively during laboratory activities.
2. Prepare temporary and permanent slides.
3. Draw and label biological specimens appropriately.

APPARATUS: Microscopes, magnifying lenses, lens tissue and specimen slides, cover slips, pipettes, prepared slides of different protozoa, Euglena, Onion/Rheo leaves.

THEORY: A study of very tiny animals and plants is only possible with the aid of a microscope. Microscope is an instrument which magnifies any object viewed which cannot be seen with naked eye. Also, it has become possible to examine not only the microscopic animals, but also the minute anatomy of all animals and plants.

In making biological drawings, the following must be respected:

1. Drawing lines must be smooth and not wavy.
2. Drawing must not be shaded.
3. All cut surfaces to be represented by double lines.
4. All labels must have their guidelines ruled, and must touch the object being labeled.
5. All labels must be horizontal
6. Ruled guidelines must not cross.

In making biological drawings, magnification of magnifying lenses, preserved specimens and prepared slides of lower plants and animals need to be determined as indicated below:

Magnification.

(i) Scales of drawing, using hand lens

Magnification - $\frac{\text{length of drawing}}{\text{length of object}}$

Length of object

With of drawing

Width of object.

(ii) Magnification of object under microscopes.

Magnification is power of the objective lens X eyepiece, this is called total magnification.

Primary Magnification L/F Where L = Tube length of microscope

F = Focal length of objective

Total Magnification = L/F x e Where e = magnification of eyepiece.

PROCEDURE: Demonstration is carried out for student to see the handing, manipulation and focusing of the light microscopes. Parts of the microscope and their functions are explained Maintenance and care of microscopes are also treated.

(A) Student Activity

(i) Make a well labeled diagram of a typical light microscope in front of you.\

(ii) Identify the parts and outline the function of each part labeled.

(iii) Carryout practice session in handling microscope and for using of specimen under low and then high power.

(iv) Mount the specimen (Slide) provided under the microscope. Examine them and make a well-labeled drawing of each.

(B) Follow the instruction in the preparation of slides of fresh specimens.

(i) Place one drop of your sample in the center of the clean slide using the pipette. (Sample of pond water).

(ii) Cover the drop by lowering the cover slip gently down onto it in a slanting position. Ensure no iar bubbles are trapped. (those air bubbles are frequently mistaken for organisms)

(iii) Use the coarse focusing knob and the low power objective to ensure the sample is properly focused.

(iv) See if you can identify any of the micro-organisms i.e. Amoeba, Paramecium or Euglena.

(v) Ask the demonstrator to confirm any identification you make. Then use the x10 or x20 objective to see more details of the micro-organisms.

(vi) Drawing under high power and label fully.

(vii) Indicate briefly the functions of the parts you have seen and labeled.

(viii) Make an onion/rheo epidermal strip and examine the layout of typical plant cell.

Draw and label a low power plan, and a high power drawing of a single cell.

(ix) With a clean finger scratch the inside of the cheek and mount in a drop of water on a clean slide. Examine under the microscope for a typical animal cell. Draw and label.

EXPECTED RESULTS/OUTCOME

(i) Students should be able to handle a microscope and other magnifying lenses effectively during laboratory activities.

(ii) Students should be able to observe/examine micro-organism with the help of a microscope and other magnifying lenses.

(iii) Students should be able to prepare slides of fresh specimens.

(iv) Students should be able to make biological drawings following guidelines and 'calculate' magnifications for all drawings.

ASSIGNMENT:

(i) Make a temporary slide preparation of the following (a) Strand of Spirogyra (b) Moss or fungi. Observe and focus under microscope. Draw, label and determine the magnification of various objects observed under the microscope.

(ii) You are provided with a cockroach. Make a scale drawing of it 15cm in length and 10cm in width. State its magnification.

1st EXPERIMENT

TITLE OF EXPERIMENT: CELL DIVISION – MITOSIS

AIM/OBJECTIVE: Demonstration of Mitosis in the root tips of Allium cepa (onion)_ squashed preparation of chromosomes using acetic orcein.

APPARATUS: Onion root tips, 18% or IMHCL, FLP Orcein (acetic orcein), 45% acetic (ethanioc) acid, clean slides and coverships, mounted needles and light microscope.

THEORY: According to the cell theory, new cells arise from pre-existing cells. During cell division, the genetic material of the parent cell is duplicated so that the new cell gets the right chromosome complement.

Mitosis is the process that ensures this faithful duplication of genetic material and it is the basis of growth and asexual reproduction in eukaryotes.

Before the commencement of mitosis, the chromosomes are duplicated or replicated. This stage is called the synthetic phase or S phase for short. Mitosis is a dynamic process but the stages are conveniently divided into four, each of each gradually leads to the other, (Prophase, metaphase, anaphase and telophase).

The chromosomes are resolved into thin threads, which shorten progressively until they become quite thick. When chromosomes have contracted maximally and they are arranged on the equator of the cell, the cell is said to be in metaphase. The sister chromotids becomes distinct and the centromere and nuclear organizer regions are closely revealed in good preparation. Anaphase is the stage when the sister chromatids separate to the poles and they keep moving towards the poles until telophase when movement stops. Cell wall forms to separate the two chromatin entities – this is called cytokinosis.

PROCEDURE: Support onion bulbs over beaker or jars of water using tooth-picks or sit onion bulbs directly on beaker of water. Keep the onion in darkness for several days until the roots growing into the H_2O is 2 – 3 cm long. Cut off about 5mm of the root tips. Place them in a watch glass and:

(a) Cover them with a few drops of acetic orcein stain glass and 1 drop of 1 molar or 15% hydrochloric acid (HCL). Leave for 10 minutes or

(b) Heat the watch glass gently over a very low Bunsen flame till steam rises from the stain, but don't boil.

(c) Leave the watch glass covered for at least five minutes.

(d) Place one of the root tips on a clean slide. Cover with 45% acetic acid (ethanol) and cut away all but the terminal 1mm or so;

(e) Cover this root tips with a clean coverslip. Press off excess stain using filter paper. Squash (macerate the softened, stained root tips by lightly tapping on the covership with the broadened end of a biro or pencil. It is important that the slide does not move so the cells do not roll over.

(f) Place your slide on the microscope for viewing. Start with scanning power to locate areas of cell concentration. The root tip will spread out as a pink mass on the slides. Move to higher power and move the slide round to locate dividing cell. Move to x40 objective for a close examination of your cells. The cell will separate clearly with their nuclei or nuclear materials. You will locate good cells in prophase, metaphase, anaphase and telophase. Make neat sketches and identify the stages you can see.

EXPECTED RESULTS AND OUTCOME:

Students are expected to make clear slides showing different stages of cell division (Mitosis). They should be able to identify prophase. Metaphase, anaphase and telophase and sketch these drawings accordingly.

ASSIGNMENT:

1. What is the chromosome number of Allium cepa (Onion)
2. At what stage do you think the chromosome number of an organism can be ascertained? Give reasons for your answer.
3. Can you see any evidence of DNA synthesis at inter phase?

3rd EXPERIMENT

TITLE OF EXPERIMENT: QUANTITATIVE TREATMENT OF AN ECOSYSTEM CONSTRUCTION OF QUADRAT CHART AND DETERMINATION OF ABUNDANCE FREQUENCY AND DENSITY OF SPECIES IN AN HABITAT

AIM:
At the end of the experiment, students should be able to select an area and

(i) Perform adequate quadrat throws

(ii) Collect samples of living organisms (floral and fauna) for the identification

(iii) Identify the species and construct quadrat chart using a key

(iv) Determine the abundance, frequency and Density of species

(v) Construct food chain and food webs of the organisms

(vi) Construct pyramid of numbers

(vii) Draw Energy Material Relationship of the organisms found

APPARATUS

Different types of Quadrats – Readymade quadrat frame, metre stick, string quadrat (circular, triangular, square, rectangular etc.), Herbaria albums, insect boxes etc.

THEORY

Ecology deals with the study of organisms (plants and animals) in their environment (Ecosystem) either biotic or abiotic. An Ecological Survey will provide the qualitative characteristics of different sites or habitats. The qualitative features include trees, shrubs, herbaceous plants, floor cover, and their associated animals (scanvengers, herbivores, carnivores). Such a survey can formf the basis of the

description of their symbolic relationships, or their mode of nutrition, and levels of adaptations within the ecosystem.

Cover index is the amount of space of ground covered by each species. **Quadrat Chart** is the diagrammatic illustration of the distribution of the various organisms (Species) found in the quadrat, using either visual estimation or a scale.

PROCEDURE:

1. Selec an area within an Habitat or Ecosystem
2. Throw the quadrat (several times)
3. Record the number of species found within each section of the quadrat for each throw
4. Collect samples of organisms within the quadrat for identification
5. Use experts or herbaria to identify all the species collected
6. Draw Quadrat Chart using a key
7. Determine the abundance, frequency and density of species/organisms, within the quadration.
8. Construct appropriate food chain and food webs of the organisms found.
9. Construct pyramid of numbers.
10. Draw energy/material relationship (Energy flow and material circulation) of organisms observed.

EXPECTED RESULTS

1. Identification of the flora and fauna species within the quadrat from site to site.
2. Drawing of a good quadrat, chart with keys
3. Determination of the abundance, frequency and density of species
4. Construction of associated food chain and food webs of the organisms.
5. Construction of pyramid of numbers.
6. Drawing of energy flow/material circulation relationship.
7. Appropriate description of the qualitative and characteristics of the selected ecology site (or habitat).

4th EXPERIMENT

TITLE OF EXPERIMENT: MEASUREMENT OF ABIOTIC FACTORS IN AN ECOSYSTEM AND IMPROVISATION OF NECESSARY INSTRUMENTS OR EQUIPMENT

AIM:

At the end of the experiment, students should be able to Construct an improvised rain gauge to measuer the quantity of rain.

ii. Use

(a) The soil thermometer to measure soil temperature

(b) Photometer and other instruments to measure high intensity duration and quality.

(c) Aneroid Barometer to measure atmospheric pressure.

(d) Psychrometer and Hygrometer to measure relative humidity (dryness of air)

iii.(a) Prepare an anhydrous cobalt chloride paper to measure the relative humidity or dryness of the air.

(b) Carry out the quantitative analysis of relative humidity data and the conversion of degree centigrade (C^o) to Fahrenheit (^oF)

iv.(a) Construct an improvised wind vane to find out the direction of wind.

(b) Use anemometer to measure the speed of wind

v. Use soil indicators Box Reagents to determine soil Ph, measure (acidity/alkalinity), texture, porosity, water retentivity, structure, etc.

vi.(a) Use flute to determine the direction or movement of water

(b) Adopt the use of a very long stick to determine the depth of water

(c) Use secci Disc to measure turbidity of water.

(d) Adopt the use of submarine illuminometer to measure light penetration.

vii. Determine the salinity of water from fresh water (or aquatic) sample using filtration method.

APARATUS: GROUP BY GROUP

GROUP 1: Gas jar, (or tin), funnel, Graph Sheet

GROUP 2: Soil Thermometer, Photometer, etc.

GROUP 3: Aneroid Barometer

GROUP 4: Psychrometer, Hygrometer, Filter or Litmus paper, (or Cobalt Chloride Solution) Desiccators, Watch-Clock.

GROUP 5: Wind vane, anemometer, Wood or Pencil, a piece of straw, feather or flat wood, pin etc.

GROUP 6: Soil sample, soil indicator box reagents, spatula, petri-dish, Bunsen burner

GROUP 7: A flute, watch-clock, a long stick, Secchi Disc, submarine illuminometer, aquatic sample of water, beaker or cylinder, Burettes, Pipettes silver Nitrate Solutes and solution, Water, Potassium Chromate (Kcro3) solution, conical flasks.

THEORY:

The factors that are responsible for the distribution of organisms in an ecosystem are the climate factors which comprise of temperature, humidity, rainfall, pressure, sunlight, wind and soil.

An adequate measurement of these factors can supply appropriate information to regulate activities on an ecosystem improve the soil and rectify anomalies where possible. Moreover, the need for improvisation of equipment cannot be over emphasized. Therefore, there is need to expose students to practicals on improvisation of some equipment or measuring instruments to facilitate the teaching-learning process both in the urban and rural areas. Through this, appropriate scientific attitudes and skills can be imparted to learners and scientific culture promoted across the globe.

PROCEDURE

Divide students into 7 groups to work on the measurement of rain, temperature, wind, soil, water, pressure and relative humidity.

GUIDELINES FOR THE EXPERIMENT

GROUP 1: MESUREMENT OF QUANTITY OF RAIN & IMPROVISATIN OF RAINGAUGE

1. Place a funnel on top of a gas jar or tin.
2. Collect rainfall drops.
3. Calculate amount of rain in cm using specified formulae.
4. Plot the climatograph.

GROUP 2: MEASUREMENT OF TEMPERATURE

1. Select a terrestrial habitat and a site.

2(a) Use soil thermometer to measure the soil temperature.

(b) Use Photometer and other instruments to measure light intensify, duration and quality.

3. Record your findings.

GROUP 3: MEASUREMENT OF PRESSURE

1. Use aneroid barometer to measure atmospheric pressure
2. Record your findings.

GROUP 4: MEASUREMENT OF RELATIVE HUMIDITY & IMPROVISATION OF A.C.C. PAPER

1. Use psychrometer and hygrometer to measure relative humidity of the air
2. Record your findings.
3. Soak filter or litmus paper in Cobalt Chloride solution.
4. Dry in desiccators (blue when dry)
5. Bring it out to measure the relative humidity of the atmosphere.
6. Notice change (colour turns pink) in

$\frac{1}{2}$ minute = High Humidity

2 minutes = Moderate

5 minutes = Low

5 minutes = Very low

7. Record your findings (quantitative estimate of relative humidity (R.H)
8. Calculate the relative humidity (R.H) using specified formulae.

GROUP 5: MEASUREMENT OF WIND & IMPROVISATION OF WIND VANE

1. Select a habitat site.
2. Use wind vane to determine the direction of wind.
3. Record your findings
4. Use anemometer to determine the speed of wind
5. Record your findings.
6. Calculate the speed of wind in km/hr using a specified formula.

TO IMPROVISE WIND VANE

7. Collect a wooden object or pencil
8. Place a piece of straw on top of it.
9. Place a feather or flat wood on top of the straw.
10. Use a pin to clip the feather to the straw and wood, flexible enough to allow for rotation.
11. Use it to determine the direction of wind, and record your observation.

GROUP 6: MEASUREMENT OF EDAPHIC FACTORS (SOIL)

1. Select a terrestrial habitat and site
2. Collect soil sample in a petri-dish
3. Put reagents from the soil indicator box using spatula
4. match colours on the attached key sheet
5. Record your observations
6. Determine how much humus is in the soil (use visual estimation) or evaporation technique.

GROUP 7: MEASUREMENT OF AQUATIC (WATER)

1. Select an aquatic habitat (or fresh water)
2. Use a flute to determine the direction or movement of water, and to determine how long (time) it takes to move from one (point to another).
3. Use a long stick to determine the depth of water, mark the point on the stick, use metre ruler to measure the depth in cm.
4. Use secchi disc to measure turbidity of water (even the direction of movement from on point to another)
5. Use submarine illuminometer to measure light penetration.

TO DETERMINE THE SALINITY OF WATER

6. Collect the aquatic sample of water
7. Pipette $10cm^3$ into conical flask.
8. Prepare silver nitrate solution by dissolving 27.09g/litre
9. Titrate this from burette.
10. Use2-3 drops of potassium chromate $kcr0_3$
11. Note change in colour from yellow to red.
12. Determine the concentration of salt (salinity)

EXPECTED RESULT/DATA ANALYSIS

1. Improvisation of rain gauge
2. Measurement and calculation of quantity (amount) of rain in cm using specified formulae.
3. Plotting of climatograph.
4. Ability to use soil thermometer to measure soil temperature
5. Use photometer and other instruments to measure light intensity, duration, and quality.
6. Acquisition of skills in using aneroid barometer to measure atmospheric pressure.
7. Ability to use psychrometer and hygrometer to measure relative humidity to the air.
8. Preparation (Improvisation) of anhydrous cobalt chloride (A.C.C.) paper to measure the relative humidity of the atmosphere.
9. Calculation of the relative humidity (R.H.) using specified formulae.
10. Measurement of wind direct ion and speed using
    (a) Anenometer
    (b) Readymade or improvised wind vane.

11. Ability to use a specified formula to calculate the speed of wind in km/jr.
12. Measurement of edaphic factors (Soil characteristics) using soil indicator box reagents and matching key sheet.
13. Measurement of aquatic factors using
    (a) Flute for water direction
    (b) Secchi disc for water turbidity
    (c) Submarine illuminometer for light penetration
14. Determine of water salinity.

5TH EXPERIMENT

TITLE OF EXPERIMENT: VARIATION

AIM/OBJECTIVE

TO STUDY VARIATION IN LIVING ORGANISMS (GENETICAL PRINCIPLES)

THEORY:

One of the fascinating things about life is the enormous diversity of living forms (viruses through bacteria to plants and animals). The diversity has been brought about by evolution and evolution essentially entails sustenance of organism with genotypes that confer preferential survival potentialities on the particular individuals and such potentials are transmitted to progenies. The various surviving genotypes can be affected by mutations being caused spontaneously by many factors in the environment.

In short, differences between species and within species are due to the differences in their genotypes which they show as variations. However, it is known that a lot of variations are also induced by the environment. But such variations, unlike those due to the genotypes, can be reversed by simply changing the environment of the original situation.

Human beings the world over belong to one large species, called Homo Sapiens. The amount of variation observed among peoples of the world is however literally infinite. Several scientists have made fruitless efforts at classifying the human species into races, but each of the criteria for such classification has always broken down as no one race absolutely possesses certain characteristics not found in other races. Perhaps one factors that has led to this distinct "human" characteristics is that no human populations is exclusive with the result that there is always a 'mixing' of the genotypes of the various populations. Indeed marriages between closely related individuals is taboo in all human societies, this further encourages genotypes mixing.

Humans being are also subject to environmental influences which may be largely cultural in origin. For example in Nigeria, over 400 languages are spoken by various groups. Ability to speak a particular

language is acquired as a child grows up and not genetically imparted. Thus, if a child born of two indigenous Yoruba parents were fostered from infant to adult by say two other indigenous Hausa parents in a typical Hausa village, such a child would grow up acquiring all the characteristics traits' of a Hausa person, speaking Hausa the way Hausa is spoken in his environment and so on. There are of course many, cultural variations among human beings worldwide. Can you name some more?

MATERIALS AND PROCEDURE:

The practical class will be divided into two parts, A and B. You require no special materials other than your power of observations, pencil and paper.

PART A:

Go out of the laboratory to undeveloped parts of the campus (a singular attribute of university campuses in developing countries, e.g. Nigeria), and collect 6-8 twigs from 3-4 different species of plants, and bring these quickly to the laboratory before the weak ones begin to wither seriously.

Sort the shoots into their individual species and label them species a,b,c and so on. Observe carefully the characteristics of each twig and note the variations existing between the different species. Write these down:

Select any two species with abundant leaves for further observations. For each leaf, measure the leaf length, the leaf breadth and leaf stalk. You should make at least 50 such measurements for each of the parameters. Next plot histograms of leaf length, leaf breadth and leaf stalk (separately) against frequency of occurrence for the two species. Comments on the variability of the parameters and give reasons for the occurrences of the variations.

PART B:

(1) Take a careful look at the members of the class and write down ten variations that are normally genetically controlled and list five variations that may be environmentally induced. List of variations: Tongue rolling, Hand clasping, Shape of ear, Earlobe, Shape of foot, length of toes, finger prints, length of fingers, pigmentation, stature (height, weight) blood group, eye colour e.t.c.

(2) For each characteristic find out the following:

- (i) Frequency for male and female (e.g. tongue rolling & hand clasping)
- (ii) Percentage for male and female
- (iii) Compare male and female (i) & (ii) using chi square
- (iv) Using stature you can measure individual height or weight.

Find average, do a frequency distribution through graphs or histographs. Use relevant tables indicated below:

TABLE 1

VARIATIONS IN HUMAN POPULATION (TRAITS)

Genetical Concept/Principles

S/N	Physical Traits/Variation	Continuous	Discontinuous	Genotypic	Phenotypic
1	Tongue Rolling				
2	Hand clasping				
3	Share of ear				
4	Ear lobe				
5	Shape of foot				
6	Length of toes				
7	Finger prints				
8	Length of fingers				
9	Skin pigmentation				
10	Stature				
11	Blood group				

TABLE II

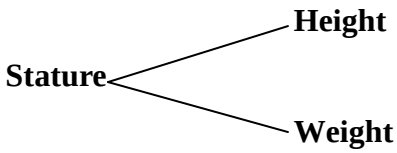
(1) TONGUE ROLLING

	Rollers	Non Rollers	Total
Female			
Male			
Total			

TABLE III

HAND CLASPING

	Right on top	Left on top	Total
Female			
Male			
Total			



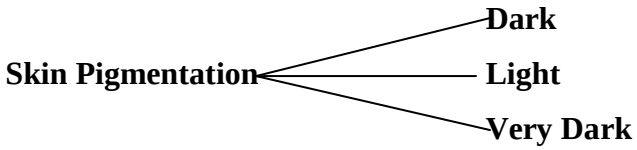


TABLE V

BLOOD GROUPS

	A	**B**	**AB**	**0**	**Total**
Female					
Male					
Total					

Other traits

TABLE IV

STATURE

Pupils heights can be measured individually in the class, & they can also draw their finger prints, fast prints etc.

	Female	Male
ASSIGNMENT		

Discuss in detail the relevance of variation to human population.

PRACTICUM IN CHEMISTRY

SEPERATION TECHNIQUES

The physical methods by which mixtures can be separated into their different components include filtration, Evaporation, Centrifuging, Chromatography, Distillation, Fractional Distillation, Magnetisation, Crystallisation, Sublimation and Decantation.

Each separation technique is based on the properties of the components of the mixtures, for some mixtures, two or more methods are used.

EXPERIMENT 1: FILTRATION

Aim: To separate an insoluble solid from solution/liquid.

Apparatus: 250cm^3 beaker, funnel, large test tube or boiling tube, filter paper, test tube rack and stirrer.

Reagents: 50cm^3 tap water and 5 grams soil.

Procedure: Mix 50cm^3 tap water with 5 grams soil and stir until a cloudy mixture appears. Fold a filter paper into cone-shape and place it in the funnel. Pour the mixture into the funnel and observe the filtrate and the residue. Record your observations.

EXPERIMENT II: EVAPORATION

Aim: To separate dissolved solid from solution

Apparatus: Evaporating dish, two 250cm^3 beakers, Bunsen Burner, wire gauze, Tripod Stand, Glass stirrer and watch glass.

Reagents: 3g of common salt (NaCl)/1 cube of sugar. Stir until the solid dissolves in water. Transfer the resulting solution into an evaporating dish. Heat the solution on a wire gauze until the salt/sugar begins to splash. Complete the evaporation on a steam bath.

