Shika Express - Chemistry
Version 1.0 TZ

Hands-On Activities Companion Guide

Tanzania

Teacher's Guide

May 22, 2014

Contents

Part I

Hands-On Activities

Chemistry Activities for Form I

Chemistry Activities for Form II

Chemistry Activities for Form III

Chemistry Activities for Form IV

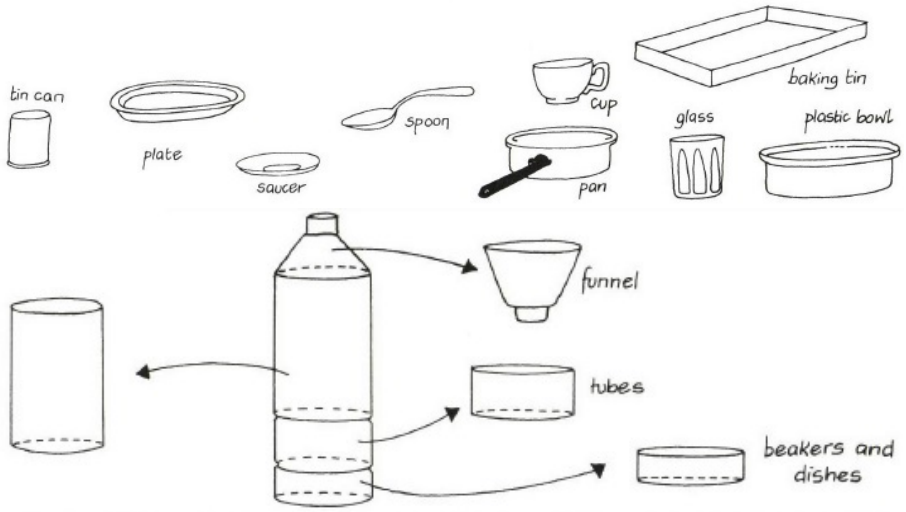
Local Materials List

In order to gain a thorough understanding of science, students must be able to make a connection between classroom learning and the outside world. The following is a list of locally available materials which may be used to substitute conventional materials and apparatus for various activities. These materials have the following advantages:

- They are readily available in the village or a nearby town;
- They are cheaper than conventional materials;
- They may safely substitute the conventional materials without fear of losing accuracy or understanding;
- They help students to draw a connection between science education and the world around them.

Imagination and innovativeness is encouraged on the part of the student and teacher to find other suitable local substitutions.

How many experiments can be carried out with everyday items?



Below are common apparatus you might order from a laboratory supply company, and comments about which have good if not superior alternatives available in villages and towns. Given equal quality, it is generally better to use local materials, because these help connect classroom learning to students' lives.

The apparatus listed in this section are the following:

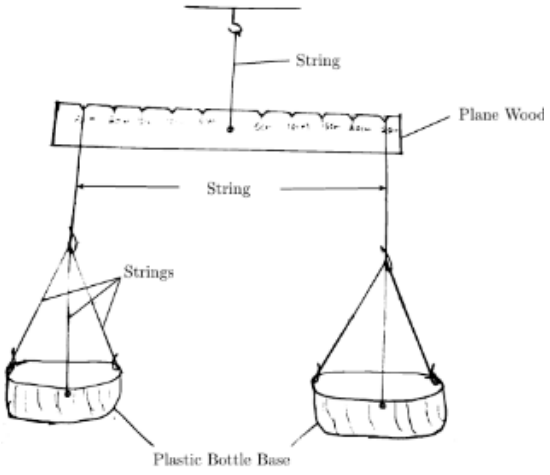
1. Alligator Clips
2. Balance
3. Beakers
4. Blowpipe
5. Bulbs
6. Bunsen Burner
7. Burettes
8. Crucible
9. Containers
10. Deflagrating Spoon
11. Delivery Tube
12. Droppers
13. Electrodes
14. Electrode Holders
15. Filter Paper
16. Flasks
17. Funnel
18. Gloves
19. Goggles
20. Heat Sources
21. Indicator
22. Iron Filings
23. Masses
24. Measuring Cylinder
25. Metre Rule
26. Microscope
27. Mortar and Pestle
28. Nichrome Wire
29. Optical Pins
30. Pipettes

A.1 Alligator Clips

Use: Connecting electrical components
Materials: Clothespins, aluminum foil, glue
Procedure: Glue aluminum foil around the clamping tips of a clothespin.

