XII. MULTIPURPOSE SYRINGES

Many chemical techniques and experiments are readily performed using disposable plastic syringes. Some of these uses will be described in this section, and the devices have been grouped according to the concepts they illustrate. In addition to those uses given here, syringes can also be used in column chromatography, ion exchange devices, and other areas in chemistry.

A. TECHNICAL DEVICES

Two items of use in the chemistry laboratory are included here.

B. GAS STUDIES APPARATUS

Included here are several ways in which syringes may be used in studying the production, collection, and properties of gases.

C. DIFFUSION APPARATUS

Diffusion of both gases and liquids can easily be studied with the aid of plastic syringes.

D. OXIDATION APPARATUS

This section describes a number of devices used in the study of oxidation reactions.

E. ANALYTICAL APPARATUS

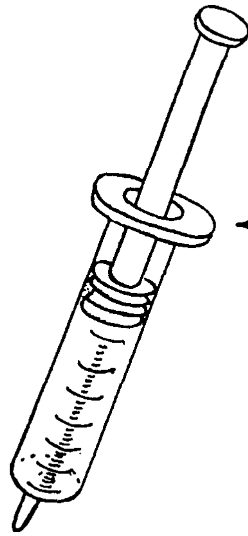
These devices are used in experiments to determine chemical formulae, structures, and molecular weight.

F. CONDUCTANCE APPARATUS

The variation in conductivity of different solutions can be studied with the aid of several devices which are fairly easily constructed with disposable syringes.

A. TECHNICAL DEVICES

Al. Dropper/Pipette



a. Materials Required

Components	Qu	Items Required	Dimensions
(1)Syringes	1	Plastic Disposable Syringe (A)	Capacity 10-50 ml

b. Construction

(1) Syringe

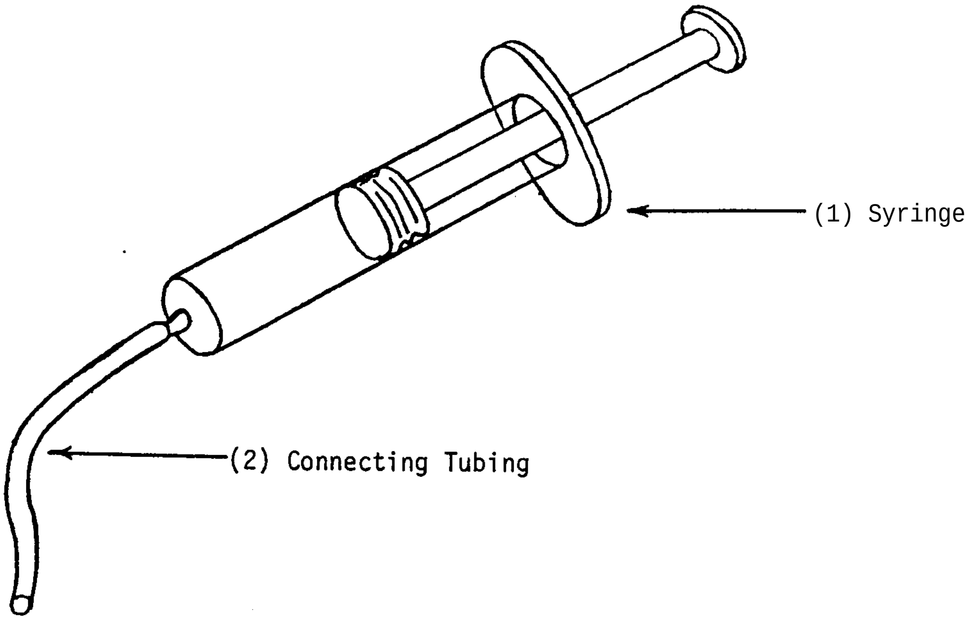
Select a calibrated, plastic disposable syringe (A) with a volume appropriate for the desired use.

c. Notes

(i) In the smaller sizes, disposable syringes make excellent droppers with an advantage being that the amount dispensed is measurable. Similarly, they can be used for the same purposes for which pipettes are used. In the larger sizes, syringes can substitute for burettes in titration experiments. Finally, syringes may be utilized in calibrating improvised flasks, beakers, etc., of unknown capacity.

(ii) Placing a medium-sized diameter needle (inside diameter approximately 0.03 cm) on the syringe nozzle will allow solutions to be carefully and accurately delivered, drop by drop.