EXPERIMENT III: SIMPLE DISTILLATION

Aim: To separate two or more miscible liquids with large difference in their boiling points.

Apparatus: Conical flask, large test tube, 250cm^3 beaker, Bunsen burner, Wire gauze, Tripod stand, Delivery tube, Thermometer, Distillation flask, Liebig condenser and corks.

Reagents: 50cm^3 tap water, blue ink and cold water.

Procedure: Pour 50cm^3 tap water into a conical flask and add few drops of blue ink. Heat the conical flask containing mixture of ink and water until when the solution boils, water vapour rises and condenses

in the cold test tube. Take a reading of the temperature at which the solution boils. Note the colour of the liquid collected in the test tube.

EXPERIMENT IV: FRACTIONAL DISTILLATION

Aim: To separate two or more miscible liquids with close boiling points.

Apparatus: Round bottomed flask, Fractionating column, thermometer, corks, Liebig condenser, flowing tap, conical flask, Bunsen burner, Wire gauze, Tripod stand and Anti Bump (broken glass or porcelain).

Reagents: Ethanol and Water.

Safety Precaution: Ethanol is flammable; it should not be taken near naked flame.

Procedure: Mix equal volumes of ethanol and water in a round-bottomed flask. Assemble the fractionating column and heat the solution while the tap is allowed to run through the Liebig condenser. Record your observations and conclusion.

EXPERIMENT V: SUBLIMATION

Aim: To separate a mixture of solid Sodium Chloride and Ammonium Chloride.

Apparatus: Glass funnel, Evaporating dish, Bunsen burner, Tripod Stand, wire gauze and beaker

Reagents: Solid Ammonium Chloride (NH_4Cl) and solid Sodium Chloride (NaCl).

Safety Precaution: Separation should be done in a fume chamber if the mixtures involve iodine which causes irritation (if vapour is inhaled) and a large dose is poisonous.

Procedure: Mix 4g of common salt (NaCl) with 2g of Ammonium Chloride (NH_4Cl) in an evaporating dish. Place a glass funnel inverted over the dish. Heat the dish and observe. Record your observations and conclusion.

EXPERIMENT VI: IMMISCIBLE LIQUIDS

Aim: To separate two immiscible liquids (Kerosene and Water) using a separating funnel.

Apparatus: Separating funnel, two $25cm^3$ beakers, Tripod stand and conical flask

Reagents: Kerosene and Water

Procedure: Carefully mix kerosene and water in a beaker and transfer the resulting mixture into a separating funnel. Let the funnel stand until two distinct layers emerge. Place an empty conical flask under the tap of the separating funnel. Open the tap to drain off the lower layer. Record your observations.

Questions: 1. Which of the two liquids is first collected in the conical flask?

2. Which of the two liquids is denser?

PREPARATION OF STANDARD SOLUTIONS

A standard solution is that which its concentration is known. Steps involved include:

(i) Weighing of the substance to be dissolved

(ii) Dissolving the substance and making up the volume to the require concentration.

Weighing of true substance can be done using any of the weighing balances available in the laboratory. For instance if a standard solution of 0.01m NaOH is to be prepared.

1. The molar mass of NaOH will contain 4g of it dissolved in $1dm^3$. It then means that the student must weigh 4g of the substance and dissolve it in 1 dm^3 ($1000cm^3$). To reduce the volume, since one may not need as much as the 1 dm^3, a 250 cm^3 volumetric flask can be used. This means that one needs to calculate the mass that has to be dissolved in 250 cm^3 and yet make 0.10m solution of NaOH.

   i.e. 1000 cm^3 require $\frac{4g \times 250\ cm^3}{1000}$

   Hence the 4g in $1000cm^3$ = 1g in 250 cm^3

   Therefore you need to weigh 1g of NaOH pellets and dissolve in 250 cm^3 (distilled) water.

This gives a solution of 0.10m. in order to do this;

(i) Get a clean dry sample or weighing bottle

(ii) Weigh the sample bottle and record the value, e.g. ag

(iii) By calculation, add the amount of the sample you want to weigh to the mass of the sample bottle already weighed and adjust the weighing balance to read this new mass (bg).

Now, place the sample on the scale pan and start adding the sample inside the sample bottle until there is a balance between the weighing instrument and the bottle containing the sample.

Record the reading as follows:

Weighing reading;

Mass of the sample bottle only = ag

Mass of bottle + sample = bg

Mass of sample alone = (b – a)g

For example, in the case of 1g NaOH

Mass of the sample bottle only = ag

Mass of bottle + sample = (a + 1)g

Mass of sample alone = 1g

After weighing, dissolve the sample as follows:

(i) Pour the sample inside a beaker

(ii) Use small amount (distilled) water to wash the sample bottle thoroughly into the beaker containing the sample

(iii) Now, using a little amount of the distilled water, dissolve the sample in the beaker and make a small solution of it

(iv) Pour this solution into a volumetric flask using a funnel

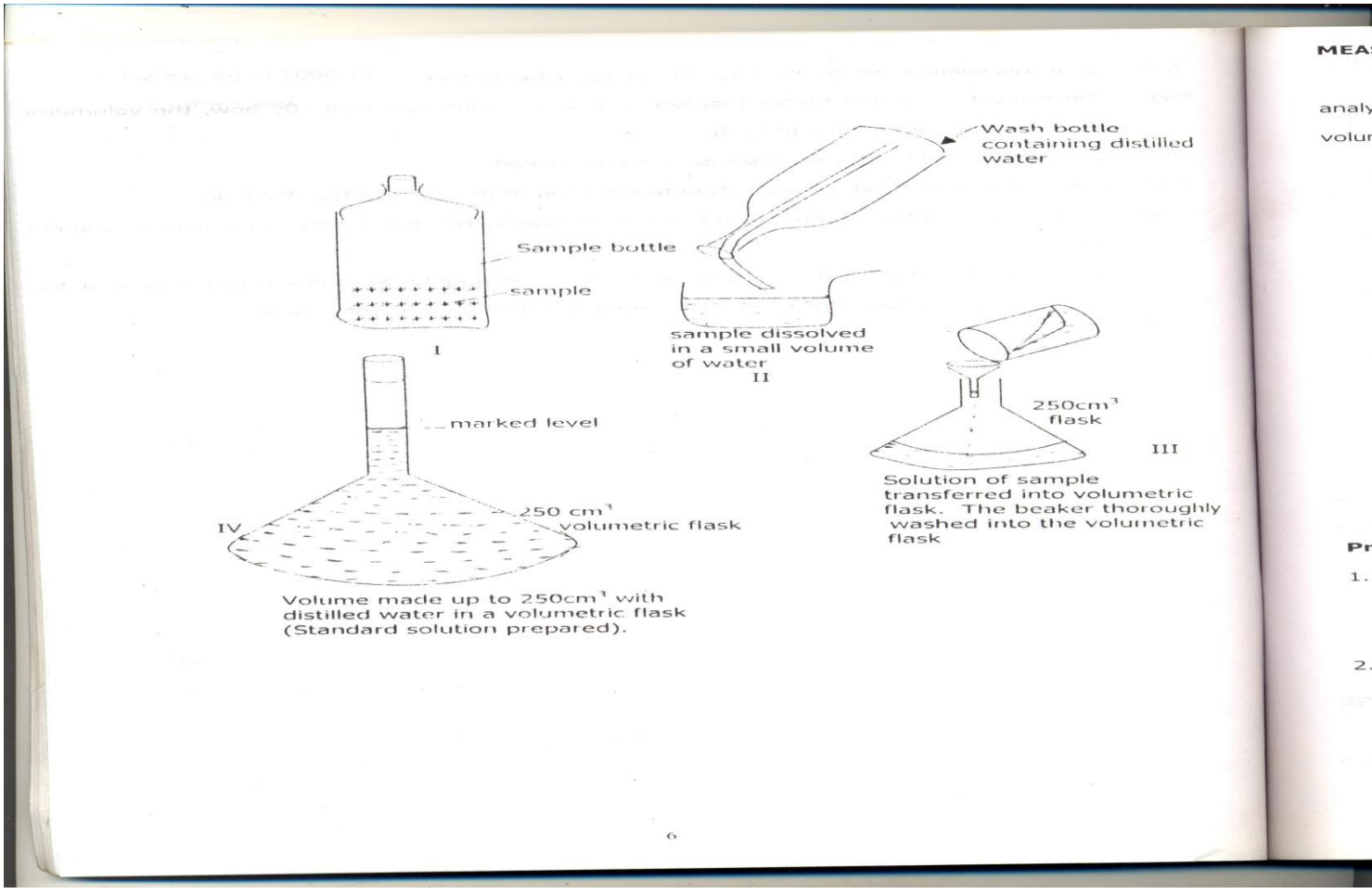
(v) Rinse the beaker and the funnel thoroughly into the volumetric flask. By now, the volumetric flask should be about one third full

(vi) Shake very well to ensure all solutes have dissolved

(vii) Now, start to add water (distilled) until it is filled to the mark of the bulb of the flask

(viii) Using wash bottle, carefully add water to reach the graduation mark exactly, without exceeding it.

(ix) Now, cork the flask with its cover and shake thoroughly for uniform distribution of the solute in the solution. This makes your standard solution of 0.10m NaOH.



MEASURING A FIXED VOLUME USING A PIPETTE

Measuring the volume of a solution is one of the essential aspects of volumetric analysis. The volume must be accurately measured otherwise it will affect your titre value. The volume of a solution can be measured using a pipette as follows:

(i) Dip the end of the pipette inside the solution

(ii) Inside the upper end of the pipette inside your mouth and carefully suck in a little of the solution

(iii) Use this to rinse the pipette thoroughly (after you might have initially washed it thoroughly with water)

(iv) Then empty the pipette

(v) Ensure that every space in it is filled with the solution

(vi) Place your right forefinger to seal the upper end immediately you remove the pipette from your mouth

(vii) With the upper end sealed, move the pipette in such a way you can see the round graduated mark as a single line from your side (if you move the pipette up and down you will see the round mark as s double line from your side).

VOLUMETRIC ANALYSIS

Procedure for a Titration Experiment

1. Pipette out 20 cm^3 or 25 cm^3 (depending on which type of pipette is available) of the solution provided (usually a base) into a conical flask. Note that this should follow the procedure described under the use of a pipette.

2. Add about 2 or 3 drops of the indicator to the base and shake the flask. Usually, Methyl Orange is provided but occasionally, Phenolphthalein may be used. Methyl Orange is yellowish in a base and pinkish in an acid solution, while Phenolphthalein is red in a base and colourless in an acid solution.

3. Fill the burette with the titrant (acid solution) following the procedure described under the use of a burette

4. Adjust the level of the solution in the burette as appropriate. Take the reading of the burette and record it as “initial reading” ensuring there is no leakage in the burette.

5. Now place the conical flask on the white tile at the base of the retort stand. Use white paper if there is no white tile.

6. In order to prevent careless spilling of the acid solution while titrating, adjust the height of the burette so that the jet just lies slightly within the mouth of the conical flask

7. Open the burette tap to allow the solution to run into the conical flask but this should be at a controlled rate. The thumb, index finger and second finger of your hand (preferably left hand) are used for the control

8. Use the other hand (right hand) to swirl the conical flask continuously as the acid solution is being added from the burette. The agitation will ensure a proper mixture of the acid and base solutions.

9. Since you are expecting a colour change at the end point, add the acid solution drop by drop towards the end point. You should end the titration by turning off the burette tap immediately you observe that

addition of a single drop of the acid solution causes a permanent colour change (yellow to faint or pink in the case of Methyl Orange indicator).

10. Read and record the burette reading. The titre value is obtained by subtracting the initial reading from the final reading. The titre value is the volume of the acid solution required to react completely with the volume of the base in the conical flask.

RULES GUIDING THE WRITING OF BURETTE READINGS AND CALCULATION OF AVERAGE TITRE VALUE

1. Usually the first titration is regarded as rough/trial, so have to repeat the titration two or three more times, ensuring that two titre values do not vary by more than 0.20 cm^3
2. Record burette reading to two decimal places and the second decimal figure must either be 0 or 5 e.g. 19.50 cm^3 not 19.51 cm^3 or 22.56 cm^3. In the same vein, the average titre value should be calculated to two decimal places e.g. average 19.50cm^3 and 19. 55 cm^3 is

$$\frac{19.50 + 19.55 = 19.53 \text{ cm}^3}{2}$$

3. The burette reading are conveniently tabulated as shown below:

Burette Readings		**Titration**	
	Trial	**First**	**Second**
Final Burette Reading (cm^3)	21.10	41.60	21.55
Initial Burette Reading (cm^3)	0.00	21.10	1.00
Volume of Acid Used (cm^3)	21.10	20.50	20.55

Average volume of acid used to neutralise 25 cm^3 of the base: $\frac{20.50 + 20.55}{2} = 20.63 \text{ cm}^3$

4. You are advised to ignore value (s) of volume (s) that is outrageous (i.e. too low or too high) in calculating the average titre value.
5. Do not average two titre values which are more than 0.20 cm^3
6. Make sure you record the calculated value of concentrations in moles per dm^3 (molarities) to three decimal places e.g. 0.560M
7. Concentration in grams per dm^3 and any other calculation should be expressed in three significant figures e.g. 2.68g/dm^3

QUESTION 1

A is a solution of tetraoxosulphate (VI) acid containing 5.8g per dm^3. Solution B contains 9.3g of an impure potassium hydroxide per dm^3.

Put the acid solution A into the burette and titrate with 25 cm^3 or (20 cm^3) portion of B, using methyl orange or screened methyl orange as indicator.

From your result, calculate;

a. The concentration in moles/dm^3 of the tetraoxosulphate (VI) acid in solution A

b. The concentration in moles/dm^3 of the potassium hydroxide in solution B

c. The concentration in grams/dm^3 of potassium hydroxide in solution B

d. The percentage purity of potassium hydroxide in solution B

The equation for the reaction is:

$H_2SO_4 + KOH \longrightarrow K_2SO_4.2H_2O$

(H = 1.0; S = 32.0; O = 16.0; K = 39.0)

QUESTION 2

Xg of anhydrous sodium trioxocarbonate (IV) was treated with 1000cm^3 or (1 dm^3) of 0.300M hydrochloric acid to obtain a solution A which contains excess hydrochloric acid after the treatment. B is a 0.09M solution of sodium hydroxide.

Put the acid solution A into the burette and titrate against 25 cm^3 or (20 cm^3) portion of B. Use methyl orange or screened methyl orange as indicator.

Record the volume of your pipette. Tabulate your burette readings and calculate the average volume of acid required to neutralise the stated volume B.

From your result calculate:

(a) The concentration of acid in solution A in mole per litre (dm^3)

(b) The mass, X, of the sodium trioxocarbonate (IV)

QUESTION 3

Solution A is a solution of sodium hydroxide containing 0.025 mole of the alkali in 250 cm^3 of solution. B is a solution of a dibasic acid, H_2Y.

Put solution B into burette. Pipette 25 cm^3 or (20 cm^3) portion of solution A into a conical flask and titrate with solution B using phenolphthalein as indicator.

Record the volume of your pipette. Tabulate your burette reading and calculate the average volume of acid used.

(a) calculate the concentration in moles/dm^3 of solution B from your results

(b) if the concentration of the acid in solution B is 4.90g/dm^3, what is the molar mass of the acid to the nearest whole number?

(c) Calculate the percentage by mass of Y in H_2Y

QUESTION 4

P is a solution of either hydrochloric acid or trioxonitrate (V) acid containing 4.6gdm^3. Q is a solution of potassium hydroxide. The concentration of solution Q is 5.75gdm^3.

Put solution P into the burette and titrate against 25 cm^3 or (20 cm^3) portion of Q. Use methyl orange or screened methyl orange as indicator.

Record the volume of your pipette. Tabulate your burette readings and calculate the average volume of acid required to neutralise the stated volume Q.

From your results, calculate:

(a) The concentration in moles/dm^3 of the base solution Q.

(b) The concentration in moles/dm^3 of the acid solution P.

(c) The molar mass of the acid

(d) From your result in (c) above identify the acid. Explain clearly how you arrived at your conclusion.

(H = 1.0; O = 16.0; Na = 23.0; Cl = 35.5; K = 39.0).

QUESTION 5

E is a solution containing 15.7g/dm^3 of hydrated sodium trioxocarbonate (IV). F is a solution of tetraoxosulphate (VI) acid. The concentration of solution F in mole per dm^3 is 0.065M.

Put F into the burette and titrate with 25 cm^3 or (20 cm^3) portion of solution E. Use methyl orange or screened methyl orange as indicator.

Record the volume of your pipette. Tabulate your burette readings and calculate the average volume of acid required to neutralise the stated volume of E.

From your result, calculate:

(a) The concentration in moles/dm^3 of solution E

(b) The molar mass of hydrated sodium trioxocarbonate (IV).

(c) The value of X.

The equation of the reaction is;

$Na_2CO_3XH_2O + H_2SO_4 \longrightarrow Na_2SO_4 + CO_2 + (X + 1)H_2O.$

QUALITATIVE ANALYSIS

Chemical compounds are made up of different particles. The particles may be atoms, molecules or ions (charged particles). The ions carrying negative charges are called anions, while those carrying positive charges are called cations.

Qualitative analysis is the identification of the anion and cation present in a simple salt or anions and cations present in a mixture of salts or salts of metallic oxides.

Analysis of a simple salt usually includes:

a. Examination of physical properties

b. The action of heat on a salt

c. The reactions of a salt or solution with acids and alkalis

d. The reactions of solutions of salt with other reagents, and

e. Flame test.

TECHNIQUES AND PROCEDURES FOR QUALITATIVE ANALYSIS

In qualitative analysis, salts or a mixture of salts are usually supplied. At times, a solution of a salt may be given. This is an unknown compound as far as the students are concerned, the containers are appropriately labelled alphabetically by the examiner, e.g. the specimen bottle containing the salt may be labelled A, B, C, X or Y.

When you are given an unknown salt, you are expected to carry out specified tests on it or the solution of it, observe the changes and carefully record them and finally arrive at inferences or conclusions about the nature and identify the unknown salt tested. For good performance, since this is part of the practical, the following guide should be carefully employed.

1. HEATING OF A DRY SALT IN A TEST TUBE

When a given substance is to be tested in a dry state, heat is gently applied at the initial state, while observing any change taking place and then heat is strongly applied until there is no further change is observed. You will be expected to describe the residue, its appearance when hot and when it has been allowed to cool down. When heating, the test tube must be held with a test tube holder in a slanting position, with its mouth pointing away from you.

a. The amount of substance required here for heating or preparing solutions is always a small quantity

b. Describe any gas evolved giving its colour, odour and a chemical test for confirmation

2. PREPARING SOLUTION OF A SALT

When you are not given the solvent for preparing the solution of an unknown substance, use a suitable solvent to prepare the solution of the substance. The following solvents should be tried in that order: water, dilute hydrochloric acid and dilute trioxonitrate (V) acid, ensuring that the solid added dissolves completely.

If dissolution is slow, you can warm the solution gently ensuring that the solution is cooled under a tap or left to cool on its own (if there is time), before carrying out chemical tests on the solution of the salt. The

solution must be clear and during filtration, the solution must be carefully poured into the middle of the cone of the filter paper.

3. ADDING A REAGENT TO A SOLUTION IN A TUBE

a. Any reagent to be added to the prepared solution must be a little at a time or (few drops at a time), shake after addition, until there is no further change. Use only about 2 – 3 cm^3 of the prepared solution. A dropping pipette is usually useful for adding reagents to solutions.

b. If you observe any precipitate after the addition of the reagent, describe its colour and/or appearance such as crystalline or gelatinous.

c. If it happens that no change is observed after adding the necessary reagents to the solution, then record 'there is no visible change'.

4. **TEST FOR GASES**

RECOGNITION AND SOURCES OF GASES

GASES	TEST	SOURCES OF GASES
Hydrogen (H_2)	Colourless, odourless, explodes with a slight pop when flame is applied	Evolves when metals react with dilute acids e.g. $Zn + 2HC \longrightarrow ZnCl_2 + H_2$
Oxygen (O_2)	Colourless, odourless, re-lights or rekindles a glowing splint	Evolves when oxides (peroxides, salts or oxyacids, trioxonitrates (V), trioxochlorates (V), trioxoiodates (V) are heated, e.g. $2KClO_3 \longrightarrow 2KCl + 3O_2$
Carbon(IV)oxide (CO_2)	Colourless, odourless, slightly acidic, turns calcium hydroxide solutions (lime water) milky.	Evolves when Trioxocarbonates (IV) or some metals are heated Dilute acids react with Trioxocarbonates (IV) e.g. $CaCO_3 \longrightarrow CaO + CO_2$ $Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$
Chlorine (Cl_2)	Yellowish green colour, choking smell, turns moist blue litmus paper red and then bleaches it.	Evolves when certain chlorides react with oxidising agents, e.g. $MnO_2 + 4HCl \longrightarrow MnCl_2 + Cl_2 + 2H_2O$
Hydrogen Chloride (HCl)	Colourless, irritating smell, turns blue litmus paper red, white fumes with ammonia, fuming in moist air (noticed clearly	Evolves when a chloride reacts with concentrated tetraoxosulphate (VI) acid (H_2SO_4), e.g. $2NaCl + H_2SO_4 \longrightarrow Na_2SO_4$

	by blowing across the mouth of the test tube)	+ 2HCl

GASES	TEST	SOURCES OF GASES
Hydrogen Sulphate (H_2S)	Colourless, smells like bad (rotten) egg, burns with light blue flame and deposits sulphur, turns Lead Ethanoate paper black	Evolves when a dilute acid reacts with a sulphide e.g. $FeS + 2HCl \longrightarrow FeCl_2 + H_2S$
Nitrogen (IV) Oxide (NO_2)	Brown gas with choking smell, turns moist blue litmus paper red, turns starch iodide paper blue black.	Evolves when Trioxonitrate (V) or dioxonitrate (III) of some metals below Na in the E.C.S. are heated, e.g. trioxosulphite (IV) $2Pb(NO_3)_2$ $2PbO + 4NO_2 + O_2 \longrightarrow$ Conc. HNO_3 reacts with metals e.g. $2Pb(NO_3)_2 \longrightarrow 2PbO + 4NO_2 + O_2$ $Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$
Sulphur (IV) Oxide (SO_2)	Colourless, irritating smell or (smell of burning sulphur), turns Potassium tetraoxomanganate (VII) solution colourless and turns litmus paper dipped in acidified potassium heptaoxodichromate (VI) solution green.	Evolves when dilute acid reacts with some tetraoxosulphates (VI), trioxosulphates (IV) or thiosulphates e.g. $Na_2SO_3 + 2HCl \longrightarrow 2NaCl + NH_3 + H_2O + SO_2$
Ammonia (NH_3)	Colourless, characteristic choking smell, turns moist red litmus blue, forms white fumes with concentrated hydrochloric acid	Evolves when sodium hydroxide is added to an ammonium salt, e.g. $NH_4Cl + NaOH \longrightarrow NaCl + NH_3 + H_2O$
Water Vapour (H_2O)	Condenses on the side or around the mouth of the test tube	Evolves when hydrated salts are heated. e.g. $CuSO_4 \longrightarrow 5H_2O +$ $CuSO_4H_20$. Bluish white

METHOD OF RECORDING QUALITATIVE ANALYSIS RESULTS

Usually, a three-column method of recording is adopted where the first, second and third column carry the captions: Test, Observation and Inference respectively.