A.2 Balance

Use: Measuring mass
Materials: Ruler or wooden bar 30 cm × 2 cm, nails, razor/knife, string/wire, pen, 2 Scale Pans
Procedure: Find the balancing point of the ruler/wood block and mark it with a pen. Use a heated nail to make a hole through this point. Make notches at 5 cm intervals on either side of the center hole using a razor/knife to suspend scale pans. Use a string/wire tied through the center hole to suspend the balance.

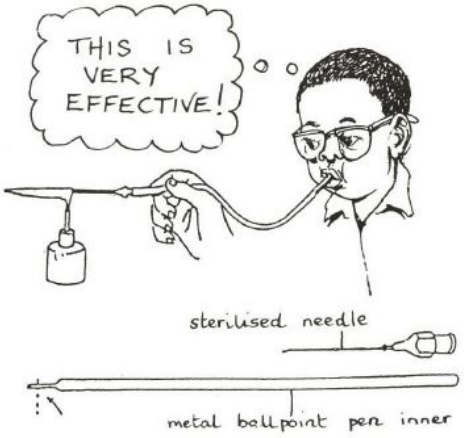


A.3 Beakers

Use: To hold liquids, to heat liquids
Materials: Water bottles, jam jars, metal cans, knife/razor
Procedure: Take empty plastic bottles of different sizes. Cut them in half. The base can be used as a beaker. Jam jars made of glass, cut off metal cans and aluminum pots may be used when heating.
Safety: Glass containers may shatter if heated too much. Use standard laboratory equipment if extreme heating is needed.

A.4 Blowpipe

Use: Increasing temperature of flames
Materials: Syringe needle, tube/straw/pen tube
Procedure: For sterilisation heat the needle in open fire for a longer time before using it. A drinking straw or a clean plastic tube can be used as a connection to the mouth.



A.5 Bulbs

Use: Electrical circuits, diodes
Materials: Broken phone chargers, flashlights, other electronic devices
Procedure: Look for LEDs from broken items at hardware stores, local technicians, or small shops.

A.6 Bunsen Burner

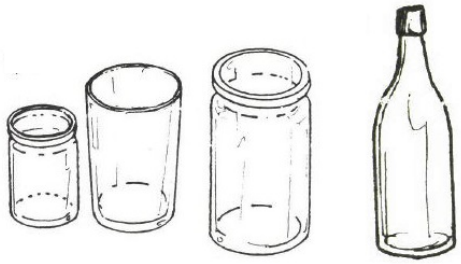
See Heat Sources (p. 13).

A.7 Burettes

Use: Titration
Materials: 10 mL syringes
Procedure: Use 10 mL disposable plastic syringes with 0.2 mL gradations. Students can estimate between the lines to at least 0.05 mL. If you must buy, buy plastic. Note that broken burettes can often be repaired – see **??** (p. **??**).

A.8 Containers

Use: Measuring large volumes (100 mL – 2 L) of solution, titration, storage
Materials: Plastic water bottles, jars, tin cans
Procedure: Identify the volume of useful marks on the bottles and combine to measure accurate volumes.

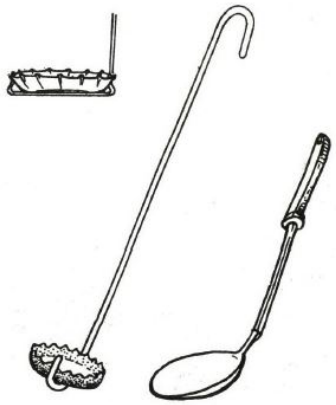


A.9 Crucible

Use: Heating substances at very high temperatures
Materials: 2 metal spoons, wire
Procedure: Place the material in one spoon and then wire 2 spoons together.