A2. Pump



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Syringe	1	Plastic Disposable Syringe (A)	Capacity approximately 20 ml
(2) Connecting Tube	1	Plastic or Rubber Tubing (B)	Approximately 10 cm long, diameter to fit syringe nozzle (A)

b. Construction

(1) Syringe

Take a plastic, disposable syringe (A) with a volume appropriate for the desired use.

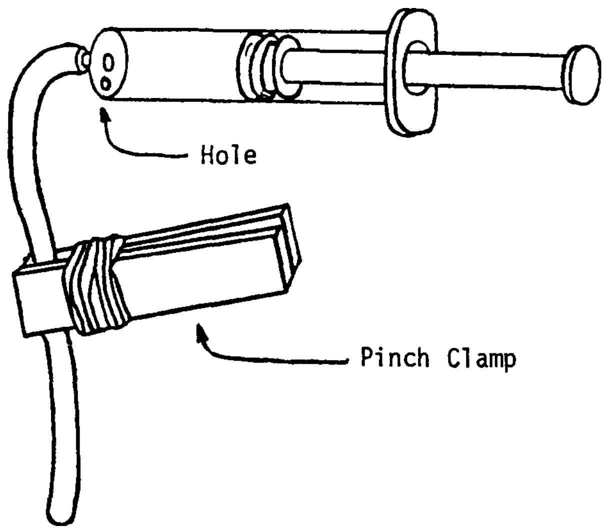
(2) Connecting Tubing

Attach a length of plastic or rubber tubing (B) to the syringe nozzle when the pump is to be used in hard-to-reach places.

c. Notes

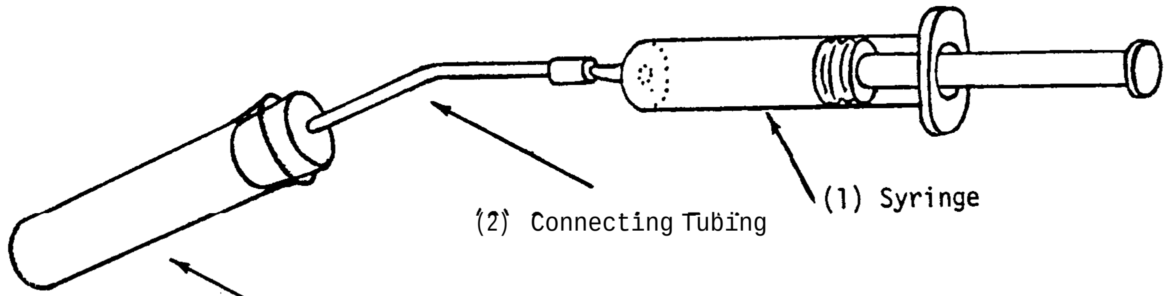
(i) To use the pump, connect the tubing to the object from which gas or liquid is to be removed. Withdraw the plunger to draw gas or liquid into the syringe. Then remove the tubing from the object or container, direct the tubing into an appropriate container or waste receptacle , and depress the plunger to expel1 the gas or liquid through the tubing.

(ii) With two modifications, the syringe may be used to provide continuous pumping action without removing the tubing from the object from which substances are pumped. Make a small hole in the base of the syringe barrel with a drill or hot wire, and add a pinch clamp (IV/A4) to the tubing to close it off. In use, the tubing is connected to the object from which gas or liquid is to be removed. Then the pinch clamp is removed from the tubing and the hole in the syringe barrel is covered with a finger. The plunger is withdrawn to draw material into the syringe. To expel1 the contents of the syringe through the hole, the tubing is closed with the pinch clamp, the hole is uncovered, and the plunger is depressed.



B. GAS STUDIES APPARATUS

B1 Gas Production and Collection Device *



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Syringe	1	Plastic Disposable Syringe (A)	Capacity 10-50 ml
(2) Connecting Tube	1	Rubber or Plastic Tubing (B)	2 cm long, diameter to fit syringe nozzle (A)
	1	Glass Tubing (C)	Approximately 0.5 cm diameter, 10 cm long
(3) Reaction Chamber	1	Hard Glass Test Tube or Flask (D)	Capacity 20-100 ml
	1	l-Hole Stopper (E)	To fit test tube or flask (D)

b. Construction

(1) Syringe

Select a plastic, disposable syringe (A) of appropriate capacity.

(3) Connecting Tubing

Connect the short piece of flexible rubber or plastic tubing (B) to the syringe nozzle.