Record ALL observations, including negative results, in the columns as indicated under identification of anion and cation. Special care is required if good result is to be achieved.

	TEST	OBSERVATION	INFERENCE
a	To the unknown salt given, add dilute HCl or dilute H_2SO_4	**i.** There is a quick effervescence of a colourless odourless gas which turns Calcium hydroxide solution (lime water) milky.	The gas given off is Carbon (IV) Oxide (CO_2) and the anion is CO_3^{2-} or HCO_3.
		ii. There is an effervescence of a colourless gas with a rotten egg smell and turns Lead Ethanoate paper black	The gas evolved is hydrogen sulphide (H_2S) and the anion is S^{2-}
		iii. There is an effervescence of brown gas with choking smell, which turns moist blue litmus paper red and starch iodide paper blue black	The gas evolved is Nitrogen (IV) Oxide (NO_2) and the anion NO_2^- (dioxonitrite (III)).
		iv. There is an effervescence of a colourless gas with irritating smell which turns both potassium tetraoxomanganate (VII) paper and acidified Potassium heptaoxodichromate (VI) paper colourless and green respectively.	The gas given off is sulphur (IV) oxide (SO_2) and the anion is SO_3^{2-} (trioxoulphite (IV))
b	To the unknown salt given, add concentrated tetraoxosulphate (VI) acid	There is an effervescence of a colourless gas with irritating smell which turns moist blue litmus red and forms white fumes with ammonia.	The gas given of is hydrogen chloride and the anion Cl^- (chloride).
c	To the unknown salt given, add concentrated tetraoxosulphate (VI) acid and heat	There is an effervescence of a brown gas (on strong heating) with choking smell, turns moist blue litmus paper red	The gas is nitrogen (IV) oxide and the anion is NO_3^- trioxonitrate (V).
d	If test (c) indicates the presence of NO_3, mix the unknown salt given with copper turnings and add concentrated tetraoxosulphate (VI) acid and heat.	There is an effervescence of a gas with choking smell, which turns moist blue litmus paper red and starch iodide paper blue black	The gas evolved is nitrogen (IV) oxide NO_2 and the anion is NO_3^- trioxonitrate (V).
e	In the same manner if the test (b) indicates the presence of cl, mix the unknown salt with MnO_2 and add concentrated tetraoxosulphate (VI) acid to the mixture	There is an effervescence yellowish green gas with choking smell, turns moist blue litmus paper red and then bleaches it.	The gas is chlorine (Cl_2) and the anion is Cl^- (chloride ion).
f	<u>Confirmatory test for chloride ion.</u> To the aqueous	A white precipitate is formed which is insoluble in excess dilute HNO_3, but soluble in	chloride ion (Cl^-) is confirmed.

	solution of the unknown salt given, add dilute HNO_3 acid if the solution is prepared in water followed by $AgNO_3$.	ammonia solution.	
g	<u>Confirmatory test for NO_3^- ion.</u> To the aqueous solution of the unknown salt given, (prepared in water or HCl), add dilute H_2SO_4 and then excess of freshly prepared $FeSO_4$ solution, followed by H_2SO_4 carefully added by the side of the test tube with the test tube being cooled under tap	A brown ring is formed at the junction of the acid and the aqueous layer.	Trioxonitrate (V) ion (NO_3^-) is confirmed.
h	<u>Confirmatory test for SO_4^{2-} ion.</u> To the aqueous solution of the unknown salt given, add excess of dilute HCl and then $BaCl_2$ solution.	A white precipitate is formed which is insoluble in excess of dilute HCl	Tetraoxosulphate (VI) ion (SO_4^{2-}) is confirmed.

Identification of Cations

<u>Test on the Unknown Salts</u>

Add Sodium hydroxide (NaOH) solution to the salt given and warm the mixture. If there is an evolution of colourless gas with characteristic choking smell, which turns moist red litmus paper blue and forms white fumes with concentrated hydrochloric acid, it indicates the presence of ammonium ion (NH_4^+).

<u>Test on the Solution of the Salts</u>

The solution of the salt is prepared in water or dilute hydrochloric acid, or dilute trioxonitrate (V) acid (as previously described).

Add Sodium hydroxide (NaOH) solution and ammonia (NH_3) solution to separate portions of the salt, little by little until in excess (shaking the test tube after each addition). These two tests will give an indication as to what cation is present in the salt or substance. The presence of this cation can be confirmed with further tests.

Scheme for Systematic Analysis of Cations

Cation	Sodium hydroxide (NaOH) Solution	Ammonia (NH_3) Solution
Ca^{2+}	A white precipitate is formed which is insoluble in excess of sodium hydroxide	There is no precipitate formed with ammonia solution

	solution	
Cu^{2+}	A blue precipitate is formed which is insoluble in excess of sodium hydroxide solution	A blue precipitate is formed which is soluble in excess of ammonia solution to give a deep blue solution
Fe^{2+}	A green precipitate is formed which is insoluble in excess of sodium hydroxide solution	A green precipitate is formed which is insoluble in excess of ammonia solution
Fe^{3+}	A reddish brown precipitate is formed which is insoluble in excess of sodium hydroxide solution	A white precipitate is formed which is soluble in excess of ammonia solution to give a clear colourless solution
Pb^{2+}	A white precipitate is formed which is soluble in excess of sodium hydroxide solution giving a clear colourless solution	A white precipitate is formed which is soluble in excess of ammonia solution to give a clear colourless solution
Zn^{2+}	A white precipitate is formed which dissolves in excess sodium hydroxide solution giving a clear colourless solution	A white precipitate is formed which is insoluble in excess of ammonia solution

Confirmatory Tests for Cations

Test	**Observation**	**Inference**
Ca^{2+} Ammonium oxalate is added to the aqueous solution of the salt	A white precipitate is formed which is soluble in dilute hydrochloric acid but insoluble in dilute ethanoic acid	Ca^{2+} confirmed
Cu^{2+} Potassium hexacyanoferrate (II) solution is added to the aqueous solution of the salt	A brown precipitate is formed which is insoluble in excess of Potassium hexacyanoferrate (II) solution	Cu^{2+} confirmed
Fe^{2+} i.Add dilute H_2SO_4 to the aqueous solution of the salt, followed by a few drops of $KMnO_4$ solution. ii. Add Potassium hexacyanoferrate (III) solution to the aqueous solution of the salt	The solution of $KMnO_4$ is decolourised, turning slightly yellow because it has been reduced by Fe^{2+} to Mn^{2+} A deep blue precipitate is formed	Fe^{2+} is confirmed Fe^{2+} is confirmed
Fe^{3+} i. Add Potassium hexacyanoferrate (III) solution to the aqueous solution of the salt. ii. Add ammonium hexacyanoferrate (II) thiocyanate solution to the	A deep blue precipitate is formed A blue-red solution results.	Fe^{3+} is confirmed Fe^{3+} is confirmed

aqueous solution of the salt		
Pb^{2+} i.Add dilute HCl to a cold aqueous solution of the salt ii. The mixture in (i) above is heated iii. The resulting solution is cooled	A white precipitate is formed which is insoluble in excess of dilute HCl A precipitate dissolves to give a clear colourless solution The precipitate reappears as white crystals.	The precipitate is $PbCl_2$ $Pb_2 + 2Cl \longrightarrow PbCl_2$ Pb^{2+} is confirmed ($PbCl_2$ is also confirmed)
Zn^{2+}: Add ammonium sulphide solution to the aqueous solution of the salt or pass H_2S gas into the solution if it is neutral (not acidic)	A white precipitate is formed	Zn^{2+} is confirmed

Note

1. $BaCl_2$ can form white precipitates with CO_3^{2-} and SO_3^{2-} as $BaCO_3$ and $BaSO_3$ respectively, but soluble in dilute HCl.
2. $AgNO_3$ can give white precipitate with CO_3^{2-} and SO_4^{2-} but not soluble in excess ammonia.

Solubility of Salts

A good knowledge of the solubility of salts is essential since it enables a student to narrow the choice of possible salts. It further helps him to suspect the identity of a salt. Information given below on solubility of salts will serve as a good guide.

a. All ammonium salts are soluble in water
b. All trioxonitrate (V) are soluble in cold or warm water
c. All common salts of sodium and potassium are soluble in water
d. All tetraoxosulphate (VI), except those of calcium, Lead (II) and barium are soluble in water
e. All chlorides, except those of Lead (II), copper (I), mercury (II) and silver are soluble in water but more soluble in hot water.
f. All trioxocarbonate (IV) are insoluble in water except those of sodium, potassium and ammonium.

Colour of Some Common Salts and Appearances of Residues

colour	**Possible Compound**
White	Fusible- probably in Alkali Metal compounds or halogen compounds of Mg, Ca or Ba
Yellow Hot	Zinc (II) Oxide, Zinc Salts
White Cold	

Yellow	Lead (II) Oxide, hydrated iron (II) salts, AgI, AgBr
Black	CuO, FeO, Fe_3O_4, FeS,CuS, PbS, MnO_2
Black Hot	Iron (II) Oxide, many Iron (II) and Iron (III) compounds
Brown Cold	
Brown	PbO_2, Iron (III) salts, e.g. $CuCrO_4$, $CuBr_2$
Blue	Hydrated copper (II) salts e.g. $CuSO_4H_2O$
Green	Hydrated Iron (II) salts, $CuCO_3$, hydrated $CuCl_2$
Red	Fe_2O_3, Cu_2O, $Pb_3O_{4,\ HgO}$
Orange	$K_2Cr_2O_7$
Purple	Potassium tetraoxomanganate (VII), ($KMnO_4$), Iodine (I_2)

Sample Practical Examination Questions

1. X is a solution of a simple salt. Carry out the following test on 20 cm^3 portions of it. Do not perform any other test. State your observation and conclusions.

    a. Add 2 drops of dilute sodium hydroxide solution, and then in excess, warm gently.

    b. Add 2 or 3 drops of dilute ammonia solution and then in excess, warm slightly

    c. Add 2 drops of hydrochloric acid and then a few drops of barium chloride solution. Name the salt in X.

2. E is a mixture of two salts, one of which is a salt. Carry out the following tests on the sample. Record your observations and identify any gases evolved. State the conclusion you draw from the result of each test.

    a. Put E in a beaker and add about 10cm^3 of water and filter. Test the filtrate with litmus paper.

    b. Take about 2 cm^3 of the filtrate and dilute trioxonitrate (V) acid followed by a few drops of silver trioxonitrate (V) solution.

PRACTICUM IN BSC (ED)COMPUTER SCIENCE

TOPIC: COMPUTER SKILLS

AIM /OBJECTIVE: Basic requirement to be computer literate and functional with computer, at the end of the exercise, the student should be able to:

- Switch on computer
- Being able to use mouse to interact with elements on the screen
- Being able to use the keyboard
- Being able to shut down the computer after use

Materials: A set of computer system, key board and mouse.

Contents

COMPUTER SKILL

Computer skills refer to the ability to use the software and hardware of a computer. Being computer functional is usually what is meant by one with computer skills: computer literacy is only really evident in advanced computer skills.

PROCEDURE: The demonstration is carried out for the student to see how to operate the computer system, from booting of the system, mastery of the keyboards and their functions are explained, use of mouse and how to save documents and shut down the system.

Students Activity:

I. **Switch on the computer system**

II. **Use the mouse to start work**

III. **Identify and mastery of the keyboard**

IV. **Type a document and save it**

V. **Switch off the computer system**

Expected Results / Outcome

I. **Student should be able to switch on / off the computer system**

II. **Students should be able to use the key board to type and save documents**

III. **Students should be able to demonstrate by using the mouse insteady of keyboard**

IV. **Students should be able to use different types of Microsoft on the computer system.**

Assignment:

(a) Type a letter and send it to your teachers e-mail by attachment

(b) Do a power point presentation

They include:

Basic computer skills

Knowing how to switch on the computer

Being able to use a mouse to interact with element on the screen

Being able to use the computer keyboard

Being able to shut down the computer after use

Intermediate Skills

Functional Knowledge of word processing

How to use e-mail

How to use Spreadsheet

How to use Databases

How to use the Internet

Installing software

Installing an operating system

ASPECTS OF COMPUTER LITERACY

Aspects of computer literacy incude:

- **What is a computer**
- **What are its limitations**

: Practicum in Science Education (Mathematics Option)

MODULE 1

Materials: A set of mathematical instrument, plain paper (drawing paper).

Activity/unit 1

Question 1). Construction of given straight lines using a pair of compasses

Question 2). Construction of parallel lines.

Question 3). Construction of perpendicular lines

Activity/Unit 2: Construction of Angles

Question 1a) Construction of angle 90^o

Question 1b) Construction of angle 60^o

Question 2) Bisection of a give angle

a. Bisection of angles 90^o , 60^o,
b. Bisection of 45^o, 30^o.

Question 3) Construction of angles 22.5^o, 75^o, 105^o, 135^o.

Students should be led to see relationship between the bisection of angles in Que. 2 and Que. 3

Module 2

Construction of Triangles and Quadrilaterals

Activity/Unit1:

1. Construction of Triangles
   Equilateral Triangle
   Isosceles triangle
   Scalene triangle
2. Construction of Quadrilaterals.
   1. Rectangle
   2. Square
   3. Quadrilaterals with given angles and sides

Activity/Unit 2

Locus

1). Locus of a point equidistant from two given points

2). Locus of a point equidistance from 2 given lines

MODULE 3

Circle Geometry

Activity/Unit 1

Question 1. Construction of a circle with a given radius.

Question 2. Using a cardboard and pair of compasses construct a circle and indicate the foolowing:

i) Diameter ii) radius iii) chord iv) arc

Question 3: Using cardboard cuttings make out the following shapes

i) Semicircle ii) sector iii) major segment of a circle of a given radius

Question 4 . think out any plane shape, use any solid materials of your choice (i.e not flexible material like paper or cardboard) repeat the activity in Que 3

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SCHOOL OF EDUCATION

SCIENCE LABORATORY MANUAL

For use of Physics Education Students in the School of Education

EXPERIMENT IN PHYSICS

GRAPHS AND DATA HANDLING

In calculating quantities in experimental physics, it is not enough to rely on a single measurement, more accurate results are obtained by taking many measurements and then plotting a suitable graph. A graph therefore is a tool for analyzing experimental results.

Different shapes of graphs are known and the few ones encountered in experimental physics are the straight line graph, the quadratic, inverse and exponential curves. A greater number of points are required to specify a curved graph than a straight line graph, however curved graphs in most cases provide less information on the relation between the variables plotted.

THE STRAIGHT LINE GRAPH

The most general equation of a straight line is

$$Y = mx + c$$

Where x and y are variables and m and c are constants , m is the slope of gradient of the line and c is the intercept of the line on the y – axis as shown below

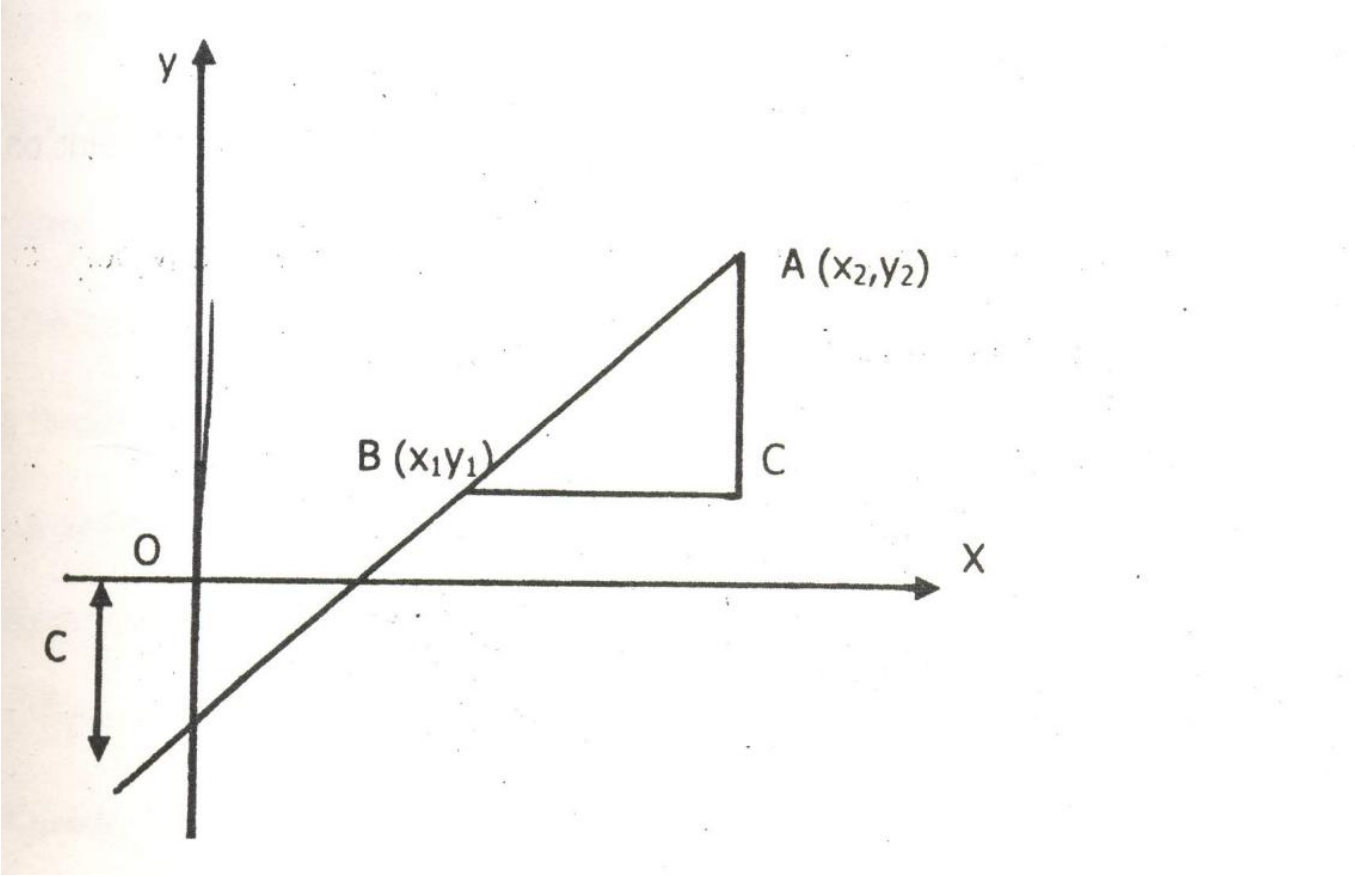


Fig. 1

The slope m is given by

$$M = \frac{AC}{BC} = \frac{y2 - y1}{X2 - X1}$$

$$= \tan q$$ q is measured in anticlockwise direction Q is the angle which the line makes with the positive X – axis.

The intercept c is read directly from the graph. At certain times, it is difficult to choose a suitable scale which starts the graph from the origin without the graph being crowded in one corner. In such cases, it is advisable not to start the graph from the origin but from some other convenient point. The intercept c can then be found by calculation from the equation y = mx + c. For example, if (5, 3) is a point on the graph, and the slope of the graph is 0. 4.

Then c is given by $3 = 0.4 \times 5 + c$

From which $c = 1$

However, in most cases it is possible to choose a suitable scale for a straight line graph so that the line cuts the y – axis but does not include the origin (0, 0) ; c can then be read directly as before.

CURVED GRAPHS;

The slope of a curve graph varies from point to point. The slope at any point on the curved is defined as the slope of the tangent to the curve at that point.

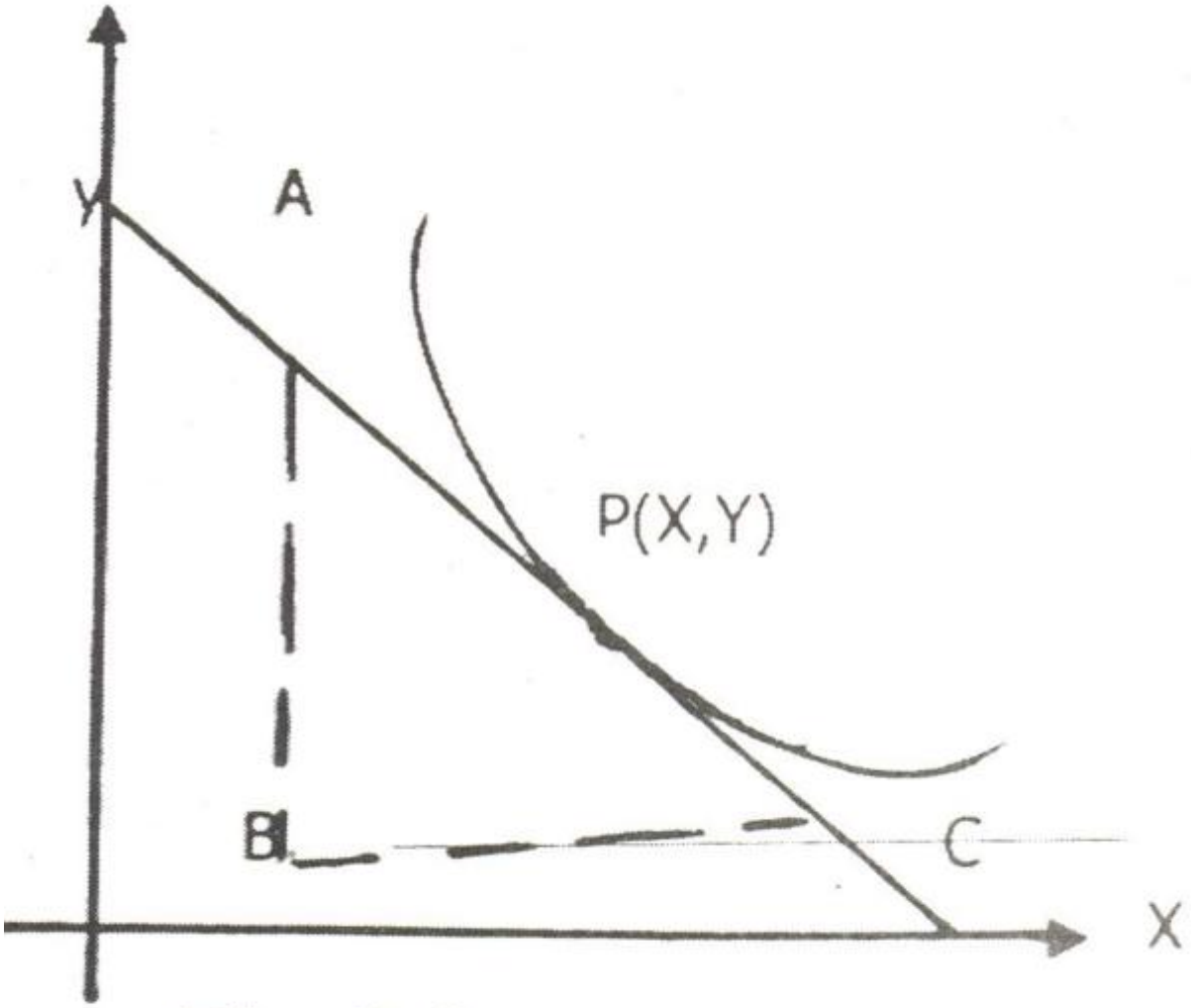


Fig 2.0

In the figure above, the slope at the point P(x, y) is given by

$$\frac{AB}{BC}$$

It is important to note that most equations of physics give smooth curves or straight lines. The plotted points may not all lie on the curve or line because of random errors which are inevitable in an experiment. A best curve or best straight line should be drawn and this is a curve or line which passes through as many points as possible such that the points which do not lie on the line are evenly distributed on either side of the line or curve.