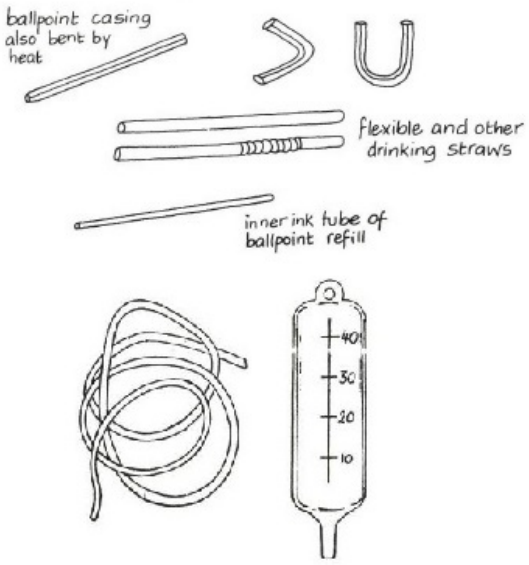
A.10 Deflagrating Spoon

Use: For heating chemicals to observe melting, decomposition, or other changes on heating
Materials: Metal spoons, galvanised wire, soda bottle cap
Procedure: Bend 30 cm of galvanised wire as shown. The wire should hold the bottle cap firmly.



A.11 Delivery Tube

Use: Movement and collection of gases, capillary tubes, hydraulic press
Materials: Straws, pen tubes, IV tubing (giving sets) from a pharmacy, bicycle tubing

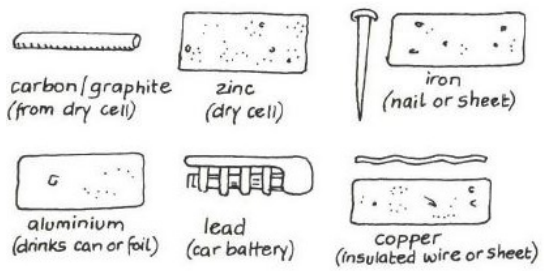


A.12 Droppers

Use: To transfer small amounts of liquid
Materials: 2 mL syringes, straws
Procedure: Take a syringe. Remove the needle to use as a dropper. Or insert a straw into a liquid and then plug the free end with a finger to remove a small amount and use as a dropper.

A.13 Electrodes

Use: Electrolysis

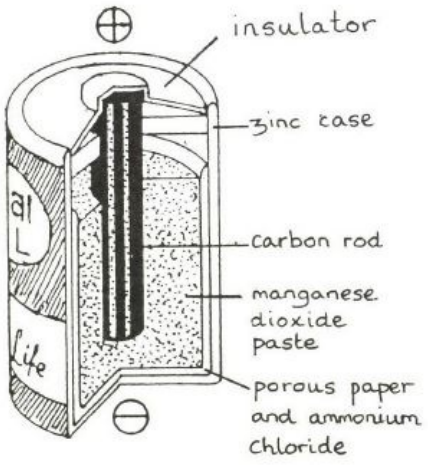


A.13.1 Graphite

Materials: Old dry cell batteries
Procedure: Gently smash an old battery (D size) with a rock and pull out the electrode with pliers. DO NOT do this with alkaline batteries (most AA size) as they contain caustic liquids.

A.13.2 Zinc

Materials: New dry cell batteries
Procedure: Carefully open up a NEW dry cell (D size) battery by peeling back the steel shell and slicing the plastic inside. You should find a cylindrical shell of zinc metal. Empty out the black powder inside (manganese dioxide mixed with zinc chloride and ammonium chloride; wash your hands after) and keep the graphite electrode for another day. The zinc shell should then be cut into strips, scraped clean, and boiled in water or washed with soap to remove any residual chemicals that might affect your experiment.



A.13.3 Iron

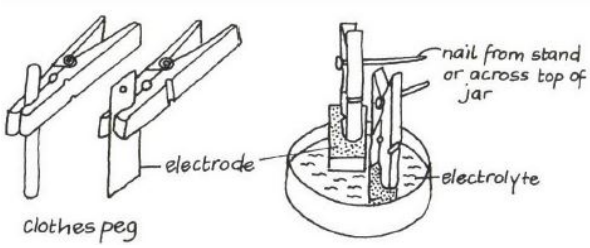
Materials: Ungalvanized nails from a hardware store

A.13.4 Copper

Materials: Thick wire stripped of its insulation, also from a hardware store. Note that copper earthing rods have only a thin surface layer of copper these days.