Heat the glass tubing (C) sufficiently to bend it to a slight angle (about 30°). Connect

*Adapted from Paul D. Merrick, Experiments with Plastic Syringes, (San Leandro, California: Educational Science Consultants, 1968), p 19.

one end of the glass tubing to the rubber or plastic tubing (B).

(3) Reaction Chamber

Seal a hard glass test tube or flask (D) (capacity from 20 to 100 ml, depending on the desired use) with a one-hole stopper (E). Use a rubber stopper if caustic materials are to be used in the apparatus. Insert the free end of the glass tubing into the hole in the stopper.

c. Notes

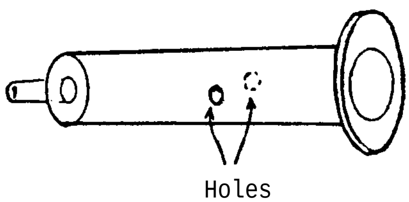
(i) This simple reaction apparatus, suitable for either lecture demonstration or student laboratory use, may be employed in a number of ways. In the simplest qualitative experiments, the use of the syringe allows liquids to be introduced into the reaction chamber where they react with solids or other liquids. A number of gases can be produced using this or similar devices. For example, injecting a 3% solution of hydrogen peroxide from the syringe into a suspension of dried yeast and water in the test tube will yield oxygen gas. Also, injecting a concentrated solution of baking soda from the syringe into vinegar will yield carbon dioxide. Finally, injecting vinegar into water and a piece of magnesium ribbon will cause hydrogen gas to be liberated. The gas liberated will collect in the syringe, pushing the plunger out as more and more gas is given off. Turning the plunger slightly will assure that the gas is at atmospheric pressure.

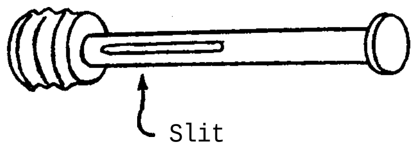
(ii) This apparatus may also be used for quantitative studies in the above reactions. The solid reactants must be carefully weighed or measured, and the use of the syringe allows very precise amounts of liquids to be introduced into the reaction chamber. The volume of the gas evolved may be read from the syringe. The change in volume of gas in the syringe may be plotted against time to give a measure of the rate of reaction. In addition, the volume of gas liberated may also be plotted as a function of temperature and/or the concentration of one or more of the reactants used.

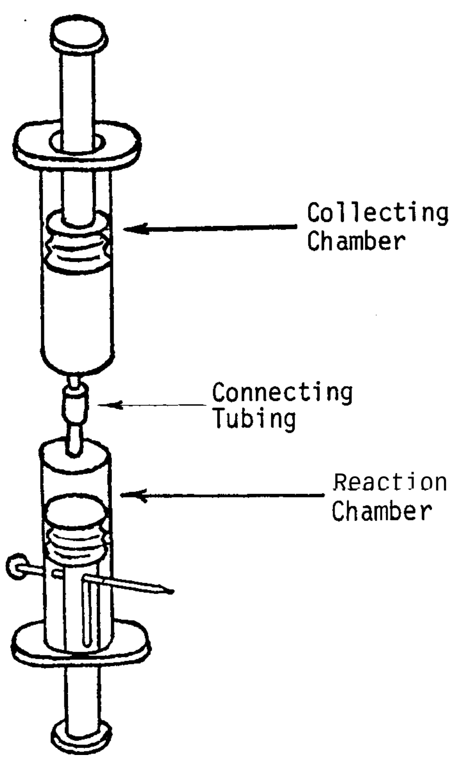
(iii) In a third type of experiment using this apparatus, solids which give off gases when heated are placed in the test tube, and the gas is collected in the syringe. Begin with the syringe plunger fully depressed, and as the gas is evolved, it will push the plunger back, giving a quantitative measure of the amount of gas produced. In using this device, clamps to hold both the test tube and syringe are needed. As an example, red lead can be heated in the test tube, and the gas evolved collected in the syringe. It should be noted, however, that this will spoil the test tube. Instead, potassium permanganate can be used, and no spoilage of the test tube will occur. However, some asbestos wool must be put in the upper end of the test tube to prevent pieces of the potassium permanganate from entering the syringe.

(iv) The experiments based on the use of this apparatus are adapted from Nuffield O-Level Chemistry, Collected Experiments, (London: Longmans/Penguin Books, 1967), pp 9, 229-231, 297-299.