ERRORS IN PRACTICAL MEASUREMENTS

Whenever a measurement of a physical quantity is performed, an error or uncertainty will appear in the reading and therefore in the result calculated from the reading. The error depends on the measuring instrument and on the observer.

Errors fall into two main groups: systematic errors and random errors. We speak of systematic errors, if the result of the measurement is always higher or lower than true value and of random error if the result is sometimes higher and sometimes lower than the true value, that is if the error is sometimes positive, and sometimes negative. For example in the timing of a pendulum using a stopwatch or a stopclock, a systematic error will arise if the stopclock or stopwatch runs fast, as the time indicated will then always be

longer than the true time. Random errors are introduced in the experiment if the observer does not start and stop the stopwatch at the right moment. For an inexperienced observer these errors may be quite large, up to 0.5 seconds for measurements with a stopwatch. The observer may also have a systematic or personal error like always starting the stopwatch too late but stopping it at the right moment.

Random errors can be detected if the measurement is repeated several times with the same apparatus and observer. The results of the different measurements will not agree if a random error is present but will be spread out through a certain range, which gives information of the magnitude of the errors.

Systematic errors cannot be detected in this way but only by repeating with a different apparatus and a different observer.

THE ACCURACY OF READINGS

Random errors arise in two ways: by all sorts of momentary external influences like sudden shaking of the hand of the observer, an air current, and by the limitation of the instrument used for the measurement. Both these types always occur, but one or the other may be of dominant importance depends on the instrument used is best illustrated by an example.

Suppose that we measure the side of a small metal cube with a metre rule. In this way we cannot get a better accuracy than 0.5mm, i.e there is always an uncertainty of 0.5mm in the reading, and this is probably much greater than errors caused by external influences. If instead we use a pair of calipers the uncertainty is ± 0.1mm, and with a micrometer screw gauge we can get down to an uncertainty of **±** 0.01. In this last case external influences

may well cause errors of the same order of magnitude as the reading uncertainty. Depending on which method we use to measure the length, the accuracy of any result we calculate from this reading, e.g. the density of the metal will vary within wide limits. Therefore the result of any physical measurement should always be given with the uncertainty, often called the reading error, started. The number of figure**s** given should be such that the error is the last figure. E. g. in the first case mentioned above the reading should be given as (34.5 ± 0.5) mm or (3.45 ± 0.05) cm

In the second case as

(34.5 ± 0.1) mm or (3.45 ± 0.01) cm

and in the third case as

(34.37 ± 0.1) mm or (3.437 ± 0.001) cm

Never give a reading like

Current: 2 amps, this has no value at all for a calculation! Instead write current: (2.0 ± 0.1) amps or whatever other reading errors you may have. In physics, a current of 2 amps means anything between 1.5 and 2.5 amps.

The following list gives the reading error of some of the commonly used instruments:

mm scale	0.5mm

Callipers	0.1mm
Micrometer screw guage	0.01mm
Stop-clock	0.3s or more
Stop watch	1.0 – 0.2s
Thermometer graded to 1^{o}	0.2^{o}
Thermometer graded to 0.5^{o}	0.1^{o}
Thermometer graded to 0.1^{o}	0.05^{o}

Standard moving coil instrument 2% of the max. scale reading (ammeter, voltmeter)

NOTE: In many cases there is an uncertainty in the adjustment of the instrument that is greater than the reading error, e.g. in in balancing a wheatstone bridge. In this case the spread of a series of reading will be greater than the error.

EXERCISES:

(1) Draw on the same axes graphs of

$y = x + 6$

$y = 2x + 4$

And $y = 7x – 5$

For values of x between -5 to 5

(2) In an experiment, the following readings were obtained:

V(V)	2.4	2.0	1.7	1.5	1.4
I(A)	0.95	0.70	0.55	0.50	0.45

Plot the graph of V against I and determine the slope of straight line obtained.

(3) The following readings were obtained in an experiment:

U(cm)	55.0	45.0	35.0	25.0	15.0	10.0
V(cm)	1.6	2.2	2.3	4.6	9.4	18.7

The equation connecting u and v is $uv - f^2$ where f is a constant. Plot a suitable graph to obtain the value of f. Write down the value of f.

(4) In an experiment, the following readings were obtained

h(cm)	5.0	16.0	23.0	43.0	59.0	82.0
t(s)	37.0	36.6	36.1	35.3	34.1	32.6

Make a table of T^2 and h where T is the periodic time for 10 complete oscillations. Plot a graph of T^2 against h. Determine the intercept on the T^2 axis and the slope of graph. Write down the linear relation between T^2 and h.

(5) In a cooling experiment, the following readings were obtained r($^{\circ}$C/min)

r($^{\circ}$C/min)	5.4	3.1	2.6	1.8	1.5	0.6
Q($^{\circ}$C)	79.0	56.0	41.5	32.0	26.5	16.5

Where r is the rate of fall of temperature and Q is the excess temperature over the surroundings. If the law of cooling is given by $\mathbf{r = aQ^n}$, find the value of the constant **a** and **n** by plotting **log r** against **log Q**

MEASUREMENT OF MASS

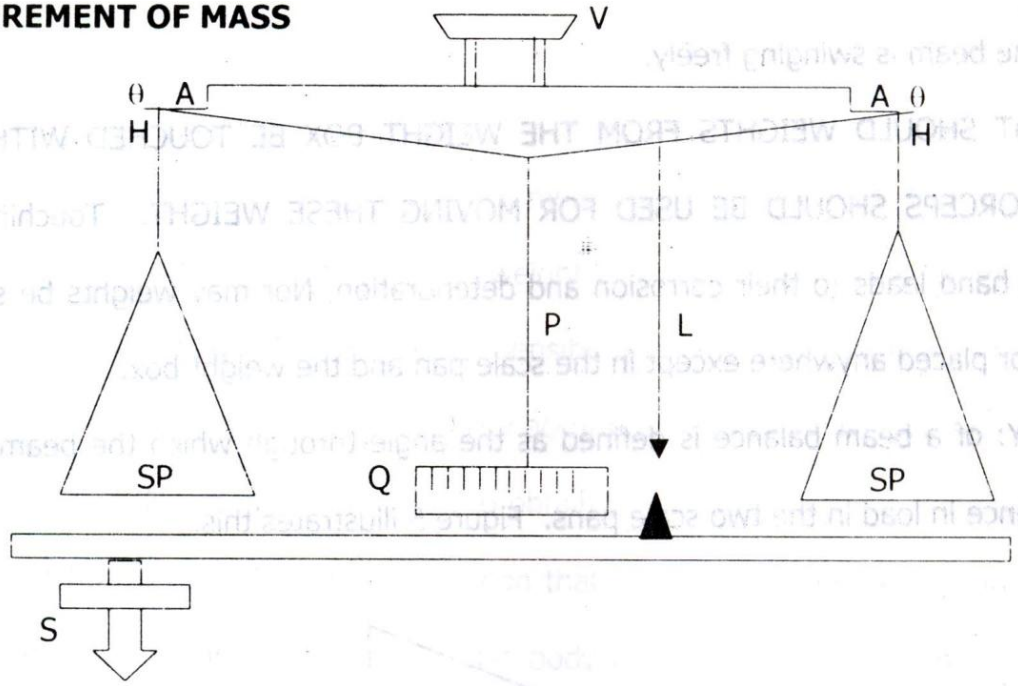


Fig. 3·0

H_1H = Horizontal screws

Q = scale

V = Gravity bab

K = Knob for raising beam

S,S = Leveling screw

A,A = A gate knife edges

L = Plumb line

SP = Scale pan

THE BEAM BALANCE

The essential features of the beam balance are shown in the above diagram Fig 3.0. Before any weighing is done, the base of the balance and the balance beam must be horizontal. To level the base, the leveling screws (S,S) are adjusted until the plumb line L is vertically above the projection on the balance case. To level the balance beam, the small nuts (H,H) are adjusted until the pointer P is at the central mark on the scale Q. Where it is not possible to level the base in this way the scale pan SP should be interchanged. The balance is set swinging in readiness for weighing by turning the knob K clockwise. To avoid damage to the gate knife edges A on which the balance beam and scale pans swing it is important to raise or lower the beam gently. For the same reason, weights should not be added to or remove from the pans when the beam is swinging freely.

ON NO ACCOUNT SHOULD WEGHTS FROM THE WEIGHT BOX BE TOUCHED WITH THE HAND. ONLY FORCEPTS SHOULD BE USED FOR MOVING THESE WEIGHTS. Touching the weights with the hand leads to their corrosion and deterioration, Nor may weights be spread out on the table or placed anywhere except in the scale pan and the weight box.

THE SENSITIVITY: of a beam balance is defined as the angle through which the beam turns for a 1 mg difference in load in the two scale pans. Figure 4 illustrates this:

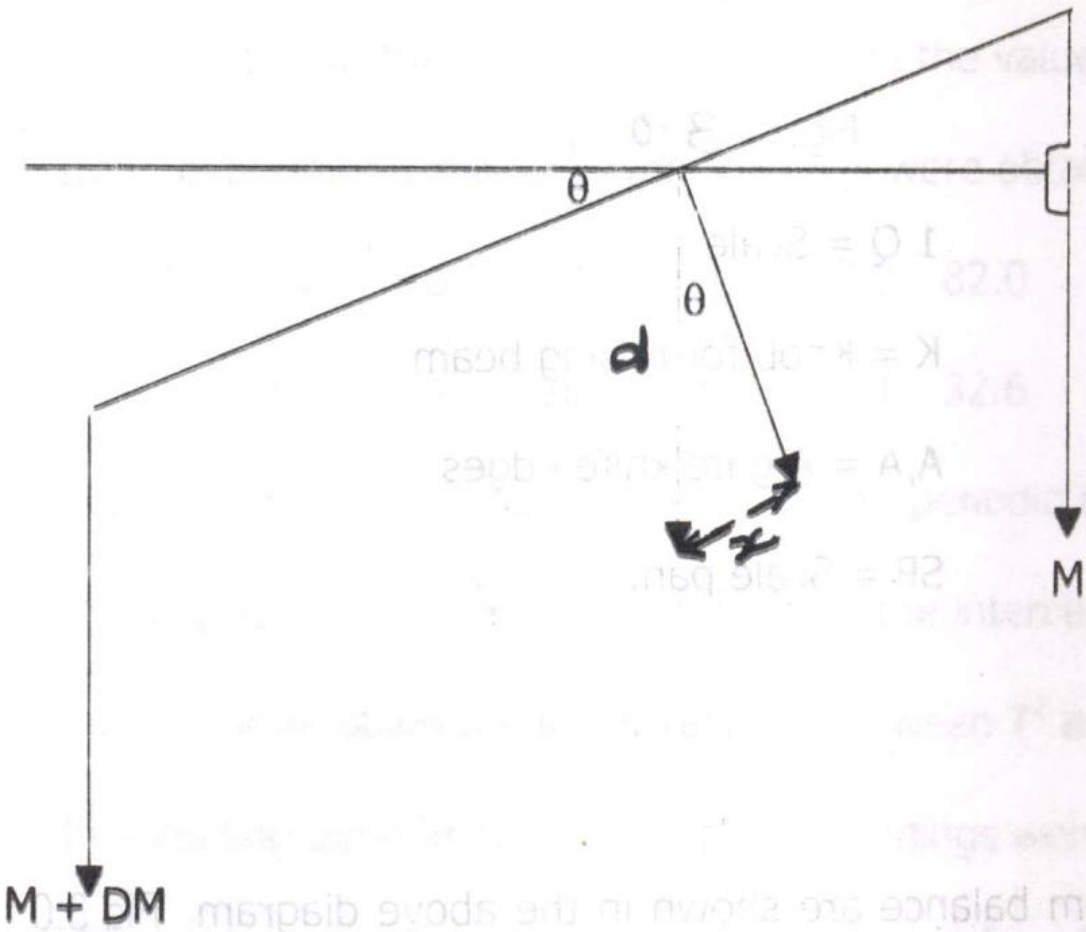


Fig 4.0

i.e $S = \frac{\theta}{DM}$ where DM is the difference in load in the two scale pans. In general, since DM is small, θ is of the order of a few hundredths of radians and may be expressed approximately as

$$\theta = \frac{x}{d}$$

Where **x** is the horizontal displacement of the tip of the pointer, and **d** the length of the pointer. For practical purposes therefore the sensitivity may be expressed as

$$S = \frac{x}{DM}$$

EXERCISE 6.0

Determine the sensitivity of the balance by measuring the displacement of the pointer from its rest position per milligram difference in weight in the two scale pans, when both pans carry loads 0, 5, 10, 20, 30, 50gf. Plot a graph of sensitivity against load DM should be chosen in such a way that the distance x can be read fairly accurately: i.e. 3-4 scale divisions.

DOUBLE WEIGHING: can be employed to obtain the actual mass of a body when the beam is initially not horizontal. This does not mean that the arms of the balance are unequal. If M_1 and M_2 are the two apparent weights of a body when placed in turns in the two scale pans, the real mass of the body is given by

$$M = ½ (M_1 + M_{2)}$$

The proof of this result is left as an exercise to the student and should be included in the report.

EXERCISE 7.0

Misplace the nut at the end of one of the arms of the balance by giving the nut one complete turn. Use the balance in this condition to weigh a body by the method of double weighing. Compare the result with that obtained with the balance in the normal condition.

TIMING

For accurate timing of oscillations of swings, it is essential to start the watch or stop-clock at a definite point of the swing and to stop the watch at the same point of the swing. Since a vibrating body, like a simple pendulum, moves fastest pass the equilibrium position, it is best to start or stop the watch when the vibrating body is at the equilibrium position. In all experiments involving timing and swings a pointer or fiducial mark should be set to mark the equilibrium position and the counted when the body moves past the pointer or mark from the direction. For more consistent results however, it is best to mark the equilibrium position of a vibrating body by means of two pointers or marks and to start or step the watch when the body is balanced with the pointers or marks. See fig 5.0

Pp = fiducial mark

passing through

equilibrium position

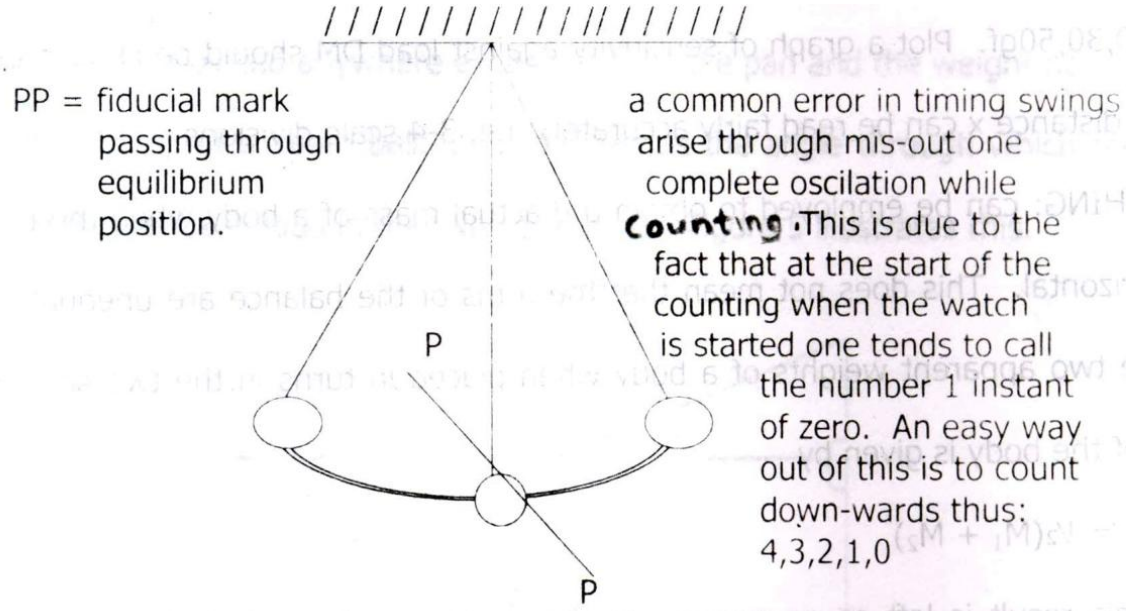


Fig. 5.0

RCISE 8.0

a common error in timing swings arise through the omission of one complete oscillation while counting. The is due to the fact that at the start of the counting when the watch is started one tends to call the number 1 instead of zero. An easy way out of this is to count downwards thus: 4,3,2,1,0

EXERCISE 8.0

Determine the period of one oscillation of the given short swing by timing 50 complete oscillations. Repeat nine times. Find the mean of the nine counts, calculate the departures of each reading from the mean and hence find the greatest deviation from the mean. Repeat the whole experiment by timing 10 complete oscillations. Comment on the accuracy of timing in the two sets of experiments.

EXERCISE 9.0

Determine the period of the oscillation of the longer pendulum (suspended from the ceiling, by timing 50 complete oscillations twice 10. Repeat the experiment by timing to complete oscillations 10 times. Compare the accuracies of the two sets of measurements.

EXERCISE 10.0

Place a load of about 300g on the scale pan of the given spiral spring. Allow the pan to move to rest and carefully displace it about 1cm in the vertical direction. Release the pan and time a convenient number of oscillations 9 times. Calculate the mean period and the greatest deviation from the means. Replace the load of 300g by a load of 100g and repeat the experiment and calculations.

QUESTIONS:

1. Which quantity is largest in these experiments, the reading error in the stop clock or the greatest deviation from the mean value of the time measured?

2. Does this type of experiment (timing a certain number of oscillations) give a more accurate result if it is repeated.

EXPERIMENT ON MECHANICS 1 (A)

Title: Relative density of a solid and a liquid

APPARATUS: Metal cube, spring balance, water, beaker, liquid, thread,

lever balance and specific gravity bottle.

METHOD: Measure the given metal cube's weight in air using the spring balance and record this value, then in water, and finally in the given liquid. Remember to record the label on your metal in your notebook.

THEORY:

Relative density of solid $= \frac{weight\ of\ solid\ in\ air}{weight\ of\ equal\ volume\ of\ water}$

$$= \frac{weight\ of\ solid\ in\ air}{upthrust\ of\ water\ on\ solid}$$

And the relative density of the liquid is given by

$$\frac{Weight\ of\ liquid}{weight\ of\ an\ equal\ volume\ of\ water}$$

$$= \frac{Upthrust\ of\ liquid\ on\ solid}{Upthrust\ of\ water\ on\ solid}$$

Calculate the relative densities of the solid and liquid using the above relations.

EXPERIMENT 1 (B)

TITLE: Relative density of a liquid using the specific gravity bottle.

METHOD: Weight an empty specific gravity bottle using the lever balance. Fill the specific gravity bottle with water, insert the stopper and weigh again using the lever balance. Empty the contents of the bottle and finally fill the bottle with the given liquid and weigh again as before. Calculate the relative density of the liquid using relation,

$$\text{Relative density} = \frac{Weight\ of\ liquid}{Weight\ of\ an\ equal\ volume\ of\ water}$$

MECHANICS 2

TITLE: Relative density of liquid – hydrometer method.

APPARATUS: Test tube, lead shot, beaker, kerosene, graph paper, water.

METHOD: Put enough lead shot in a test tube so that it can float vertically in a beaker of water as shown in the diagram below. With the aid of a scale made from graph paper, measure the height of the test-tube submerged below the liquid surface level h_k.

Repeat the experiment with water and record the height h_w

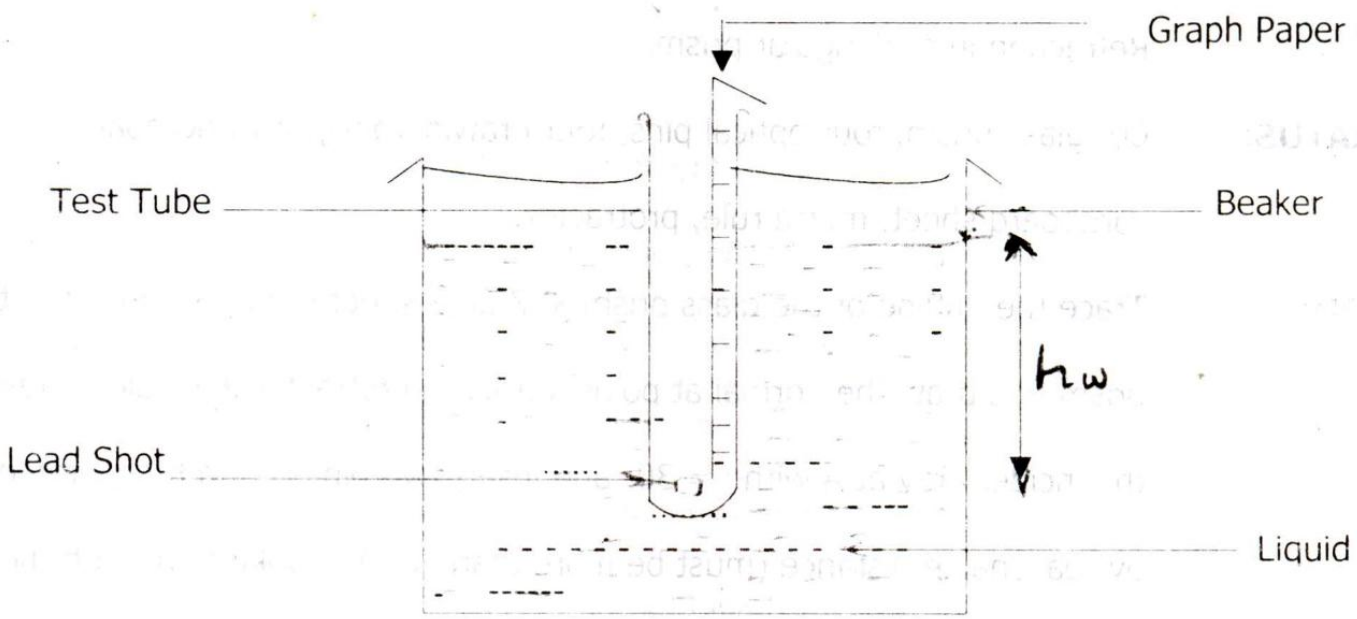


Fig. 6.0

Determination of the relative densities of a liquid using the hydrometer.