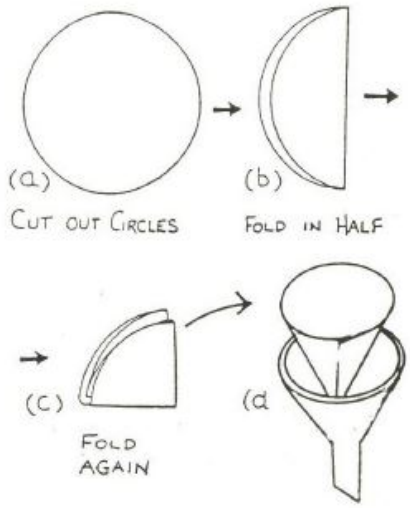
A.14 Electrode Holders

Use: Electrolysis
Materials: Clothes pins



A.15 Filter Paper

Use: Filtration, separating mixtures, solutions
Materials: Cement bag paper, toilet paper, cloth

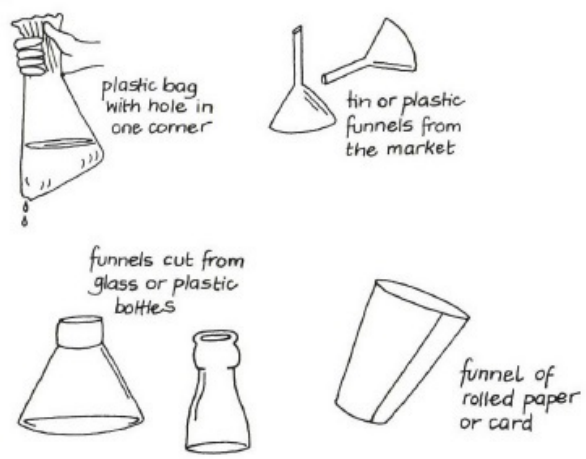


A.16 Flasks

Use: Titrations, mixing solutions
Materials: Clean used liquor bottles, small water bottles
Procedure: When using these flasks for titrations, students must practice swirling enough that the solution remains well mixed.
Safety: When heating glass liquor bottles, make sure the cap is off.

A.17 Funnel

Use: To guide liquid or powder into a small opening
Materials: Empty water bottles, knife
Procedure: Take an empty water bottle and remove the cap. Cut it in half. The upper part of the bottle can be used as a funnel.



A.18 Gloves

A.18.1 Latex gloves

Use: First aid, when one has open cuts on hands, handling specimens. They are worthless to the chemist because they make the hands less agile and give the user a false sense of security.
Safety: Concentrated acids and organic chemicals burn straight through latex.

A.18.2 Thick gloves

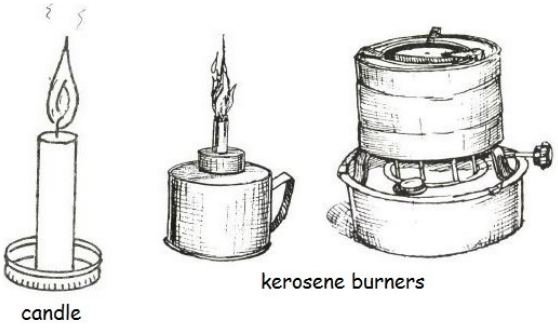
Use: For working with organic solvents. Remember that the most dangerous organic solvents (benzene, carbon tetrachloride) should never be used in a school, with or without gloves.
Materials: Thick rubber gloves from village industry supply companies and some hardware stores
Safety: In general, avoid using chemicals that would make you want to wear gloves.