(v) If a glass reaction chamber is not available or is not desired, a second syringe, the same size as the first but slightly modified, may be substituted. First, with a hand drill or hot nail or wire, bore two holes, approximately 0.3 cm in diameter, opposite each other about half-way along the length of the barrel. With a drill and saw or hot nail, make a slit in the syringe plunger as shown. Push the plunger into the syringe, and lock it in place by inserting a nail approximately 0.3 cm wide and 5 cm long through the holes in the barrel and slit in the plunger. Place in the lower syringe a small piece of material which will react with the liquid to be placed in the upper syringe. Replace the plunger in the lower syringe, insert the nail stop, and depress the plunger until the nail prevents further movement. Draw a quantity of liquid into the upper syringe, and fasten the two together with the short piece of tubing. Next, inject all of the liquid into the lower syringe and



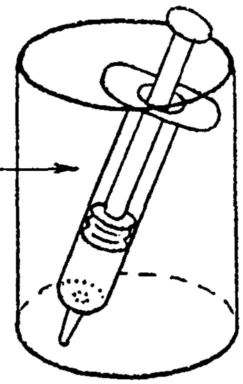




leave the upper syringe plunger in the depressed position. As gas is given off in the lower syringe, it will expand and push out the plunger of the upper syringe until the upper syringe is filled with gas or the reaction stops. Solids and liquids which can be used as outlined to produce gases include animal charcoal and hydrogen peroxide (to form oxygen), metals and dilute acids, carbonates and acids.

(vi) The above modification is based on a design by Andrew Farmer, "The Disposable Syringe--A Rival to the Test Tube?," School Science Review, CLXXIV (1969), 30-31.

B2. Micro-Generator *



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Syringe	1	Disposable Plastic Syringe (A)	Capacity 10-50 ml
(2) Beaker	1	Glass Jar or Beaker (B)	To accommodate syringe as shown

b. Construction

(1) Syringe

Select a plastic, disposable syringe (A) of a size appropriate to the amount of gas desired.

(2) Beaker

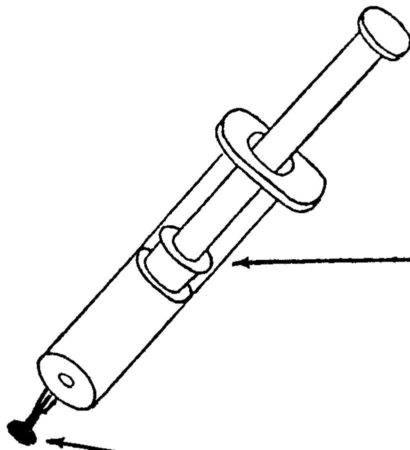
Select a glass jar or beaker (B) such that the syringe can be rested in it more or less vertically.

C. Notes

(i) As an example of its use, the micro-generator can be employed to generate hydrogen sulphide gas (H_2S). Simply place a small piece of ferrous sulphide in the syringe, and put a small amount of dilute hydrochloric acid in the beaker. Draw a portion of the acid up into the syringe until it touches the ferrous sulphide, and leave the syringe resting in the beaker. The gas will collect in the syringe, above the acid. If desired, the needle may be reattached to the syringe when it comes time to bubble the gas through a test solution.

*Adapted from L. A. George, "Two Further Uses for Disposable Syringes," School Science Review, CLXX (1968), 113.

B3. Gas Solubility Device/Reaction Rate Chamber



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Syringe	1	Plastic Disposable Syringe (A)	Capacity approximately 25 ml
(2) Plug	1	Nail (B)	To fit syringe nozzle (A)

b. Construction

(1) Syringe

Take a plastic, disposable syringe (A) of 25 ml or other desired capacity.

(2) Plug

Use the nail (B) to completely seal the syringe after a substance has been drawn into it.

c. Notes

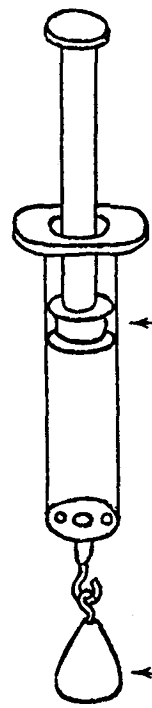
(i) A number of simple solubility experiments may be done with syringes that can be sealed airtight. For example, the syringe may be half filled with cold water, with the plunger just above the water level. Seal the nozzle, and when the plunger is withdrawn further, air will be seen to bubble out of the water. This same demonstration may be repeated with distilled water, or cold water through which CO_2, O_2, N_2, etc., have been bubbled. A slightly more sophisticated demonstration involves water through which has been bubbled for about five minutes. When a small amount of bromothymol blue is added, the solution will be yellow. Add this to a sealed syringe, and as the plunger is withdrawn, CO_2 will bubble out and the color of the solution will change to pale green. If the syringe is shaken, the CO_2 will be redissolved, and the solution will once again be yellow. The experiment may be tried repeatedly.