Fig. 6.0

Determination of the relative densities of a liquid using the hydrometer

THEORY: Let the cross-sectional area of the test-tube be **A** therefore,

Volume of liquid displaced = Ah

And weight of liquid displaced = Ahρg

(Where ρ is the density of the liquid) from the principle of floatation.

Weight of the hydrometer = Weight of the liquid displaced = Ahρg

Therefore $Ah_w \rho_w = Ah_k\rho_k$

And $\frac{\rho w}{\rho k} = \frac{hk}{hw}$

0r $\frac{\rho k}{\rho w} = \frac{\rho w}{hk}$

= relative density of kerosene

QUESTION: Calculate the quantity $\frac{hw}{hk}$

EXPERIMENT ON LIGHT

TITLE: Refraction in a triangular prism.

APPARATUS: 60^0 glass prism, four optical pins, four drawing pins, drawing board, cardboard sheet, metre rule, protractor.

METHOD: Trace the outline of the glass prism XYZ on a sheet of paper. Remove the prism and draw the normal at point A using a protractor and ruler, Draw the incident ray at A with i = 30^o and insert two pins H and K separated by reasonable distance (must be more than 5cm). Looking through the prism, insert two other pins at **M** and **N** so that they appear to be in line with the images of **H** and **K**. Produce **NM** to meet the edge of the prism at **P**. Join AP. Measure the angles of deviation **D** and emergence **e**. Repeat the experiment for values of i = 40^o,45^o,50^o, and 65^o. Tabulate your results as shown below.

i	D	E	(D – e)

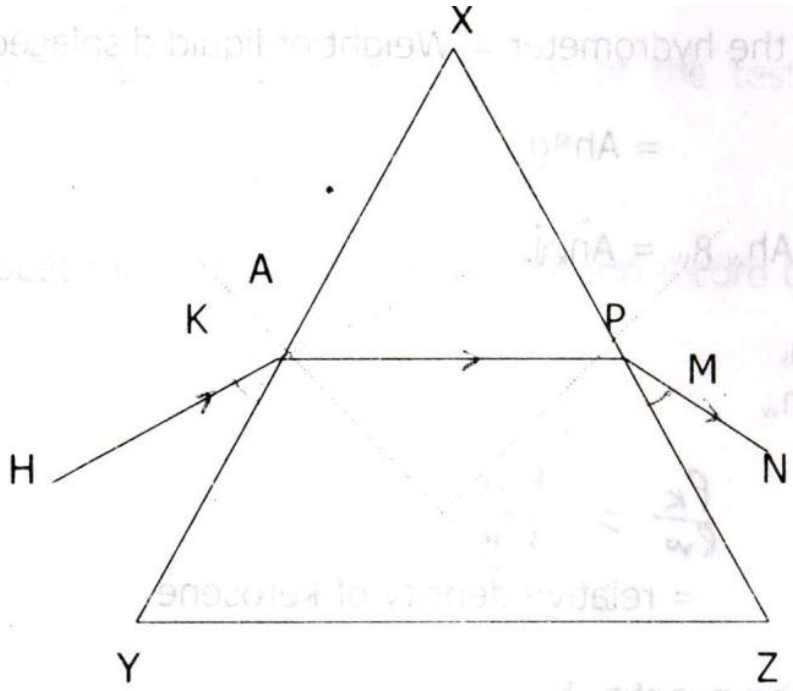


Fig 7.0
Refraction through a triangular prism

Refraction through a triangular prism

QUESTIONS: (a) Plot a graph of (D – e) against i

(b) Measure the slope

(c) Measure also the intercept on both axes.

(d) What can you conclude from the experiment?

(e) On a separate sheet, plot a graph of D against i.

(f) From your graph obtain the minimum deviation

Dm and the angle of incidence at minimum deviation im.

(g) Calculate the refractive index from

$$N = \frac{\sin ½ (Dm + A)}{Sin\ ½\ A}$$

Where A = angle of prism = 60^{o}

EXPERIMENT ON MECHANICS (1C)

Determination of acceleration due to gravity using a coiled spring

APPARATUS: A coiled spring, slotted weights 0-250g metre rule, retort stand and cl

scale pan, plasticine, stop watch.

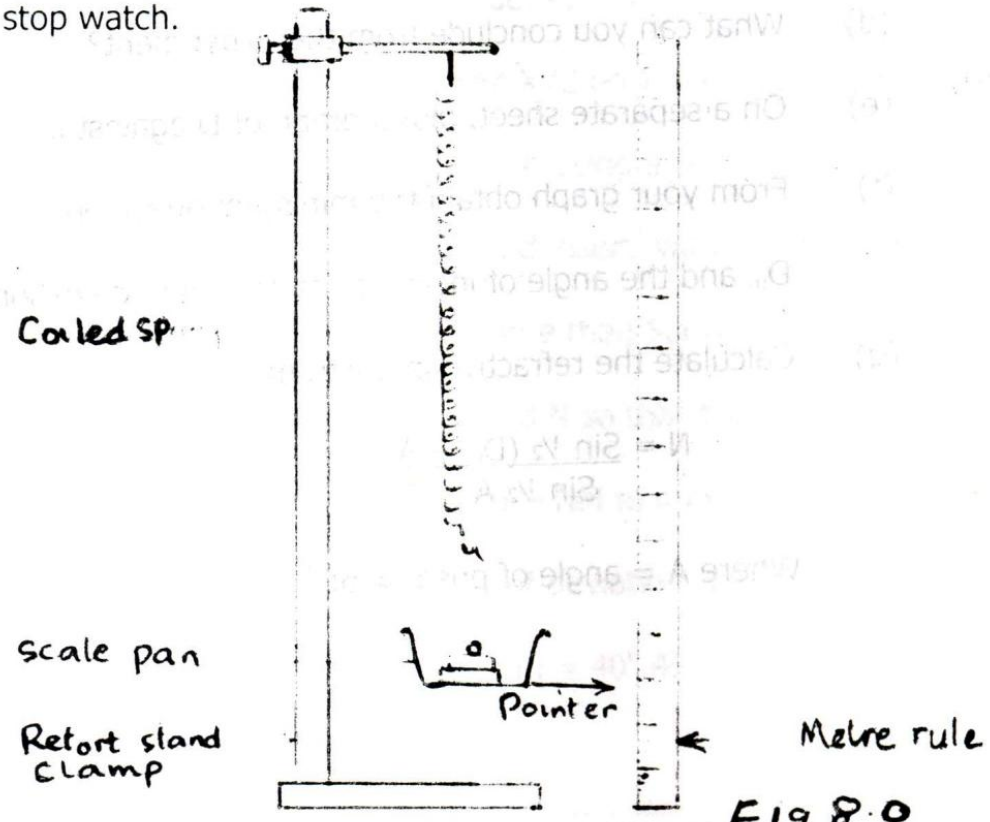


Fig 8.0

METHOD:

Suspend the coiled spring from the clamp as shown and hang a small scale pan or slotted

weight from its lower end. Add a 50 gramme mass to the scale pan and observe the pointe

position x. Now increase the mass by adding 20g at a time and observe the new pointer position X. Add another 20g mass and note the new pointer position X_2. Continue the experiment by adding

20g to the existing masses each time and obtain the reading X_3, X_4, X_5, X_6, and X_7. Obtain the extensions e_1, e_2, e_3.....e_7 e.g. Tabulate your results.

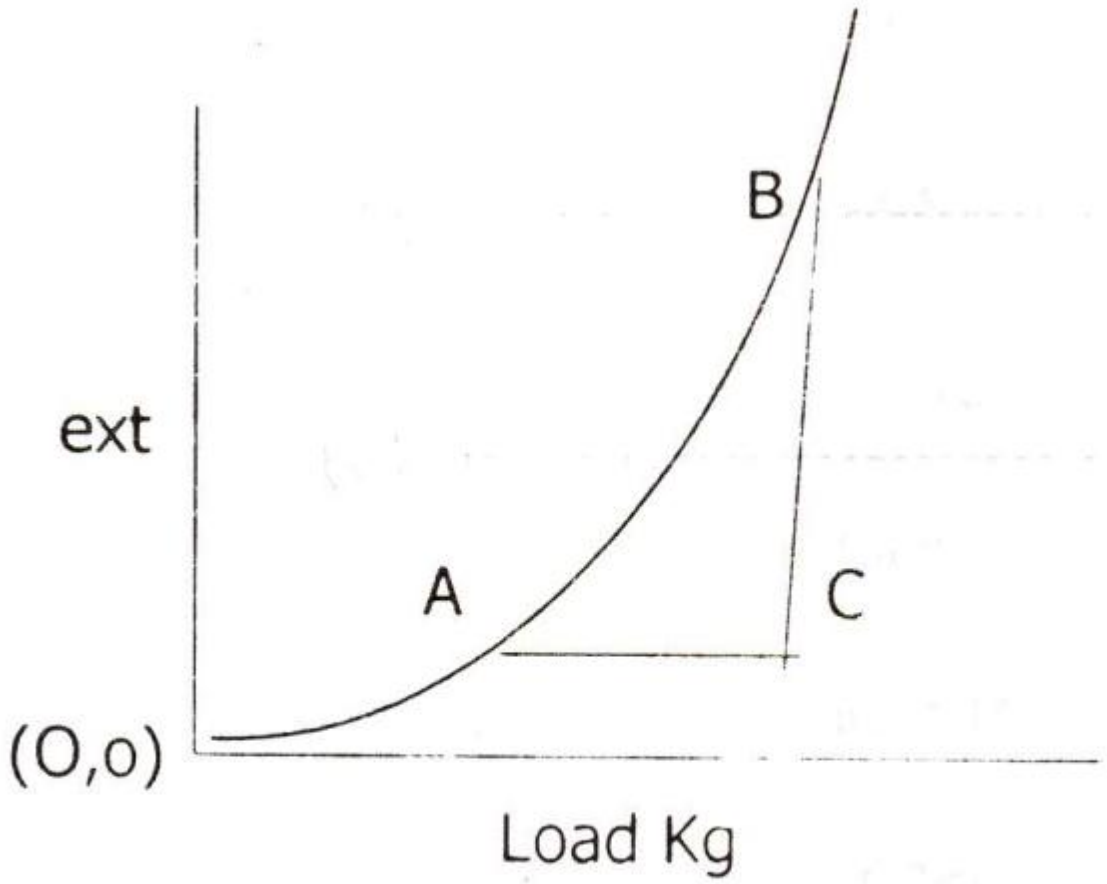
S/N	Mass of load No of Kg	Extensions CM^{-1}		Average Extension
		Load Increasing	Load Decreasing	

Repeat the experiment by obtaining the results when, the load is decreased by 20g at a time until the entire load are removed.

Plot a graph of mass of load on x axis against extension on the y-axis. Find the slope of the graph.

Slopes S = $\frac{BC}{AC}$ M/Kg

AC



2C) Fig 9.0.

a kink removing load (between 50 to 80g

EXPERIMENT (2C)

Suspend a kink removing load (between 50 to 80g) on the spring and observe that the spring has no more kinks. Attach the pointer formally. Now add

another 20g mass and note the new extension e cm. Now displace the scale pan slightly downward by pulling along the vertical. Release the scale pan. Notice

that the pointer oscillates vertically. Measure the time for 20 oscillations. Find the time for one oscillation i.e the periodic time T. Record the total load on spring, the time for 20 oscillations, and the period. Repeat the experiment when the additional loads to the kink-removing load are 20, 40, 60, 80, 100g. Tabulate your results

S/N	Load Kg^{-1}	Time for 20 Oscillation	Period T/S^{-1}	T^2/S^2

Plot a graph of T^2 on the y-axis against load M Kg on the x-axis

(a). Find the slope and the intercepts of this graph.

THEORY

The theory of this experiment is based on simple harmonic motion of the mass M attached to the spring and the spring extended further by x, the period is given by

$$T = 2\pi \frac{\sqrt{MS}}{g} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where S = the extension per unit load = slope of the **e** versus **load** graph

M = the load on the spring, g = acceleration due to gravity.

For spring with effective mass M,

The period of oscillation

$$T = 2\pi \frac{\sqrt{(M+m)s}}{g} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$T^2 = 4\pi^2 \frac{(M+m)}{g}$ ..... (3)

Equation 3 is of form

Y = Kx + c

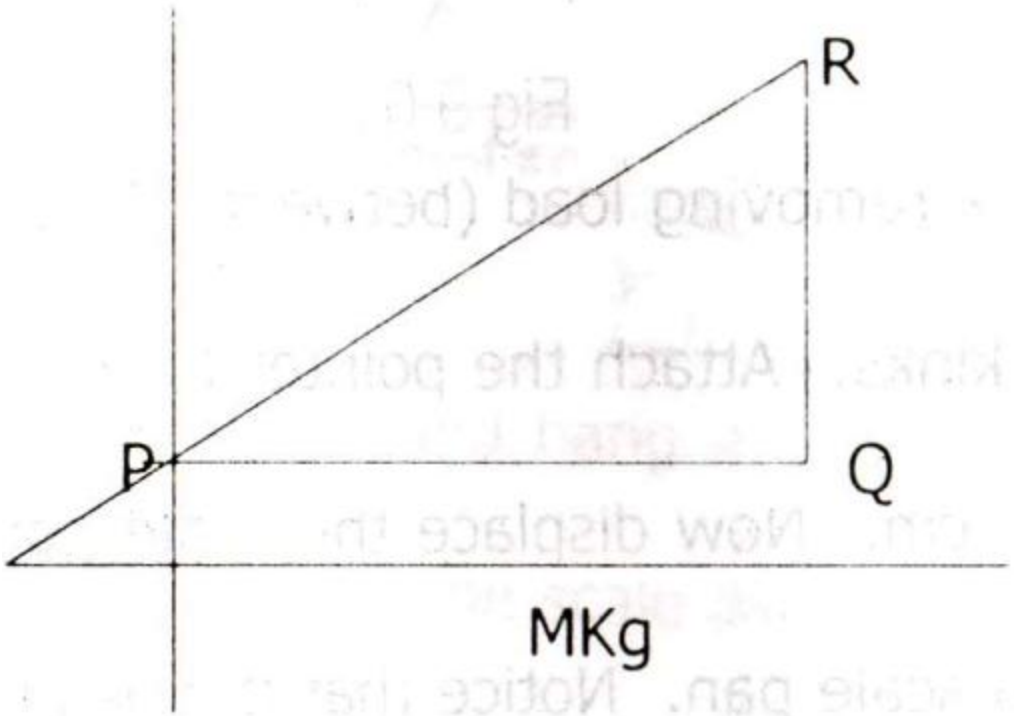


Fig 10.0

(b) Find the value of $\frac{4\pi \; x \; Slope \; of \; extension \; Vs \; Load \; graph}{Slope \; of \; T^2 \; Vs \; M \; graph}$

(c) Comment on your results.

EXPERIMENT 2

Determination of the density of a liquid using a loaded boiling-tube

APPRATUS

A boiling-tube or tall test-tube fitted with a calibrated tape (e.g strip of graph paper attached inside) a deep beaker, lead-shots, set of masses, cellipers, Kerosene or other liquid e.g Alcohol, orange juice, diluted acid.

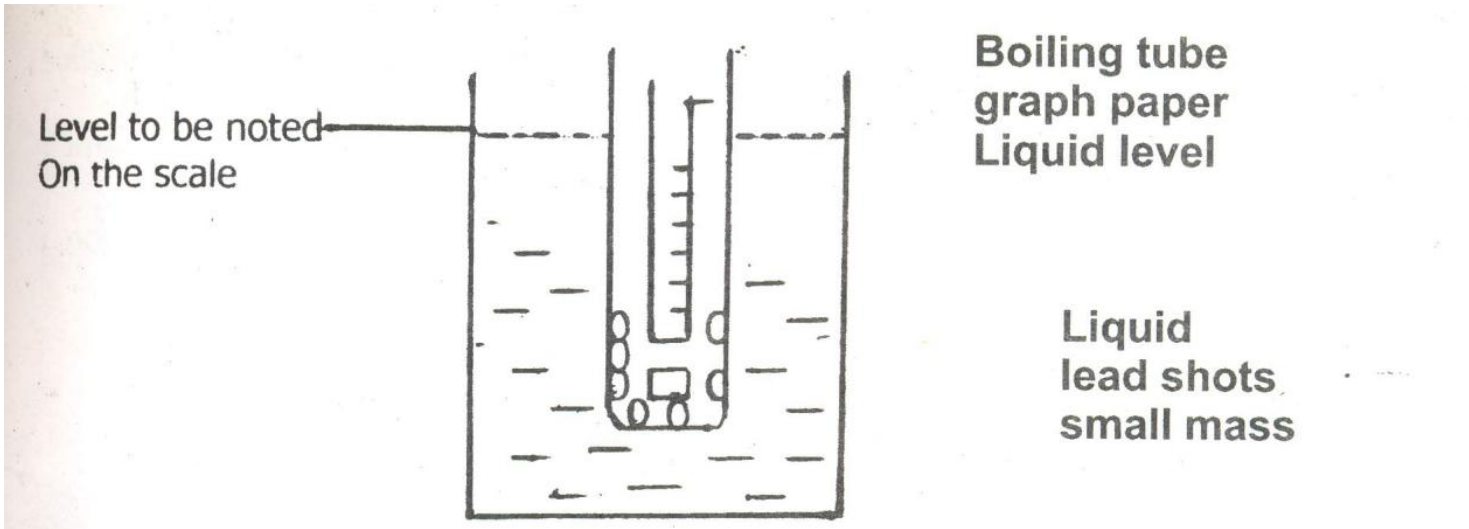


Fig 11:0 Diagram of set-up

METHOD:

Add sufficient lead shot or white dry river sand in the boiling tube until the t

vertically in the liquid. Note the level x_0 at which the tube floats upright. Gently pla

METHOD

Add sufficient lead shot or white dry river sand in the boiling tube until the tube floats vertically in the liquid. Note the level x_o at which the tube floats upright. Gently place a small mass (1 or 2g) inside the boiling tube and note the new position x at which the tube floats. Repeat the experiment for four different $_{additional}$ masses (e.g 2g, 3g, 4g, 5g).

For each additional load, measure the depth of immersion $d = x - x_o$. Complete the table.

RESULTS:

Additional Load/g	Scale reading xcm	Depth of immersion $D = (x - x_o)$ cm
0 1 2 3 4 5		

INSTRUCTION

Measure the diameter of the boiling tube in about four points and find the mean radius of tube.

Plot a graph of immersion on the y-axis against additional mass on the x-axis. Start the graph from the origin.

1. Find the slope of the graph
2. Find the value of P = $\frac{1}{\pi r^2 k}$

   P = $\pi r^2 K$

QUESTIONS

1. What does P represents?
2. Why was it necessary to measure the diameter of the tube at different points?
3. What are the essential precautions in this experiment?

EXPERIMENT 3

Determination of the refractive index of a liquid using a concave mirror

APPARATUS

A concave mirror, Liquid e.g. Water, retort stand and clamp, rubber cork, optic pin, metric rule.

Fig. 12.0 (a)

METHOD:

The concave mirror is placed on the base of a retort of a stand which is on a level floor. Adjust a bright optical pin along the principal axis of the mirror until the pin coincides with its image at c. Now put sufficient liquid into the mirror and find a new position c where the pin now coincides with its image.

Measure the distance CA and C'A

Calculate the value $\frac{CA}{C'A}$

QUESTION:

1. What is the physical meaning of CA/C'A?
2. Deduce the theory of the experiment
3. What are the essential precautions in this experiment?

EXPERIMENT

Determination of the refractive index of a liquid using a concave mirror

APPARATUS

A concave mirror, liquid e.g water, retort stand and clamp, rubber cork, optic pin, metric rule.

Fig. 12.0 (a)

METHOD:

The concave mirror is placed on the base of a retort of a stand which is on a level floor. Adjust a bright optical pin along the principal axis of the mirror until the pin coincides with its image at **c.** Now put sufficient liquid into the mirror and find a new position c’ where the pin now coincides with its image.

Measure the distance CA and C’A.

Calculate the value $\frac{CA}{C'A}$

QUESTION:

1. What is the physical meaning of CA/C’A?
2. Deduce the theory of the experiment
3. What precautions are essential for accurate results?

EXPERIMENT 4

Determination of the focal length of a convex lens by the illuminated object method

APPARATUS: Convex lens (f 10 – 20cm), lens holder, ray box, illuminated object, white screen, meter rule

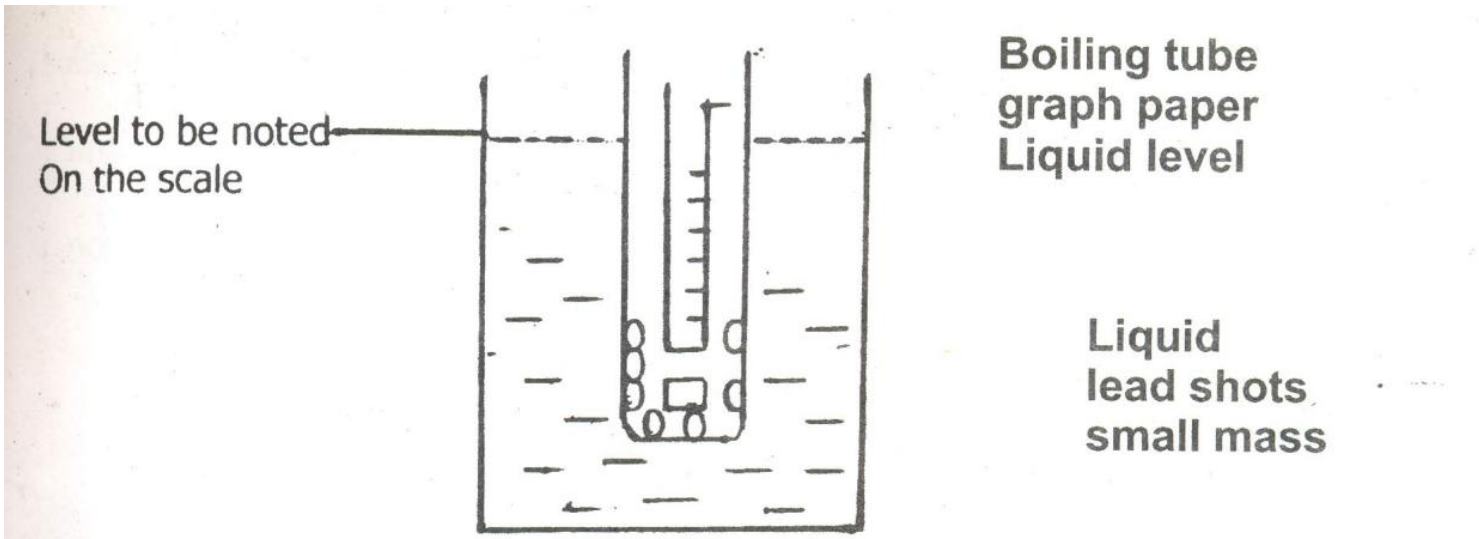


Fig 11:0 Diagram of set-up

METHOD:

Add sufficient lead shot or white dry river sand in the boiling tube until the vertically in the liquid. Note the level x_0 at which the tube floats upright. Gently

Fig. 13.0

METHOD:

Place the ray box on a flat horizontal table. Place the illuminated object at the open hole of the box. Then place the convex lens with the lens stand in front of the illuminated object such that the separating distance must be greater than the approximate focal length of the lens.