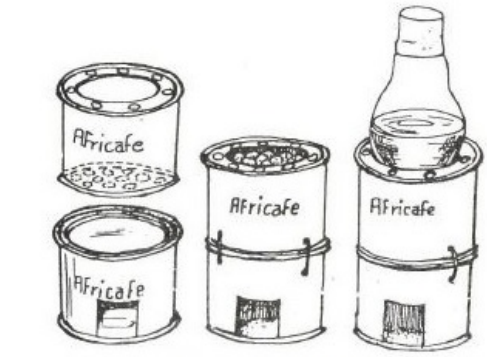
A.19 Goggles

Use: Handling concentrated acids
Materials: 1.5 L plastic water bottles, cardboard, sunglasses
Procedure: Cut a strip of plastic from a water bottle. Attach around your head with string or by using stiff cardboard as a frame. Goggles do not need to be impact resistant – they just need to stand between hazardous chemicals and your eyes.

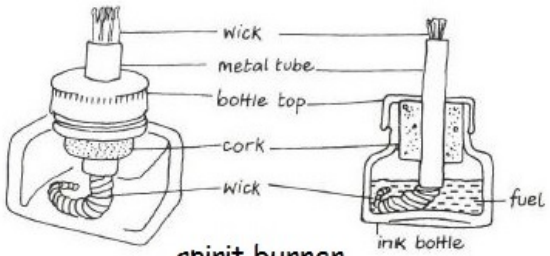
A.20 Heat Sources

Use: Heating substances
Materials: Candles, kerosene stoves, charcoal burners, Motopoa (alcohol infused heavy oil), butane lighters, spirit burners, metal can, bottle caps Motopoa provides the best compromise heat source - it is the easiest to use and safest heat source with locally available burners.
Procedure: Cut a metal can in half or use a bottle cap and add a small amount of Motopoa.
Safety: Always have available fire-fighting equipment that you know how to use. Remember that to put out a Bunsen burner safely, you need to turn off the gas.





charcoal burner



spirit burner

A.20.1 Heating Solutions

The ideal heat source has a high heat rate (Joules transferred per second), little smoke, and cheap fuel, i.e. Motopoa. A charcoal stove satisfies all of these but takes time to light and requires relatively frequent re-fueling. Kerosene stoves have excellent heat rates but are smoky.

A.20.2 Heating Solids

The ideal heat source has a high temperature and no smoke, i.e. a Bunsen burner. For heating small objects for a short time (no more than 10-20 seconds), a butane lighter provides a very high temperature. Motopoa will provide a flame of satisfactory temperature for as long as necessary.

A.20.3 Flame Tests

The ideal heat source has a high temperature and produces a non-luminous flame, i.e. a Bunsen burner. Motopoa is next best hot and non-luminous. Spirit burners produce a non-luminous flame at much greater cost, unless methylated spirits are used as fuel in which case the flame is much cooler. A butane lighter produces a very hot flame of sufficient size and time for flame tests although the non-luminous region is small. Kerosene stoves will work for some salts.

A.21 Indicator

Use: Determine presence of acid or base, determine pH

Materials: Rosella leaves, hot water, bottle

Procedure: Place some coloured leaves into a bottle of warm water to extract the colour. Use a straw to drop onto solutions or prepare indicator paper by dipping thing strips into the coloured solution. Rosella turns red for acids and greenish blue for bases.

A.22 Iron Filings

Use: To map magnetic fields

Materials: Steel wool / Iron wool used for cleaning pots

Procedure: Rub some steel wool between your thumb and fingers. The small pieces that fall are iron filings. Collect them in a matchbox or other container to use again.

A.23 Masses

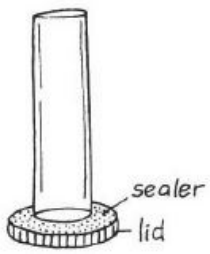
See Weights (p. 18).

A.24 Measuring Cylinder

Use: Measuring volume

Materials: Plastic bottles of different sizes, syringes (10 mL - 50 mL), fluorescent light tubes, marker pen, ruler, bucket of water

Procedure: Using the syringe, transfer a known volume of water from the bucket to the empty bottle. Use the marker pen to mark the level of water on the bottle. Repeat for a range of volumes, using a ruler to complete the scale.



A.25 Metre Rule

Use: Measuring length

Materials: Slabs of wood, ceiling board, permanent pen

Procedure: Buy one, take it and a permanent

pen to a carpenter, and leave with twenty. Measure each new one to the original rule to prevent compounding errors.

A.26 Microscope

See ?? (p. ??).

A.27 Mortar and Pestle

Use: To powder chemicals
Materials: 2 metal spoons, glass bottle
Procedure: Place chemicals between two nested metal spoons and grind down. Alternatively, crush chemicals on a sheet of paper by pressing on them with the bottom of a glass bottle.

A.28 Nichrome Wire

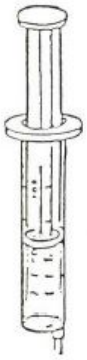
For flame tests in chemistry, you can use a steel wire thoroughly scraped clean with iron or steel wool. For physics experiments, see Wire (p. 18).

A.29 Optical Pins

Use: Compass needles, making holes, dissection, mirror practicals
Materials: Office pins, sewing needles, needles from syringes

A.30 Pipettes

Use: Transferring small amounts of liquid
Materials: Disposable plastic syringes (1, 2, 5, 10, 20, 25, 30 and 50 mL sizes)
Procedure: Suck first 1 mL of air and then put the syringe into the solution to suck up the liquid. There should be a flat meniscus under the layer of air.
Safety: Avoid standard pipettes to eliminate danger of mouth pipetting.



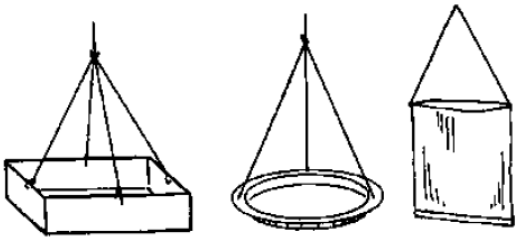
A.31 Retort Stand

Use: To hold springs, burettes, pendulums or other objects
Materials: Filled 1.5 L water bottle, straight bamboo stick, tape, marker
Procedure: Tape the bamboo stick across the top of the water bottle so that it reaches out 20 cm to one side. Attach a small clamp if required or hang the object directly from the bamboo stick.

Alternatively, place a 1 cm piece of reinforcing rod in a paint can full of wet cement and let it dry. Then attach a boss head and clamp.

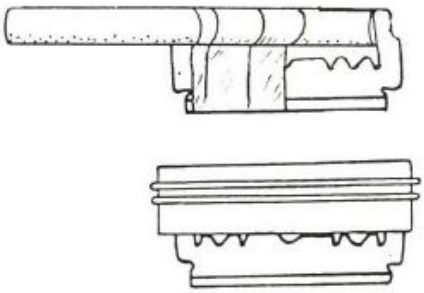
A.32 Scale Pans

Use: Beam balance
Materials: Plastic bottle, cardboard box, string
Procedure: Cut off the bottom of a plastic bottle or cardboard box. Poke 3 or more holes near the top and tie string through each hole. Join strings and tie at the top to hang from a single point.



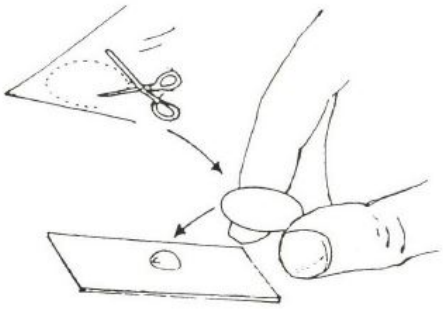
A.33 Scalpels

Use: Dissection
Materials: Razor blades, tongue depressors, super glue
Procedure: Add a handle by gluing a tongue depressor on either side of the razor blade. Hold together with a rubber band until dry.
Safety: Dull blades should be discarded. Because students need to apply more pressure when using them, there is a greater risk of slipping and thus of cuts. Sharp tools are much safer.



A.34 Slides and Cover Slips

Use: Microscopy
Materials: Small pieces of glass, stiff plastic
Procedure: Small piece of glass provides a slide for mounting the specimen. Cover slips can be made from thin (but stiff) transparent plastic from display packing or bottles. Cut into small squares or circles.



A.35 Spatula

Use: Transferring salts
Materials: Stainless steel spoons
Procedure: Use the handle end to remove salts from containers.
Safety: Clean all metal tools promptly after using with hydroxide, potassium manganate (VII), or manganese (IV) oxide. If the spoon corrodes, scrape with another spoon or steel wool.