Place and adjust the white screen on the opposite side of the lens until a sharp image of the illuminated object in formed on it.

Now measure and record

(a) The distance between the illuminated object and lens (u)

(b) The distance between the lens and screen (v)

Displace the lens by 5cm and obtain new values for u and v. Repeat the experiment for four other positions of the lens.

INSTRUCTION: Plot a graph of $\frac{1}{v}$ on the vertical against $\frac{1}{u}$ on the horizon at starting from (0, 0). Find the slope and intercepts of the graph.

QUESTIONS:

1. Measure the slope and intercepts of this graph.
2. What precautions do you requires for the experiment?

EXPERIMENT 5

Focal length of a convex lens by plotting magnification against image distance

APPARATUS: Convex lens, lens stand, meter rule, cork with two optical pins 2cm apart, split cork with pins retort stand with clamp to support pins.

(Illuminated object and screen could be used)

Fig. 14.0

METHOD: the cork with two optical pins is placed near the convex lens but at a distance greater than f so that an enlarge image is formed. The positions of the two images of the pins are located. On the other side using the split corks. Assure that there is no parallax between the image and locating pins.

Then measure the separation of the two image pins (d) and the separation of the object pins (a) and the image distance V.

Repeat the experiment with four other positions of the object pin – carrying cork, and measure corresponding v, a, and d.

Calculate the value of magnification m = $\frac{d}{a}$ for each position.

Tabulate your results as follows

S/N	v	a	d	M = $\frac{d}{a}$

Plot a graph of magnification on the vertical axis against image distance v on the horizontal.

NATIONAL OPEN UNIVERSITY OF NIGERIA

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SCHOOL OF EDUCATION

SCIENCE LABORATORY MANUAL

For use of Integrated Science Students in the School of Education

INTEGRATED SCIENCE

Activities on Microscopy, Improvisation of an ecosystem, Activities on Energy transformation, Simple machines, Thermo dynamics, Test for gases, Separation techniques, Activities on Volumetric Analysis.

1ST EXPERIMENT

TITLE OF EXPERIMENT: MICROSCOPY

AIM/OBJECTIVE: Introduction to the use of microscopes and other magnifying lenses, so that at the end of the experiment:

4. Students should be able to use microscopes and other magnifying lenses effectively during laboratory activities.
5. Prepare temporary and permanent slides.
6. Draw and label biological specimens appropriately.

APPARATUS: Microscopes, magnifying lenses, lens tissue and specimen slides, cover slips, pipettes, prepared slides of different protozoa, Euglena, Onion/Rheo leaves.

THEORY: A study of very tiny animals and plants is only possible with the aid of a microscope. Microscope is an instrument which magnifies any object viewed which cannot be seen with naked eye. Also, it has become possible to examine not only the microscopic animals, but also the minute anatomy of all animals and plants.

In making biological drawings, the following must be respected:

7. Drawing lines must be smooth and not wavy.
8. Drawing must not be shaded.
9. All cut surfaces to be represented by double lines.
10. All labels must have their guidelines ruled, and must touch the object being labeled.
11. All labels must be horizontal
12. Ruled guidelines must not cross.

In making biological drawings, magnification of magnifying lenses, preserved specimens and prepared slides of lower plants and animals need to be determined as indicated below:

Magnification.

(i) Scales of drawing, using hand lens

$$\text{Magnification} - \frac{\text{length of drawing}}{\text{Length of object}}$$

$$\frac{\text{With of drawing}}{}$$

Width of object.

(ii) Magnification of object under microscopes.

Magnification is power of the objective lens X eyepiece, this is called total magnification.

Primary Magnification L/F Where L = Tube length of microscope

F = Focal length of objective

Total Magnification = L/F x e Where e = magnification of eyepiece.

PROCEDURE: Demonstration is carried out for student to see the handing, manipulation and focusing of the light microscopes. Parts of the microscope and their functions are explained Maintenance and care of microscopes are also treated.

(A) Student Activity

(i) Make a well labeled diagram of a typical light microscope in front of you.\

(ii) Identify the parts and outline the function of each part labeled.

(iii) Carryout practice session in handling microscope and for using of specimen under low and then high power.

(iv) Mount the specimen (Slide) provided under the microscope. Examine them and make a well-labeled drawing of each.

(B) Follow the instruction in the preparation of slides of fresh specimens.

(i) Place one drop of your sample in the center of the clean slide using the pipette. (Sample of pond water).

(ii) Cover the drop by lowering the cover slip gently down onto it in a slanting position. Ensure no iar bubbles are trapped. (those air bubbles are frequently mistaken for organisms)

(iii) Use the coarse focusing knob and the low power objective to ensure the sample is properly focused.

(iv) See if you can identify any of the micro-organisms i.e. Amoeba, Paramecium or Euglena.

(v) Ask the demonstrator to confirm any identification you make. Then use the x10 or x20 objective to see more details of the micro-organisms.

(vi) Drawing under high power and label fully.

(vii) Indicate briefly the functions of the parts you have seen and labeled.

(viii) Make an onion/rheo epidermal strip and examine the layout of typical plant cell.

Draw and label a low power plan, and a high power drawing of a single cell.

(ix) With a clean finger scratch the inside of the cheek and mount in a drop of water on a clean slide. Examine under the microscope for a typical animal cell. Draw and label.

EXPECTED RESULTS/OUTCOME

(v) Students should be able to handle a microscope and other magnifying lenses effectively during laboratory activities.

(vi) Students should be able to observe/examine micro-organism with the help of a microscope and other magnifying lenses.

(vii) Students should be able to prepare slides of fresh specimens.

(viii) Students should be able to make biological drawings following guidelines and 'calculate' magnifications for all drawings.

ASSIGNMENT:

(iii) Make a temporary slide preparation of the following (a) Strand of Spirogyra (b) Moss or fungi. Observe and focus under microscope. Draw, label and determine the magnification of various objects observed under the microscope.

(iv) You are provided with a cockroach. Make a scale drawing of it 15cm in length and 10cm in width. State its magnification.

3rd EXPERIMENT

TITLE OF EXPERIMENT: QUANTITATIVE TREATMENT OF AN ECOSYSTEM CONSTRUCTION OF QUADRAT CHART AND DETERMINATION OF ABUNDANCE FREQUENCY AND DENSITY OF SPECIES IN AN HABITAT

AIM:
At the end of the experiment, students should be able to select an area and

(i) Perform adequate quadrat throws

(ii) Collect samples of living organisms (floral and fauna) for the identification

(iii) Identify the species and construct quadrat chart using a key

(iv) Determine the abundance, frequency and Density of species

(v) Construct food chain and food webs of the organisms

(vi) Construct pyramid of numbers

(vii) Draw Energy Material Relationship of the organisms found

APPARATUS

Different types of Quadrats – Readymade quadrat frame, metre stick, string quadrat (circular, triangular, square, rectangular etc.), Herbaria albums, insect boxes etc.

THEORY

Ecology deals with the study of organisms (plants and animals) in their environment (Ecosystem) either biotic or abiotic. An Ecological Survey will provide the qualitative characteristics of different sites or habitats. The qualitative features include trees, shrubs, herbaceous plants, floor cover, and their associated animals (scanvengers, herbivores, carnivores). Such a survey can formf the basis of the description of their symbolic relationships, or their mode of nutrition, and levels of adaptations within the ecosystem.

Cover index is the amount of space of ground covered by each species. **Quadrat Chart** is the diagrammatic illustration of the distribution of the various organisms (Species) found in the quadrat, using either visual estimation or a scale.

PROCEDURE:

1. Selec an area within an Habitat or Ecosystem
2. Throw the quadrat (several times)
3. Record the number of species found within each section of the quadrat for each throw
4. Collect samples of organisms within the quadrat for identification
5. Use experts or herbaria to identify all the species collected
6. Draw Quadrat Chart using a key
7. Determine the abundance, frequency and density of species/organisms, within the quadration.
8. Construct appropriate food chain and food webs of the organisms found.
9. Construct pyramid of numbers.

10. Draw energy/material relationship (Energy flow and material circulation) of organisms observed.

EXPECTED RESULTS

1. Identification of the flora and fauna species within the quadrat from site to site.
2. Drawing of a good quadrat, chart with keys
3. Determination of the abundance, frequency and density of species
4. Construction of associated food chain and food webs of the organisms.
5. Construction of pyramid of numbers.
6. Drawing of energy flow/material circulation relationship.
7. Appropriate description of the qualitative and characteristics of the selected ecology site (or habitat).

4^{th} EXPERIMENT

TITLE OF EXPERIMENT: MEASUREMENT OF ABIOTIC FACTORS IN AN ECOSYSTEM AND IMPROVISATION OF NECESSARY INSTRUMENTS OR EQUIPMENT

AIM:

At the end of the experiment, students should be able to Construct an improvised rain gauge to measuer the quantity of rain.

ii. Use

(a) The soil thermometer to measure soil temperature

(b) Photometer and other instruments to measure high intensity duration and quality.

(c) Aneroid Barometer to measure atmospheric pressure.

(d) Psychrometer and Hygrometer to measure relative humidity (dryness of air)

iii.(a) Prepare an anhydrous cobalt chloride paper to measure the relative humidity or dryness of the air.

(b) Carry out the quantitative analysis of relative humidity data and the conversion of degree centigrade (C^o) to Fahrenheit (^oF)

iv.(a) Construct an improvised wind vane to find out the direction of wind.

(b) Use anemometer to measure the speed of wind

v. Use soil indicators Box Reagents to determine soil Ph, measure (acidity/alkalinity), texture, porosity, water retentivity, structure, etc.

vi.(a) Use flute to determine the direction or movement of water

(b) Adopt the use of a very long stick to determine the depth of water

(c) Use secci Disc to measure turbidity of water.

(d) Adopt the use of submarine illuminometer to measure light penetration.

vii. Determine the salinity of water from fresh water (or aquatic) sample using filtration method.

APARATUS: GROUP BY GROUP

GROUP 1: Gas jar, (or tin), funnel, Graph Sheet

GROUP 2: Soil Thermometer, Photometer, etc.

GROUP 3: Aneroid Barometer

GROUP 4: Psychrometer, Hygrometer, Filter or Litmus paper, (or Cobalt Chloride Solution) Desiccators, Watch-Clock.

GROUP 5: Wind vane, anemometer, Wood or Pencil, a piece of straw, feather or flat wood, pin etc.

GROUP 6: Soil sample, soil indicator box reagents, spatula, petri-dish, Bunsen burner

GROUP 7: A flute, watch-clock, a long stick, Secchi Disc, submarine illuminometer, aquatic sample of water, beaker or cylinder, Burettes, Pipettes silver Nitrate Solutes and solution, Water, Potassium Chromate (Kcro3) solution, conical flasks.

THEORY:

The factors that are responsible for the distribution of organisms in an ecosystem are the climate factors which comprise of temperature, humidity, rainfall, pressure, sunlight, wind and soil.

An adequate measurement of these factors can supply appropriate information to regulate activities on an ecosystem improve the soil and rectify anomalies where possible. Moreover, the need for improvisation of equipment cannot be over emphasized. Therefore, there is need to expose students to practicals on improvisation of some equipment or measuring instruments to facilitate the teaching-learning process both in the urban and rural areas. Through this, appropriate scientific attitudes and skills can be imparted to learners and scientific culture promoted across the globe.

PROCEDURE

Divide students into 7 groups to work on the measurement of rain, temperature, wind, soil, water, pressure and relative humidity.

INTRODUCTION OF EXPERIMENT IN PHYSICS

GRAPHS AND DATA HANDLING

In calculating quantities in experimental physics, it is not enough to rely on a single measurement, more accurate results are obtained by taking many measurements and then plotting a suitable graph. A graph therefore is a tool for analyzing experimental results.

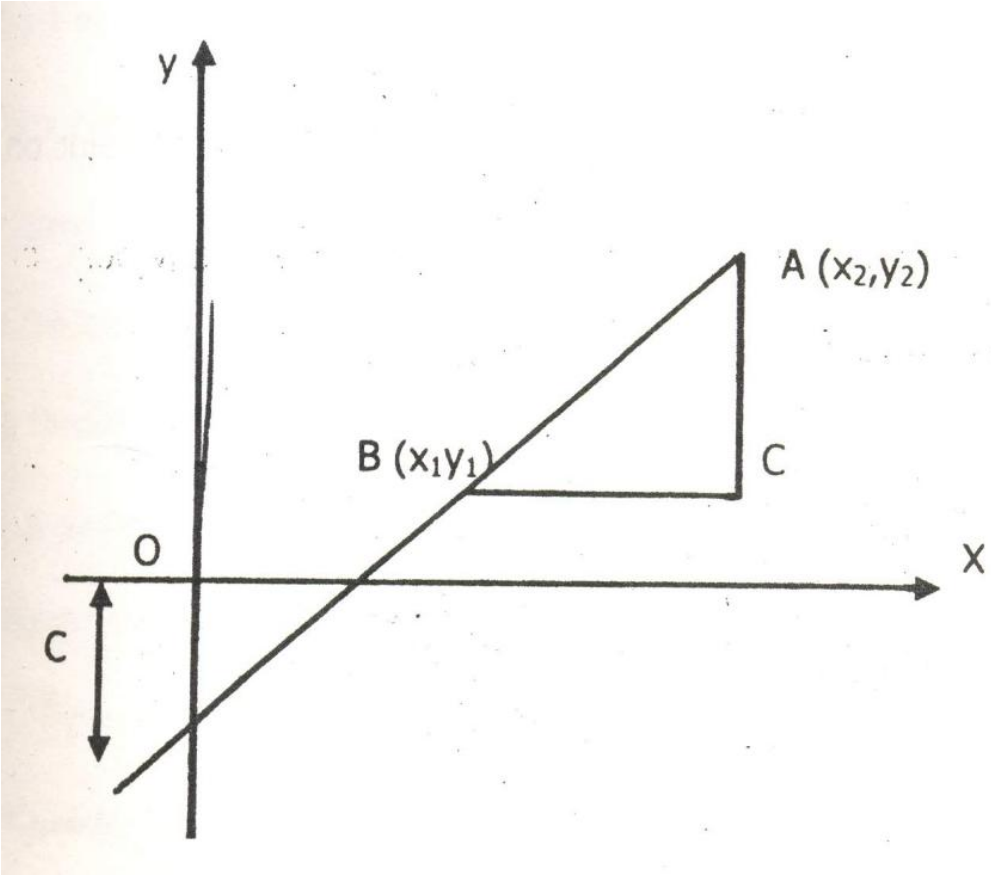
Different shapes of graphs are known and the few ones encountered in experimental physics are the straight line graph, the quadratic, inverse and exponential curves. A greater number of points are required to specify a curved graph than a straight line graph, however curved graphs in most cases provide less information on the relation between the variables plotted.

THE STRAIGHT LINE GRAPH

The most general equation of a straight line is

$$Y = mx + c$$

Where x and y are variables and m and c are constants , m is the slope of gradient of the line and c is the intercept of the line on the y – axis as shown below



The slope m is given by

$$M = \frac{AC}{BC} = \frac{y2 - y1}{X2 - X1}$$

= tan q q is measured in anticlockwise direction Q is the angle which the line makes with the positive X – axis.

The intercept c is read directly from the graph. At certain times, it is difficult to choose a suitable scale which starts the graph from the origin without the graph being crowded in one corner. In such cases, it is advisable

not to start the graph from the origin but from some other convenient point. The intercept c can then be found by calculation from the equation y = mx + c. For example, if (5, 3) is a point on the graph, and the slope of the graph is 0. 4.

Then c is given by $3 = 0.4 \times 5 + c$

From which c = 1

However, in most cases it is possible to choose a suitable scale for a straight line graph so that the line cuts the y – axis but does not include the origin (0, 0) ; c can then be read directly as before.

CURVED GRAPHS;

The slope of a curve graph varies from point to point. The slope at any point on the curved is defined as the slope of the tangent to the curve at that point.

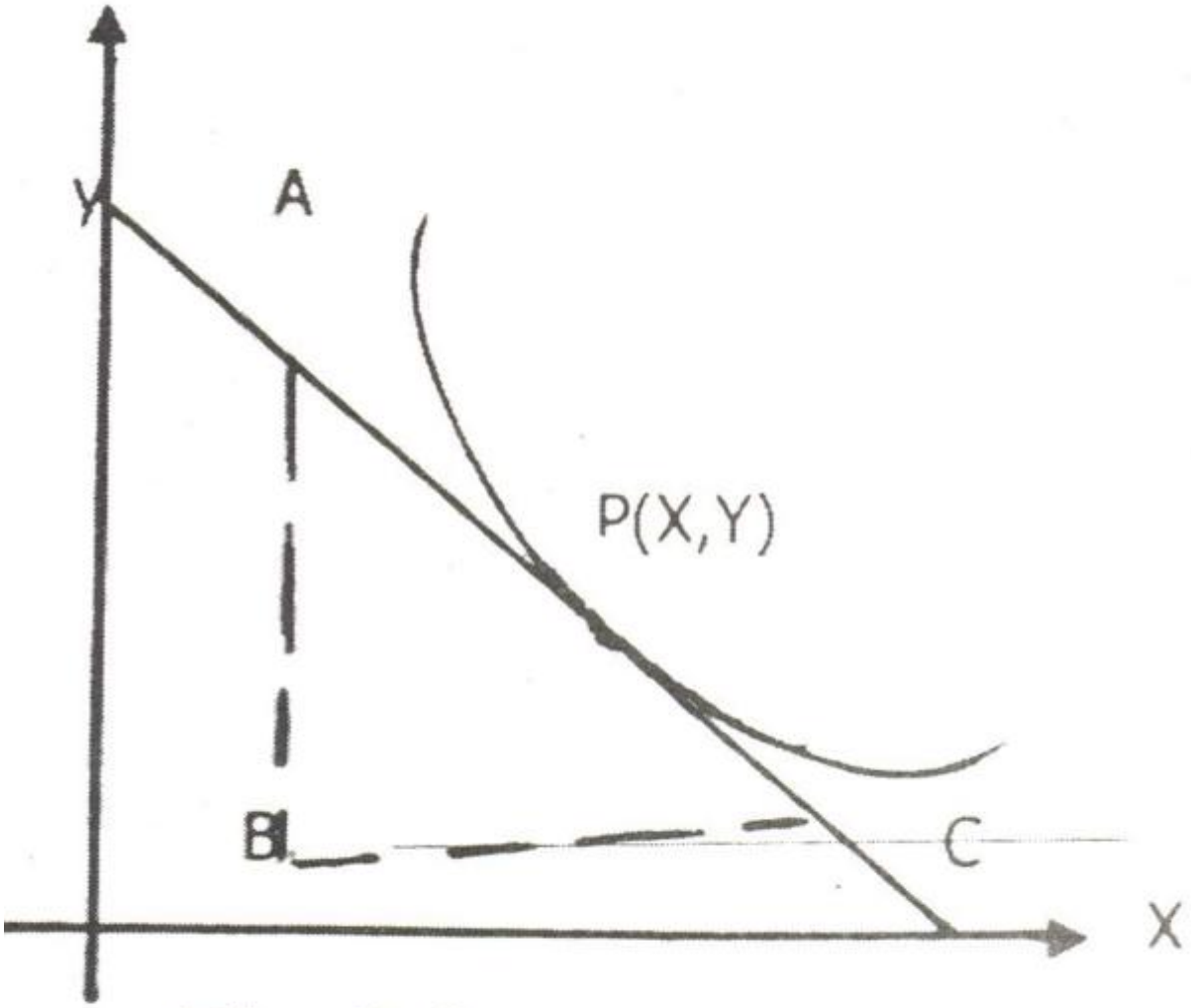


Fig 2.0

In the figure above, the slope at the point P(x, y) is given by

$$\frac{AB}{BC}$$

It is important to note that most equations of physics give smooth curves or straight lines. The plotted points may not all lie on the curve or line because of random errors which are inevitable in an experiment. A best curve or best straight line should be drawn and this is a curve or line which passes through

as many points as possible such that the points which do not lie on the line are evenly distributed on either side of the line or curve.

ERRORS IN PRACTICAL MEASUREMENTS

Whenever a measurement of a physical quantity is performed, an error or uncertainty will appear in the reading and therefore in the result calculated from the reading. The error depends on the measuring instrument and on the observer.

Errors fall into two main groups: systematic errors and random errors. We speak of systematic errors, if the result of the measurement is always higher or lower than true value and of random error if the result is sometimes higher and sometimes lower than the true value, that is if the error is sometimes positive, and sometimes negative. For example in the timing of a pendulum using a stopwatch or a stopclock, a systematic error will arise if the stopclock or stopwatch runs fast, as the time indicated will then always be longer than the true time. Random errors are introduced in the experiment if the observer does not start and stop the stopwatch at the right moment. For an inexperienced observer these errors may be quite large, up to 0.5 seconds for measurements with a stopwatch. The observer may also have a systematic or personal error like always starting the stopwatch too late but stopping it at the right moment.

Random errors can be detected if the measurement is repeated several times with the same apparatus and observer. The results of the different measurements will not agree if a random error is present but will be spread out through a certain range, which gives information of the magnitude of the errors.

Systematic errors cannot be detected in this way but only by repeating with a different apparatus and a different observer.

THE ACCURACY OF READINGS

Random errors arise in two ways: by all sorts of momentary external influences like sudden shaking of the hand of the observer, an air current, and by the limitation of the instrument used for the measurement. Both these types always occur, but one or the other may be of dominant importance depends on the instrument used is best illustrated by an example.

Suppose that we measure the side of a small metal cube with a metre rule. In this way we cannot get a better accuracy than 0.5mm, i.e there is always an uncertainty of 0.5mm in the reading, and this is probably much greater than errors caused by external influences. If instead we use a pair of calipers the uncertainty is ± 0.1mm, and with a micrometer screw gauge we can get down to an uncertainty of **±** 0.01. In this last case external influences may well cause errors of the same order of magnitude as the reading uncertainty. Depending on which method we use to measure the length, the accuracy of any result we calculate from this reading, e.g. the density of the metal will vary within wide limits. Therefore the result of any physical measurement should always be given with the uncertainty, often called the reading error, started. The number of figure**s** given should be such that the error is the last figure. E. g. in the first case mentioned above the reading should be given as (34.5 ± 0.5) mm or (3.45 ± 0.05) cm

In the second case as

(34.5 ± 0.1) mm or (3.45 ± 0.01) cm

and in the third case as

(34.37 ± 0.1) mm or (3.437 ± 0.001) cm

Never give a reading like

Current: 2 amps, this has no value at all for a calculation! Instead write current: (2.0 ± 0.1) amps or whatever other reading errors you may have. In physics, a current of 2 amps means anything between 1.5 and 2.5 amps.