A.36 Springs

Use: Hooke's Law, potential energy, work, spring balance
Materials: Springs from hardware stores, bike stores, junk merchants in markets, window blinds; stiff wire; rubber bands; strips of elastic
Procedure: Remove plastic covering if necessary and cut to a desired length (5 cm). Alternatively wind a stiff wire around a marker pen or use rubber bands or elastic from a local tailor.

A.37 Stoppers

Use: To cover the mouth of a bottle, hold a capillary tube
Materials: Rubber from old tires or sandals, cork, plastic bottle cap, pen tube, super glue
Procedure: Cut a circular piece of rubber. If the stopper is being used to hold a capillary tube, a hole can be melted in a plastic cap or rubber stopper. Alternatively, super glue a pen tube to a plastic bottle cap and connect to rubber tubing.

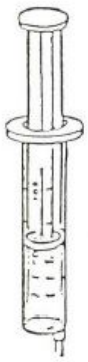
A.38 Stopwatches

Use: Simple pendulum, velocity, acceleration
Materials: Athletic and laboratory stopwatches from markets, digital wristwatches

A.39 Test Tubes

A.39.1 Plastic Test Tubes

Use: To heat materials without a direct flame, to combine solutions
Materials: 10 mL syringes, matches
Procedure: Remove the needle and plunger from 10 mL syringes. Heat the end of the shell with a match until it melts. Press the molten end against a flat surface (like the end of the plunger) to fuse it closed. If the tube leaks, fuse it again. Test tubes made this way may be heated in a water bath up to boiling, hot enough for most experiments.

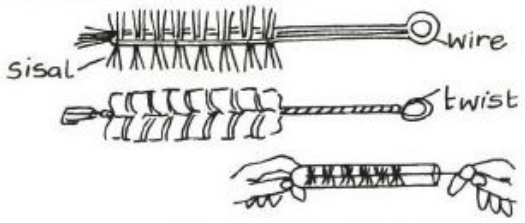


A.39.2 For Thermal Decomposition

See Deflagrating Spoon (p. 11).

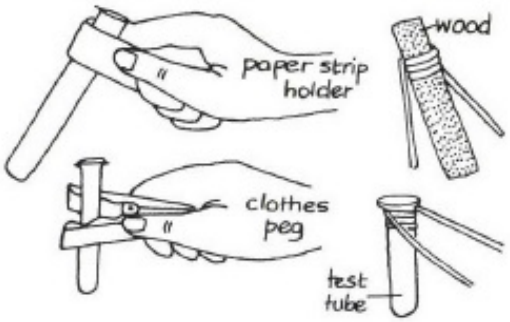
A.40 Test Tube Brush

Use: Cleaning test tubes
Materials: Sisal, wire
Procedure: Twist the wire around the sisal as shown or put a little sand in the test tube as an abrasive.



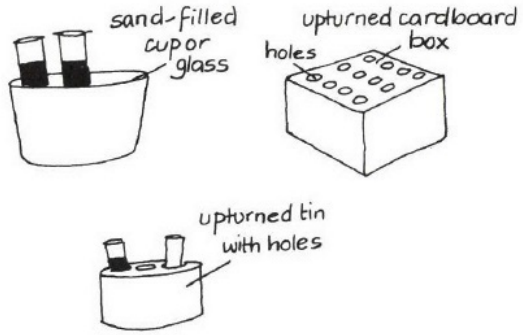
A.41 Test Tube Holder / Tongs

Use: To handle test tubes
Materials: Wooden clothespins, stiff wire, strip of paper or cloth
Procedure: Use clothespins or stiff wire for prolonged heating, or strips of paper or cloth for short-term heating.



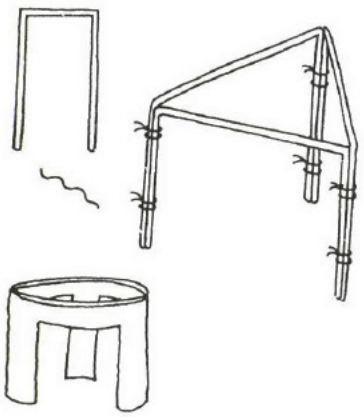
A.42 Test Tube Racks

Use: To hold test tubes vertically in place
Materials: Wire grid from local gardening store, styrofoam block, plastic bottle, sand, knife
Procedure: Fold a sheet of wire grid to make a table; punch holes in a piece of styrofoam; cut a plastic bottle in half and fill it with sand to increase stability. Or cut a plastic bottle along its vertical axis and rest the two cut edges on a flat surface. Cut holes into it for the test tubes.



A.43 Tripod Stands

Use: For supporting containers above heat sources, for elevating items
Materials: Stiff wire, metal rods, tin can
Procedure: Join bent pieces of thick wire together. Or cut the sides of a tin can to leave 3 legs.



A.44 Volumetric "Glass"ware

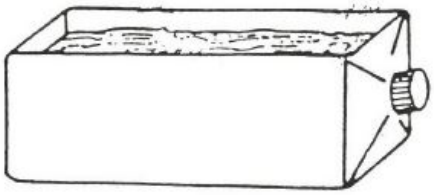
See Containers (p. 11).

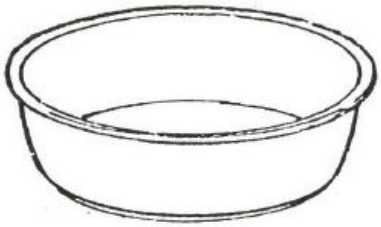
A.45 Wash Bottle

Use: Washing hands after experiments
Materials: Water bottle, detergent, needle
Procedure: Put a hole in the cap of a water bottle using a syringe needle.

A.46 Water Bath

Use: To heat substances without using a direct flame
Materials: Heat Sources, water, cooking pot
Procedure: Bring water to a boil in a small aluminum pot, then place the test tubes in the water to heat the substance inside the test tube. Prevent test tubes from falling over by clamping with clothespins or placing parallel wires across the container.





A.47 Weights

A.47.1 Crude Weights

Use: Concept of units, mass, weight
Materials: Batteries, coins, glass marbles from town, etc.
Procedure: Use objects of unknown mass to create new units and impart the concept of unit measure.

A.47.2 Adding Weight in Known Intervals

Use: Hooke's Law practical
Materials: Water bottles, syringe
Procedure: Consider "zero added mass" the displacement of the pan with an empty water bottle. Then add masses of water in g equal to their volumes in mL (e.g. 50 mL = 50 g).

A.47.3 Precise Weights

Materials: Plastic bags, sand, stones, 250 mL water bottles (all identical), tape, pen
Procedure: Use a beam balance and known masses at a market or nearby school to measure exact masses of bags of sand or stones. Use a marker pen to mark the masses on the bags.

If using water, use a beam balance from a nearby school to measure the exact mass of an empty water bottle. Add a volume of water in mL equal to the mass in g needed to reach a desired total mass. (The density of water is 1.0 g/mL.) This can be done precisely by using a plastic syringe. Label the bottle with tape and a pen.

A.48 White Tiles

Use: Titration
Materials: White paper
Procedure: If students are using syringes as burettes, they can also hold their flask up against a white wall.

A.49 Wire

A.49.1 Connecting Wires

Use: Connecting circuit components, current electricity
Materials: Speaker wire, knife
Procedure: Speaker wire can be found at any hardware store or taken from old appliances - the pairs of colored wires brained together. Strip using a knife, scissors or a wire stripper.

A.49.2 Specific Gauge Wire

Use: Electrical components, motors, transformers, simple generators
Materials: Copper wire without plastic covering (transformer wire), knife/scissors, matches
Procedure: Scrape or burn off the insulating varnish at any points you wish to make electrical contact. These wires come in a variety of diameters (gauges). A useful chart for converting diameter to gauge may be found at http://www.dave-cushman.net/elect/wiregauge.html. If the wire is sold by weight, you can find the length if you know the diameter - the density of copper metal at room temperature is 8.94 g/cm^3. For example, with 0.375 mm wire, 250 g is about 63 metres.

A.50 Wire Gauze

Use: Placing objects over heat
Materials: Tin can lid
Procedure: Poke holes in a tin can lid.