The following list gives the reading error of some of the commonly used instruments:

mm scale	0.5mm
Callipers	0.1mm
Micrometer screw guage	0.01mm
Stop-clock	0.3s or more
Stop watch	1.0 – 0.2s
Thermometer graded to 1^{o}	0.2^{o}

Thermometer graded to 0.5° 0.1°

Thermometer graded to 0.1° 0.05°

Standard moving coil instrument 2% of the max. scale reading (ammeter, voltmeter)

NOTE: In many cases there is an uncertainty in the adjustment of the instrument that is greater than the reading error, e.g. in in balancing a wheatstone bridge. In this case the spread of a series of reading will be greater than the error.

EXERCISES:

(1) Draw on the same axes graphs of

$y = x + 6$

$y = 2x + 4$

And $y = 7x – 5$

For values of x between -5 to 5

(2) In an experiment, the following readings were obtained:

V(V)	2.4	2.0	1.7	1.5	1.4
I(A)	0.95	0.70	0.55	0.50	0.45

Plot the graph of V against I and determine the slope of straight line obtained.

(3) The following readings were obtained in an experiment:

U(cm)	55.0	45.0	35.0	25.0	15.0	10.0
V(cm)	1.6	2.2	2.3	4.6	9.4	18.7

The equation connecting u and v is $uv - f^2$ where f is a constant. Plot a suitable graph to obtain the value of f. Write down the value of f.

(4) In an experiment, the following readings were obtained

h(cm)	5.0	16.0	23.0	43.0	59.0	82.0
t(s)	37.0	36.6	36.1	35.3	34.1	32.6

Make a table of T^2 and h where T is the periodic time for 10 complete oscillations. Plot a graph of T^2 against h. Determine the intercept on the T^2 axis and the slope of graph. Write down the linear relation between T^2 and h.

(5) In a cooling experiment, the following readings were obtained r(^{o}C/min)

r(^{o}C/min)	5.4	3.1	2.6	1.8	1.5	0.6
Q(^{o}C)	79.0	56.0	41.5	32.0	26.5	16.5

Where r is the rate of fall of temperature and Q is the excess temperature over the surroundings. If the law of cooling is given by $\mathbf{r = aQ^n}$, find the value of the constant **a** and **n** by plotting **log r** against **log Q**

MEASUREMENT OF MASS

MEASUREMENT OF MASS

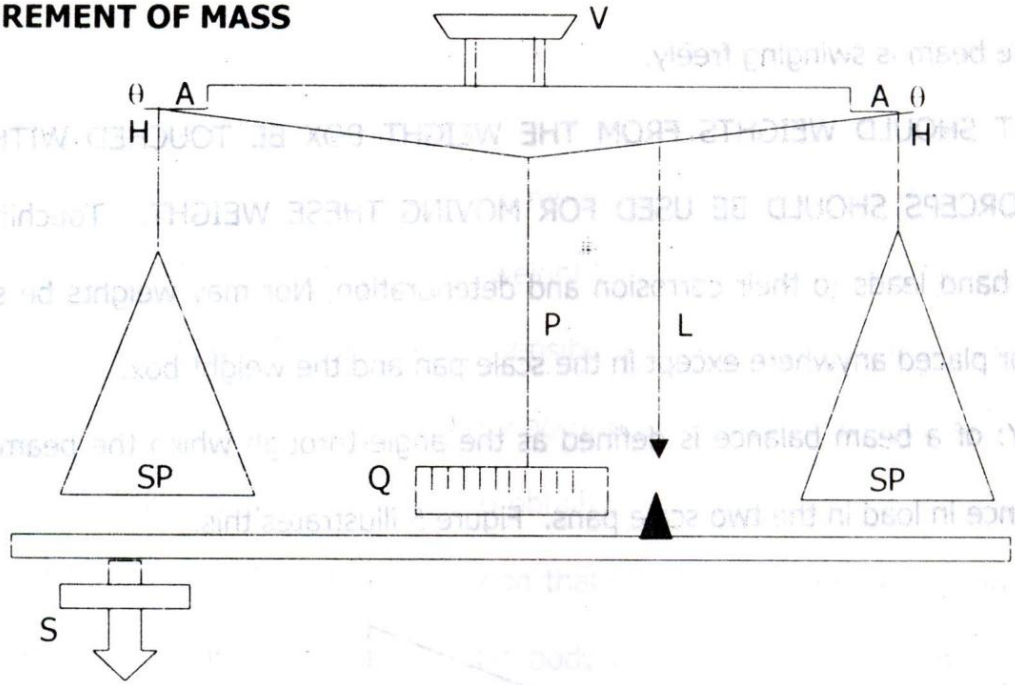


Fig. 3·0

H_1H = Horizontal screws

Q = scale

V = Gravity bab

K = Knob for raising beam

S,S = Leveling screw

A,A = A gate knife edges

L = Plumb line

SP = Scale pan

THE BEAM BALANCE

The essential features of the beam balance are shown in the above diagram Fig 3.0. Before any weighing is done, the base of the balance and the balance beam must be horizontal. To level the base, the leveling screws (S,S) are adjusted until the plumb line L is vertically above the projection on the balance case. To level the balance beam, the small nuts (H,H) are adjusted until the pointer P is at the central mark on the scale Q. Where it is not possible to level the base in this way the scale pan SP should be interchanged. The balance is set swinging in readiness for weighing by turning the knob K clockwise. To avoid damage to the gate knife edges A on which the balance beam and scale pans swing it is important to raise or lower the beam gently. For the same reason, weights should not be added to or remove from the pans when the beam is swinging freely.

ON NO ACCOUNT SHOULD WEGHTS FROM THE WEIGHT BOX BE TOUCHED WITH THE HAND. ONLY FORCEPTS SHOULD BE USED FOR MOVING THESE WEIGHTS. Touching the weights with the hand leads to their corrosion and deterioration, Nor may weights be spread out on the table or placed anywhere except in the scale pan and the weight box.

THE SENSITIVITY: of a beam balance is defined as the angle through which the beam turns for a 1 mg difference in load in the two scale pans. Figure 4 illustrates this:

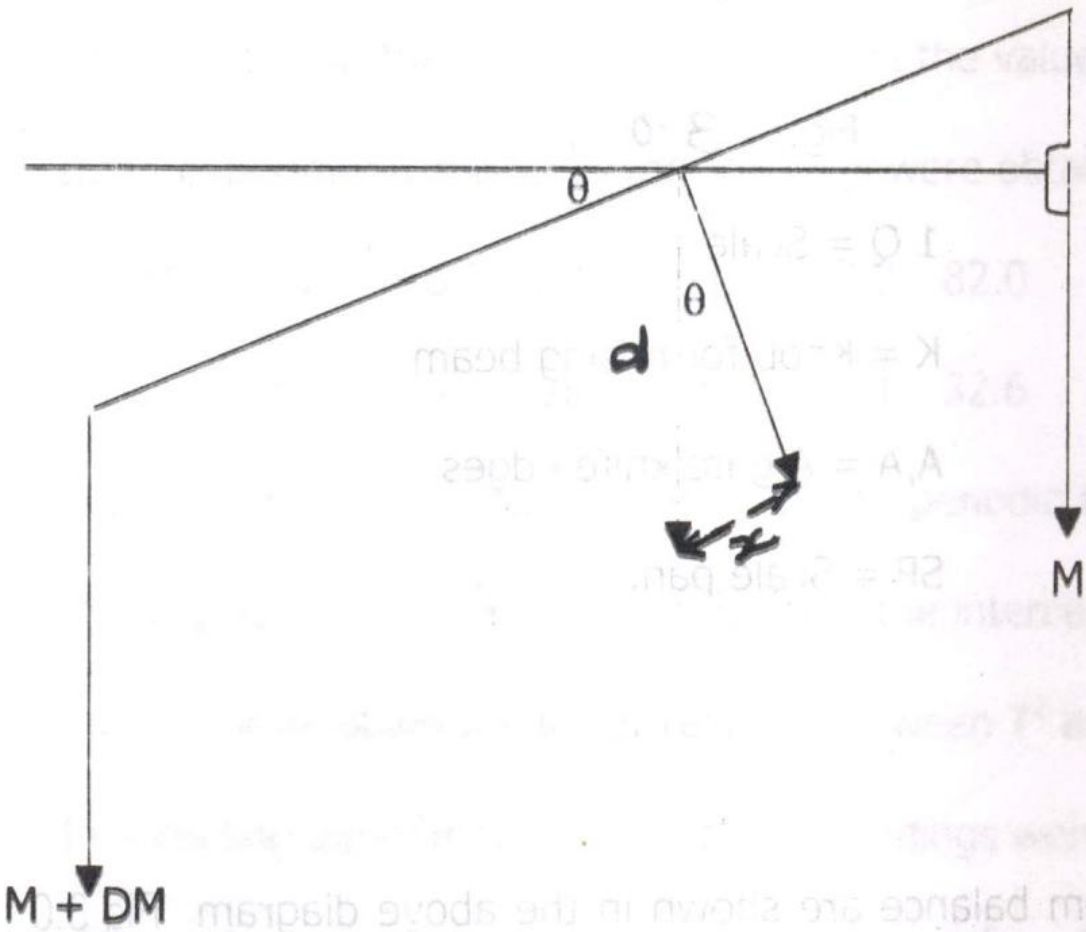


Fig 4.0

i.e $S = \frac{\theta}{DM}$ where DM is the difference in load in the two scale pans. In general, since DM is small, θ is of the order of a few hundredths of radians and may be expressed approximately as

$$\theta = \frac{x}{d}$$

Where **x** is the horizontal displacement of the tip of the pointer, and **d** the length of the pointer. For practical purposes therefore the sensitivity may be expressed as

$$S = \frac{x}{DM}$$

EXERCISE 6.0

Determine the sensitivity of the balance by measuring the displacement of the pointer from its rest position per milligram difference in weight in the two scale pans, when both pans carry loads 0, 5, 10, 20, 30, 50gf. Plot a graph of sensitivity against load DM should be chosen in such a way that the distance x can be read fairly accurately: i.e. 3-4 scale divisions.

DOUBLE WEIGHING: can be employed to obtain the actual mass of a body when the beam is initially not horizontal. This does not mean that the arms of the balance are unequal. If M_1 and M_2 are the two apparent weights of a body when placed in turns in the two scale pans, the real mass of the body is given by

$$M = ½ (M_1 + M_{2)}$$

The proof of this result is left as an exercise to the student and should be included in the report.

EXERCISE 7.0

Misplace the nut at the end of one of the arms of the balance by giving the nut one complete turn. Use the balance in this condition to weigh a body by the method of double weighing. Compare the result with that obtained with the balance in the normal condition.

TIMING

For accurate timing of oscillations of swings, it is essential to start the watch or stop-clock at a definite point of the swing and to stop the watch at the same point of the swing. Since a vibrating body, like a simple pendulum, moves fastest pass the equilibrium position, it is best to start or stop the watch when the vibrating body is at the equilibrium position. In all experiments involving timing and swings a pointer or fiducial mark should be set to mark the equilibrium position and the counted when the body moves past the pointer or mark from the direction. For more consistent results however, it is best to mark the equilibrium position of a vibrating body by means of two pointers or marks and to start or step the watch when the body is balanced with the pointers or marks. See fig 5.0

Pp = fiducial mark

passing through

equilibrium position

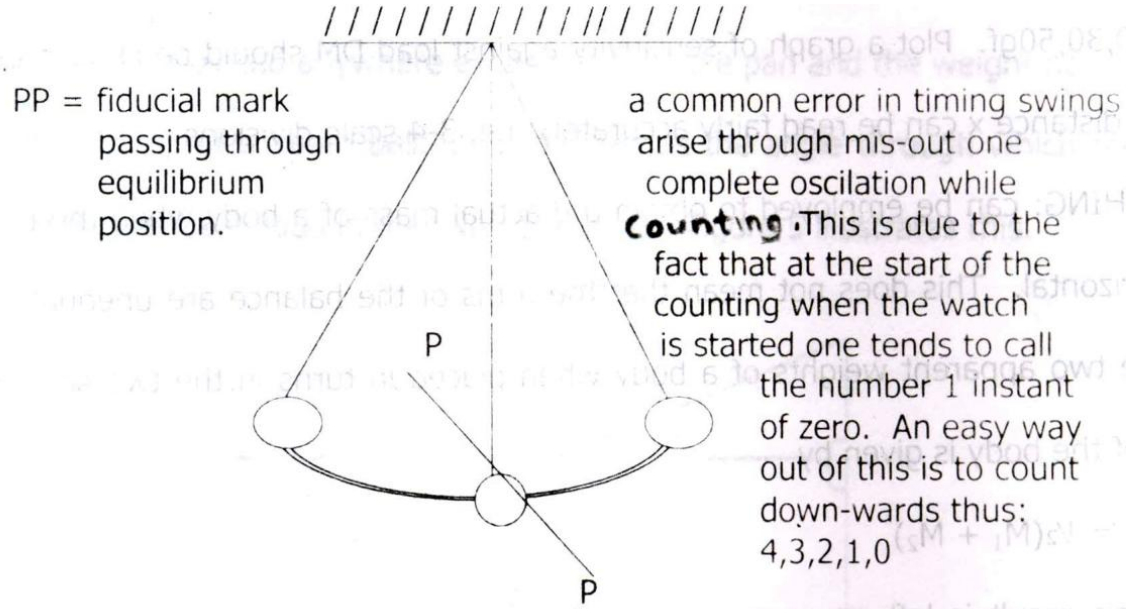


Fig. 5.0

RCISE 8.0

a common error in timing swings arise through the omission of one complete oscillation while counting. The is due to the fact that at the start of the counting when the watch is started one tends to call the number 1 instead of zero. An easy way out of this is to count downwards thus: 4,3,2,1,0

EXERCISE 8.0

Determine the period of one oscillation of the given short swing by timing 50 complete oscillations. Repeat nine times. Find the mean of the nine counts, calculate the departures of each reading from the mean and hence find the greatest deviation from the mean. Repeat the whole experiment by timing 10 complete oscillations. Comment on the accuracy of timing in the two sets of experiments.

EXERCISE 9.0

Determine the period of the oscillation of the longer pendulum (suspended from the ceiling, by timing 50 complete oscillations twice 10. Repeat the experiment by timing to complete oscillations 10 times. Compare the accuracies of the two sets of measurements.

EXERCISE 10.0

Place a load of about 300g on the scale pan of the given spiral spring. Allow the pan to move to rest and carefully displace it about 1cm in the vertical direction. Release the pan and time a convenient number of oscillations 9 times. Calculate the mean period and the greatest deviation from the means. Replace the load of 300g by a load of 100g and repeat the experiment and calculations.

QUESTIONS:

3. Which quantity is largest in these experiments, the reading error in the stop clock or the greatest deviation from the mean value of the time measured?

4. Does this type of experiment (timing a certain number of oscillations) give a more accurate result if it is repeated.

EXPERIMENT ON MECHANICS 1 (A)

Title: Relative density of a solid and a liquid

APPARATUS: Metal cube, spring balance, water, beaker, liquid, thread,

lever balance and specific gravity bottle.

METHOD: Measure the given metal cube's weight in air using the spring balance and record this value, then in water, and finally in the given liquid. Remember to record the label on your metal in your notebook.

THEORY:

Relative density of solid $= \frac{weight\ of\ solid\ in\ air}{weight\ of\ equal\ volume\ of\ water}$

$$= \frac{weight\ of\ solid\ in\ air}{upthrust\ of\ water\ on\ solid}$$

And the relative density of the liquid is given by

$$\frac{Weight\ of\ liquid}{weight\ of\ an\ equal\ volume\ of\ water}$$

$$= \frac{Upthrust\ of\ liquid\ on\ solid}{Upthrust\ of\ water\ on\ solid}$$

Calculate the relative densities of the solid and liquid using the above relations.

EXPERIMENT 1 (B)

TITLE: Relative density of a liquid using the specific gravity bottle.

METHOD: Weight an empty specific gravity bottle using the lever balance. Fill the specific gravity bottle with water, insert the stopper and weigh again using the lever balance. Empty the contents of the bottle and finally fill the bottle with the given liquid and weigh again as before. Calculate the relative density of the liquid using relation,

$$\text{Relative density} = \frac{Weight\ of\ liquid}{Weight\ of\ an\ equal\ volume\ of\ water}$$

MECHANICS 2

TITLE: Relative density of liquid – hydrometer method.

APPARATUS: Test tube, lead shot, beaker, kerosene, graph paper, water.

METHOD: Put enough lead shot in a test tube so that it can float vertically in a beaker of water as shown in the diagram below. With the aid of a scale made from graph paper, measure the height of the test-tube submerged below the liquid surface level h_k.

Repeat the experiment with water and record the height h_w

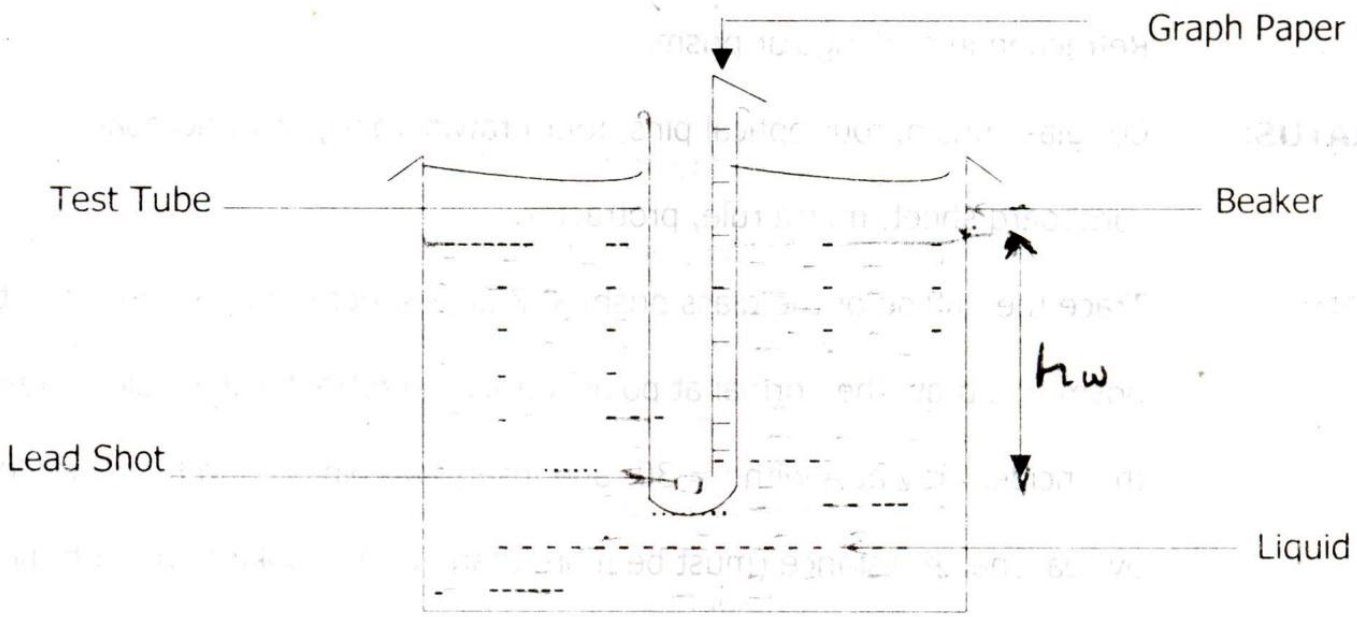


Fig. 6.0

Determination of the relative densities of a liquid using the hydrometer.

Determination of the relative densities of a liquid using the hydrometer

THEORY: Let the cross-sectional area of the test-tube be **A** therefore,

Volume of liquid displaced = Ah

And weight of liquid displaced = Ahρg

(Where ρ is the density of the liquid) from the principle of floatation.

Weight of the hydrometer = Weight of the liquid displaced = $Ah\rho g$

Therefore $Ah_w \rho_w = Ah_k \rho_k$

And $\frac{\rho w}{\rho k} = \frac{hk}{hw}$

Or $\frac{\rho k}{\rho w} = \frac{\rho w}{hk}$

= relative density of kerosene

QUESTION: Calculate the quantity $\frac{hw}{hk}$

EXPERIMENT ON LIGHT

TITLE: Refraction in a triangular prism.

APPARATUS: 60^0 glass prism, four optical pins, four drawing pins, drawing board, cardboard sheet, metre rule, protractor.

METHOD: Trace the outline of the glass prism XYZ on a sheet of paper. Remove the prism and draw the normal at point A using a protractor and ruler, Draw the incident ray at A with i = 30^{o} and insert two pins H and K separated by reasonable distance (must be more than 5cm). Looking through the prism, insert two other pins at **M** and **N** so that they appear to be in line with the images of **H** and **K**. Produce **NM** to meet the edge of the prism at **P**. Join AP. Measure the angles of deviation **D** and emergence **e**. Repeat the experiment for values of i = 40^{o},45^{o},50^{o}, and 65^{o}. Tabulate your results as shown below.

i	D	E	(D – e)

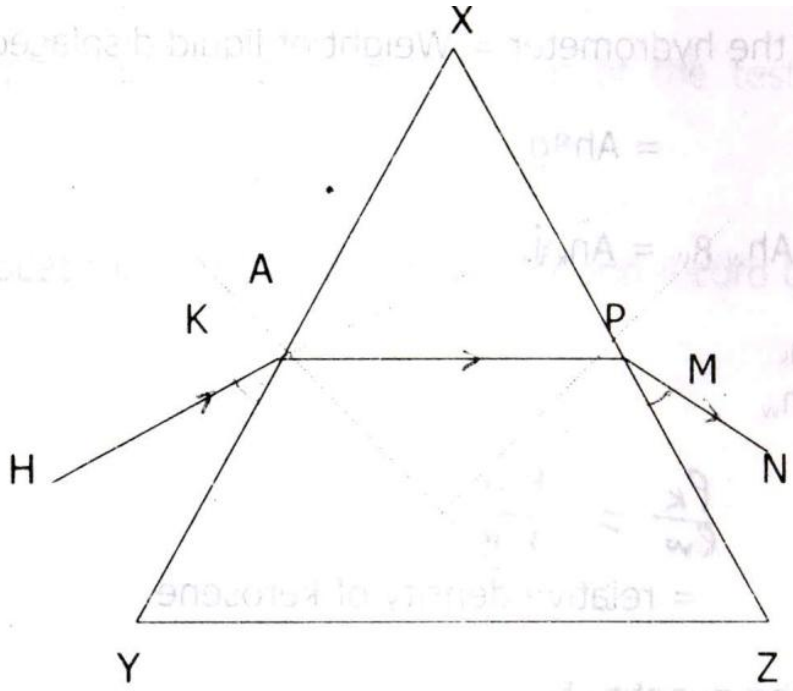


Fig 7.0
Refraction through a triangular prism

Refraction through a triangular prism

QUESTIONS: (a) Plot a graph of (D – e) against i

(b) Measure the slope

(c) Measure also the intercept on both axes.

(d) What can you conclude from the experiment?

(e) On a separate sheet, plot a graph of D against i.

(f) From your graph obtain the minimum deviation

Dm and the angle of incidence at minimum deviation im.

(g) Calculate the refractive index from

$$N = \frac{\sin ½ (Dm + A)}{Sin\ ½\ A}$$

Where A = angle of prism = 60^o

PREPARATION OF STANDARD SOLUTIONS

A standard solution is that which its concentration is known. Steps involved include:

(iii) Weighing of the substance to be dissolved

(iv) Dissolving the substance and making up the volume to the require concentration.

Weighing of true substance can be done using any of the weighing balances available in the laboratory. For instance if a standard solution of 0.01m NaOH is to be prepared.

2. The molar mass of NaOH will contain 4g of it dissolved in $1dm^3$. It then means that the student must weigh 4g of the substance and dissolve it in 1 dm^3 ($1000cm^3$). To reduce the volume, since one may not need as much as the 1 dm^3, a 250 cm^3 volumetric flask can be used. This means that one needs to calculate the mass that has to be dissolved in 250 cm^3 and yet make 0.10m solution of NaOH.

   i.e. 1000 cm^3 require $\frac{4g \times 250\ cm^3}{1000}$

   Hence the 4g in $1000cm^3$ = 1g in 250 cm^3

   Therefore you need to weigh 1g of NaOH pellets and dissolve in 250 cm^3 (distilled) water.

This gives a solution of 0.10m. in order to do this;

(iv) Get a clean dry sample or weighing bottle

(v) Weigh the sample bottle and record the value, e.g. ag

(vi) By calculation, add the amount of the sample you want to weigh to the mass of the sample bottle already weighed and adjust the weighing balance to read this new mass (bg).

Now, place the sample on the scale pan and start adding the sample inside the sample bottle until there is a balance between the weighing instrument and the bottle containing the sample.

Record the reading as follows:

Weighing reading;

Mass of the sample bottle only = ag

Mass of bottle + sample = bg

Mass of sample alone = (b – a)g

For example, in the case of 1g NaOH

Mass of the sample bottle only = ag

Mass of bottle + sample = (a + 1)g

Mass of sample alone = 1g

After weighing, dissolve the sample as follows:

(x) Pour the sample inside a beaker

(xi) Use small amount (distilled) water to wash the sample bottle thoroughly into the beaker containing the sample

(xii) Now, using a little amount of the distilled water, dissolve the sample in the beaker and make a small solution of it

(xiii) Pour this solution into a volumetric flask using a funnel

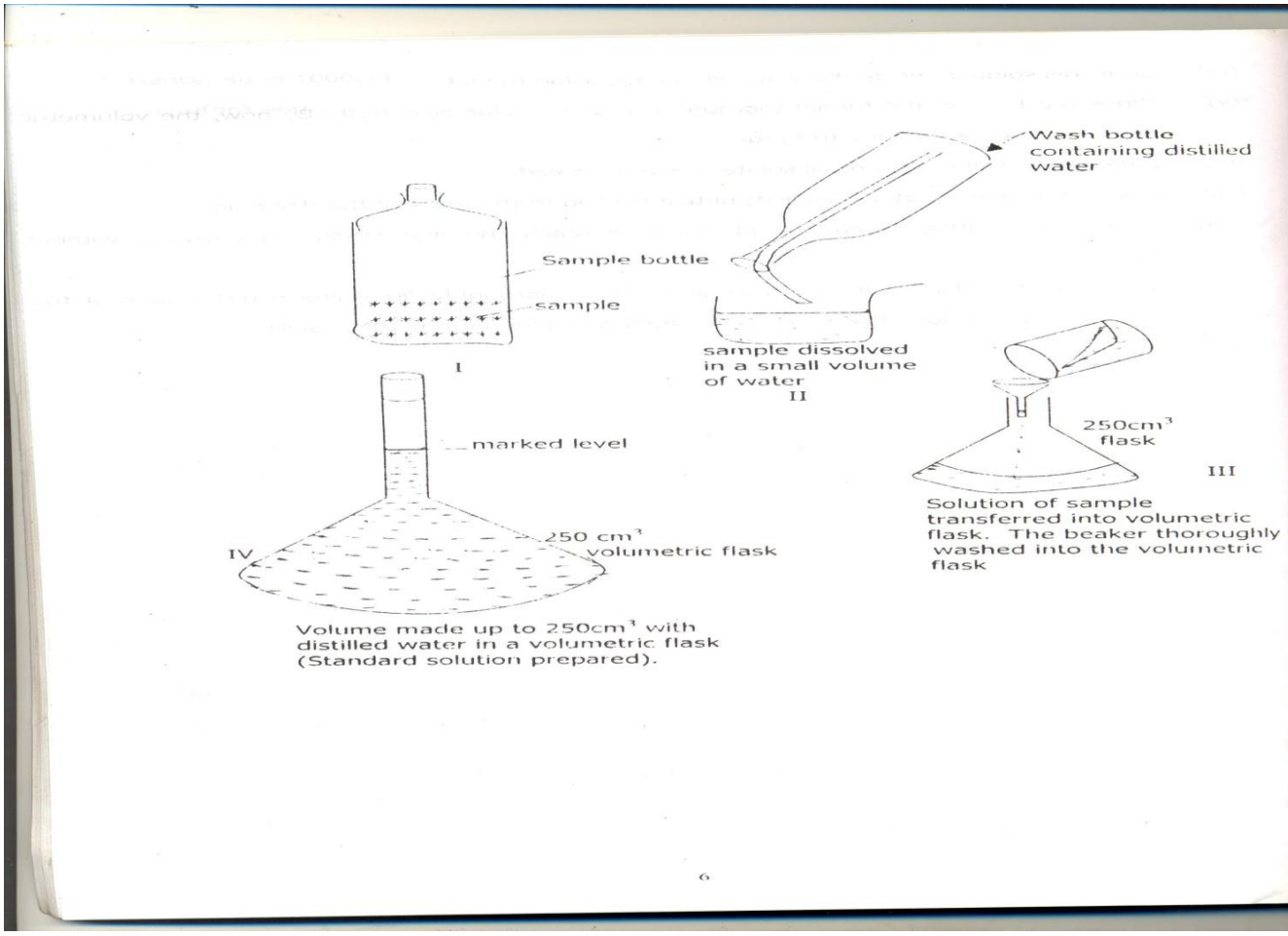
(xiv) Rinse the beaker and the funnel thoroughly into the volumetric flask. By now, the volumetric flask should be about one third full

(xv) Shake very well to ensure all solutes have dissolved

(xvi) Now, start to add water (distilled) until it is filled to the mark of the bulb of the flask

(xvii) Using wash bottle, carefully add water to reach the graduation mark exactly, without exceeding it.

(xviii) Now, cork the flask with its cover and shake thoroughly for uniform distribution of the solute in the solution. This makes your standard solution of 0.10m NaOH.



MEASURING A FIXED VOLUME USING A PIPETTE

Measuring the volume of a solution is one of the essential aspects of volumetric analysis. The volume must be accurately measured otherwise it will affect your titre value. The volume of a solution can be measured using a pipette as follows:

(viii) Dip the end of the pipette inside the solution

(ix) Inside the upper end of the pipette inside your mouth and carefully suck in a little of the solution

(x) Use this to rinse the pipette thoroughly (after you might have initially washed it thoroughly with water)

(xi) Then empty the pipette

(xii) Ensure that every space in it is filled with the solution

(xiii) Place your right forefinger to seal the upper end immediately you remove the pipette from your mouth

(xiv) With the upper end sealed, move the pipette in such a way you can see the round graduated mark as a single line from your side (if you move the pipette up and down you will see the round mark as s double line from your side).

Procedure for a Titration Experiment

11. Pipette out 20 cm^3 or 25 cm^3 (depending on which type of pipette is available) of the solution provided (usually a base) into a conical flask. Note that this should follow the procedure described under the use of a pipette.

12. Add about 2 or 3 drops of the indicator to the base and shake the flask. Usually, Methyl Orange is provided but occasionally, Phenolphthalein may be used. Methyl Orange is yellowish in a base and pinkish in an acid solution, while Phenolphthalein is red in a base and colourless in an acid solution.

13. Fill the burette with the titrant (acid solution) following the procedure described under the use of a burette

14. Adjust the level of the solution in the burette as appropriate. Take the reading of the burette and record it as "initial reading" ensuring there is no leakage in the burette.

15. Now place the conical flask on the white tile at the base of the retort stand. Use white paper if there is no white tile.

16. In order to prevent careless spilling of the acid solution while titrating, adjust the height of the burette so that the jet just lies slightly within the mouth of the conical flask

17. Open the burette tap to allow the solution to run into the conical flask but this should be at a controlled rate. The thumb, index finger and second finger of your hand (preferably left hand) are used for the control

18. Use the other hand (right hand) to swirl the conical flask continuously as the acid solution is being added from the burette. The agitation will ensure a proper mixture of the acid and base solutions.

19. Since you are expecting a colour change at the end point, add the acid solution drop by drop towards the end point. You should end the titration by turning off the burette tap immediately you observe that addition of a single drop of the acid solution causes a permanent colour change (yellow to faint or pink in the case of Methyl Orange indicator).

20. Read and record the burette reading. The titre value is obtained by subtracting the initial reading from the final reading. The titre value is the volume of the acid solution required to react completely with the volume of the base in the conical flask.

RULES GUIDING THE WRITING OF BURETTE READINGS AND CALCULATION OF AVERAGE TITRE VALUE

8. Usually the first titration is regarded as rough/trial, so have to repeat the titration two or three more times, ensuring that two titre values do not vary by more than 0.20 cm^3

9. Record burette reading to two decimal places and the second decimal figure must either be 0 or 5 e.g. 19.50 cm^3 not 19.51 cm^3 or 22.56 cm^3. In the same vein, the average titre value should be calculated to two decimal places e.g. average 19.50cm^3 and 19. 55 cm^3 is

$$\frac{19.50 + 19.55}{2} = 19.53\ cm^3$$

10. The burette reading are conveniently tabulated as shown below:

Burette Readings		**Titration**	
	Trial	**First**	**Second**
Final Burette Reading (cm^3)	21.10	41.60	21.55
Initial Burette Reading (cm^3)	0.00	21.10	1.00
Volume of Acid Used (cm^3)	21.10	20.50	20.55

Average volume of acid used to neutralise 25 cm^3 of the base: $\frac{20.50 + 20.55}{2} = 20.63\ cm^3$

11. You are advised to ignore value (s) of volume (s) that is outrageous (i.e. too low or too high) in calculating the average titre value.
12. Do not average two titre values which are more than 0.20 cm^3
13. Make sure you record the calculated value of concentrations in moles per dm^3 (molarities) to three decimal places e.g. 0.560M
14. Concentration in grams per dm^3 and any other calculation should be expressed in three significant figures e.g. 2.68g/dm^3

QUESTION 1

A is a solution of tetraoxosulphate (VI) acid containing 5.8g per dm^3. Solution B contains 9.3g of an impure potassium hydroxide per dm^3.

Put the acid solution A into the burette and titrate with 25 cm^3 or (20 cm^3) portion of B, using methyl orange or screened methyl orange as indicator.

From your result, calculate;

e. The concentration in moles/dm^3 of the tetraoxosulphate (VI) acid in solution A

f. The concentration in moles/dm^3 of the potassium hydroxide in solution B

g. The concentration in grams/dm^3 of potassium hydroxide in solution B

h. The percentage purity of potassium hydroxide in solution B

The equation for the reaction is:

$H_2SO_4 + KOH \longrightarrow K_2SO_4.2H_2O$

(H = 1.0; S = 32.0; O = 16.0; K = 39.0)

QUESTION 2

Xg of anhydrous sodium trioxocarbonate (IV) was treated with 1000cm^3 or (1 dm^3) of 0.300M hydrochloric acid to obtain a solution A which contains excess hydrochloric acid after the treatment. B is a 0.09M solution of sodium hydroxide.

Put the acid solution A into the burette and titrate against 25 cm^3 or (20 cm^3) portion of B. Use methyl orange or screened methyl orange as indicator.

Record the volume of your pipette. Tabulate your burette readings and calculate the average volume of acid required to neutralise the stated volume B.

From your result calculate:

(c) The concentration of acid in solution A in mole per litre (dm^3)

(d) The mass, X, of the sodium trioxocarbonate (IV)

QUESTION 3

Solution A is a solution of sodium hydroxide containing 0.025 mole of the alkali in 250 cm^3 of solution. B is a solution of a dibasic acid, H_2Y.

Put solution B into burette. Pipette 25 cm^3 or (20 cm^3) portion of solution A into a conical flask and titrate with solution B using phenolphthalein as indicator.

Record the volume of your pipette. Tabulate your burette reading and calculate the average volume of acid used.

(d) calculate the concentration in moles/dm^3 of solution B from your results

(e) if the concentration of the acid in solution B is 4.90g/dm^3, what is the molar mass of the acid to the nearest whole number?

(f) Calculate the percentage by mass of Y in H_2Y

QUESTION 4

P is a solution of either hydrochloric acid or trioxonitrate (V) acid containing 4.6gdm^3. Q is a solution of potassium hydroxide. The concentration of solution Q is 5.75gdm^3.

Put solution P into the burette and titrate against 25 cm^3 or (20 cm^3) portion of Q. Use methyl orange or screened methyl orange as indicator.

Record the volume of your pipette. Tabulate your burette readings and calculate the average volume of acid required to neutralise the stated volume Q.

From your results, calculate:

(e) The concentration in moles/dm^3 of the base solution Q.

(f) The concentration in moles/dm^3 of the acid solution P.

(g) The molar mass of the acid

(h) From your result in (c) above identify the acid. Explain clearly how you arrived at your conclusion.

(H = 1.0; O = 16.0; Na = 23.0; Cl = 35.5; K = 39.0).

QUESTION 5

E is a solution containing 15.7g/dm^3 of hydrated sodium trioxocarbonate (IV). F is a solution of tetraoxosulphate (VI) acid. The concentration of solution F in mole per dm^3 is 0.065M.

Put F into the burette and titrate with 25 cm^3 or (20 cm^3) portion of solution E. Use methyl orange or screened methyl orange as indicator.

Record the volume of your pipette. Tabulate your burette readings and calculate the average volume of acid required to neutralise the stated volume of E.

From your result, calculate:

(d) The concentration in moles/dm^3 of solution E

(e) The molar mass of hydrated sodium trioxocarbonate (IV).

(f) The value of X.

The equation of the reaction is;

$Na_2CO_3XH_2O + H_2SO_4 \longrightarrow Na_2SO_4 + CO_2 + (X + 1)H_2O.$

QUALITATIVE ANALYSIS

Chemical compounds are made up of different particles. The particles may be atoms, molecules or ions (charged particles). The ions carrying negative charges are called anions, while those carrying positive charges are called cations.

Qualitative analysis is the identification of the anion and cation present in a simple salt or anions and cations present in a mixture of salts or salts of metallic oxides.

Analysis of a simple salt usually includes:

f. Examination of physical properties

g. The action of heat on a salt

h. The reactions of a salt or solution with acids and alkalis

i. The reactions of solutions of salt with other reagents, and

j. Flame test.

TECHNIQUES AND PROCEDURES FOR QUALITATIVE ANALYSIS

In qualitative analysis, salts or a mixture of salts are usually supplied. At times, a solution of a salt may be given. This is an unknown compound as far as the students are concerned, the containers are appropriately

labelled alphabetically by the examiner, e.g. the specimen bottle containing the salt may be labelled A, B, C, X or Y.

When you are given an unknown salt, you are expected to carry out specified tests on it or the solution of it, observe the changes and carefully record them and finally arrive at inferences or conclusions about the nature and identify the unknown salt tested. For good performance, since this is part of the practical, the following guide should be carefully employed.

5. HEATING OF A DRY SALT IN A TEST TUBE

When a given substance is to be tested in a dry state, heat is gently applied at the initial state, while observing any change taking place and then heat is strongly applied until there is no further change is observed. You will be expected to describe the residue, its appearance when hot and when it has been allowed to cool down. When heating, the test tube must be held with a test tube holder in a slanting position, with its mouth pointing away from you.

c. The amount of substance required here for heating or preparing solutions is always a small quantity

d. Describe any gas evolved giving its colour, odour and a chemical test for confirmation

6. PREPARING SOLUTION OF A SALT

When you are not given the solvent for preparing the solution of an unknown substance, use a suitable solvent to prepare the solution of the substance. The following solvents should be tried in that order: water, dilute hydrochloric acid and dilute trioxonitrate (V) acid, ensuring that the solid added dissolves completely.

If dissolution is slow, you can warm the solution gently ensuring that the solution is cooled under a tap or left to cool on its own (if there is time), before carrying out chemical tests on the solution of the salt. The solution must be clear and during filtration, the solution must be carefully poured into the middle of the cone of the filter paper.

7. ADDING A REAGENT TO A SOLUTION IN A TUBE

d. Any reagent to be added to the prepared solution must be a little at a time or (few drops at a time), shake after addition, until there is no further change. Use only about 2 – 3 cm^3 of the prepared solution. A dropping pipette is usually useful for adding reagents to solutions.

e. If you observe any precipitate after the addition of the reagent, describe its colour and/or appearance such as crystalline or gelatinous.

f. If it happens that no change is observed after adding the necessary reagents to the solution, then record ‘there is no visible change’.

8. **TEST FOR GASES**

RECOGNITION AND SOURCES OF GASES

GASES	TEST	SOURCES OF GASES

Hydrogen (H_2)	Colourless, odourless, explodes with a slight pop when flame is applied	Evolves when metals react with dilute acids e.g. $Zn + 2HC \longrightarrow ZnCl_2 + H_2$
Oxygen (O_2)	Colourless, odourless, re-lights or rekindles a glowing splint	Evolves when oxides (peroxides, salts or oxyacids, trioxonitrates (V), trioxochlorates (V), trioxoiodates (V) are heated, e.g. $2KClO_3 \longrightarrow 2KCl + 3O_2$
Carbon(IV)oxide (CO_2)	Colourless, odourless, slightly acidic, turns calcium hydroxide solutions (lime water) milky.	Evolves when Trioxocarbonates (IV) or some metals are heated Dilute acids react with Trioxocarbonates (IV) e.g. $CaCO_3 \longrightarrow CaO + CO_2$ $Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$
Chlorine (Cl_2)	Yellowish green colour, choking smell, turns moist blue litmus paper red and then bleaches it.	Evolves when certain chlorides react with oxidising agents, e.g. $MnO_2 + 4HCl \longrightarrow MnCl_2 + Cl_2 + 2H_2O$
Hydrogen Chloride (HCl)	Colourless, irritating smell, turns blue litmus paper red, white fumes with ammonia, fuming in moist air (noticed clearly by blowing across the mouth of the test tube)	Evolves when a chloride reacts with concentrated tetraoxosulphate (VI) acid (H_2SO_4), e.g. $2NaCl + H_2SO_4 \longrightarrow Na_2SO_4 + 2HCl$

GASES	**TEST**	**SOURCES OF GASES**
Hydrogen Sulphate (H_2S)	Colourless, smells like bad (rotten) egg, burns with light blue flame and deposits sulphur, turns Lead Ethanoate paper black	Evolves when a dilute acid reacts with a sulphide e.g. $FeS + 2HCl \longrightarrow FeCl_2 + H_2S$
Nitrogen (IV) Oxide (NO_2)	Brown gas with choking smell, turns moist blue litmus paper red, turns starch iodide paper blue black.	Evolves when Trioxonitrate (V) or dioxonitrate (III) of some metals below Na in the E.C.S. are heated, e.g. trioxosulphite (IV) $2Pb(NO_3)_2 \longrightarrow 2PbO + 4NO_2 + O_2$ Conc. HNO_3 reacts with metals e.g. $2Pb(NO_3)_2 \longrightarrow 2PbO + 4NO_2 + O_2$ $Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

Chlorine (Cl_2)	Yellowish green colour, choking smell, turns moist blue litmus paper red and then bleaches it.	Evolves when certain chlorides react with oxidising agents, e.g. $MnO_2 + 4HCl \longrightarrow MnCl_2 + Cl_2 + 2H_2O$
Hydrogen Chloride (HCl)	Colourless, irritating smell, turns blue litmus paper red, white fumes with ammonia, fuming in moist air (noticed clearly by blowing across the mouth of the test tube)	Evolves when a chloride reacts with concentrated tetraoxosulphate (VI) acid (H_2SO_4), e.g. $2NaCl + H_2SO_4 \longrightarrow Na_2SO_4 + 2HCl$

GASES	**TEST**	**SOURCES OF GASES**
Hydrogen Sulphate (H_2S)	Colourless, smells like bad (rotten) egg, burns with light blue flame and deposits sulphur, turns Lead Ethanoate paper black	Evolves when a dilute acid reacts with a sulphide e.g. $FeS + 2HCl \longrightarrow FeCl_2 + H_2S$
Nitrogen (IV) Oxide (NO_2)	Brown gas with choking smell, turns moist blue litmus paper red, turns starch iodide paper blue black.	Evolves when Trioxonitrate (V) or dioxonitrate (III) of some metals below Na in the E.C.S. are heated, e.g. trioxosulphite (IV) $2Pb(NO_3)_2 \longrightarrow 2PbO + 4NO_2 + O_2$ Conc. HNO_3 reacts with metals e.g. $2Pb(NO_3)_2 \longrightarrow 2PbO + 4NO_2 + O_2$ $Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$
Sulphur (IV) Oxide (SO_2)	Colourless, irritating smell or (smell of burning sulphur), turns Potassium tetraoxomanganate (VII) solution colourless and turns litmus paper dipped in acidified potassium heptaoxodichromate (VI) solution green.	Evolves when dilute acid reacts with some tetraoxosulphates (VI), trioxosulphates (IV) or thiosulphates e.g. $Na_2SO_3 + 2HCl \longrightarrow 2NaCl + NH_3 + H_2O + SO_2$
Ammonia (NH_3)	Colourless, characteristic choking smell, turns moist red litmus blue, forms white fumes with concentrated	Evolves when sodium hydroxide is added to an ammonium salt, e.g. $NH_4Cl + NaOH \longrightarrow NaCl +$

	hydrochloric acid	$NH_3 + H_2O$
Water Vapour (H_2O)	Condenses on the side or around the mouth of the test tube	Evolves when hydrated salts are heated. e.g. $CuSO_4 \longrightarrow 5H_2O +$ $CuSO_4H_20$. Bluish white