(ii) A single syringe can also be used to illustrate the effect of pressure on solubility. Attach a short length of rubber tubing to the nozzle, and also attach a clamp or piece of wire to the rubber tube which can be used to close the tube. Fill the syringe half full of water, and fill the remainder of the barrel with CO_2. Shake the syringe vigorously, then hold the tube under water, release the clamp (or loosen the wire), and note the rise in water level in the syringe. Repeat the experiment, but depress the syringe plunger while shaking it. There will be a noticeable difference in the rise of the water level.

(iii) The above experiments have been adapted from Andrew Farmer, "The Disposable Syringe--A Rival to the Test Tube?," School Science Review, CLXXIV (1969), 35-37.

(iv) Another experiment that can be performed with the sealed syringe involves the relationship between reaction rate and pressure. Fill the syringe partially with vinegar and add sodium bicarbonate. Carbon dioxide will be given off, and this reaction can be speeded up or slowed down and stopped by decreasing or increasing the internal pressure with the plunger, respectively. This experiment is based on Paul D. Merrick, Experiments with Plastic Syringes, (San Leandro, California: Educational Science Consultants, 1968), p 6.

B4. Charles' Law: Volume/Temperature Device *

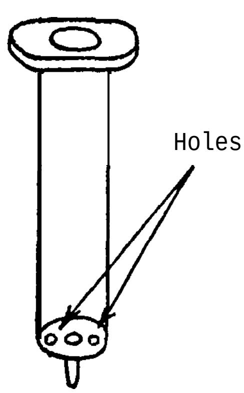


a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Syringe	1	Plastic Disposable Syringe (A)	Capacity 35 ml
	1	Small Eyed Screw (B)	To seal syringe nozzle (B)
(2) Weight	1	Lead Sinker or Weight (C)	Approximately 30 g

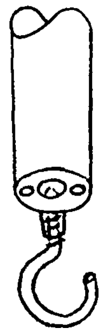
b. Construction

(1) Syringe



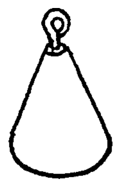
Make two small holes in the bottom of the syringe barrel (A) with a hand drill or hot wire.

*Adapted from Paul D. Merrick, Experiments with Plastic Syringes, (San Leandro, California: Educational Science Consultants, 1968), p 32.



Screw a small, eyed screw (B) into the syringe nozzle to seal the nozzle and to provide an attachment for the weight (C).

(2) Weight



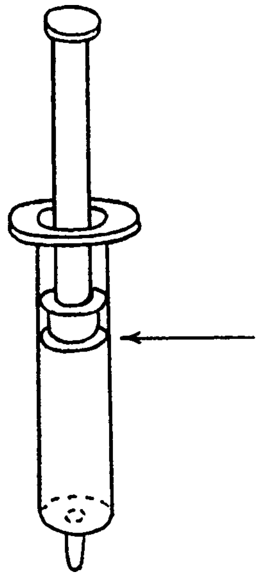
Hang a lead sinker (C) or other suitably sized weight (approximately 30 g) from the eyed screw.

C. Notes

(i) With the plunger set so that a 35 cc volume of air is trapped in the syringe barrel, the device is put into a container of hot water. Water will be seen to enter the syringe barrel as the expanding air leaves it through the small holes (the effect will be more visible if a drop of vegetable dye is placed in the nozzle depression before beginning). Varying amounts of water will enter the syringe depending upon the water temperature. Good quantitative data can be gotten by comparing the water temperature with the amount of water entering the syringe (or the air volume of the syringe after the water enters). The device should be removed from the water to return the air volume to its original reading for each temperature/pressure reading.

C. DIFFUSION APPARATUS

Cl. Liquid Diffusion Device



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Syringe	1	Plastic Disposable Syringe (A)	Capacity approximately 50 ml

b. Construction

(1) Syringe

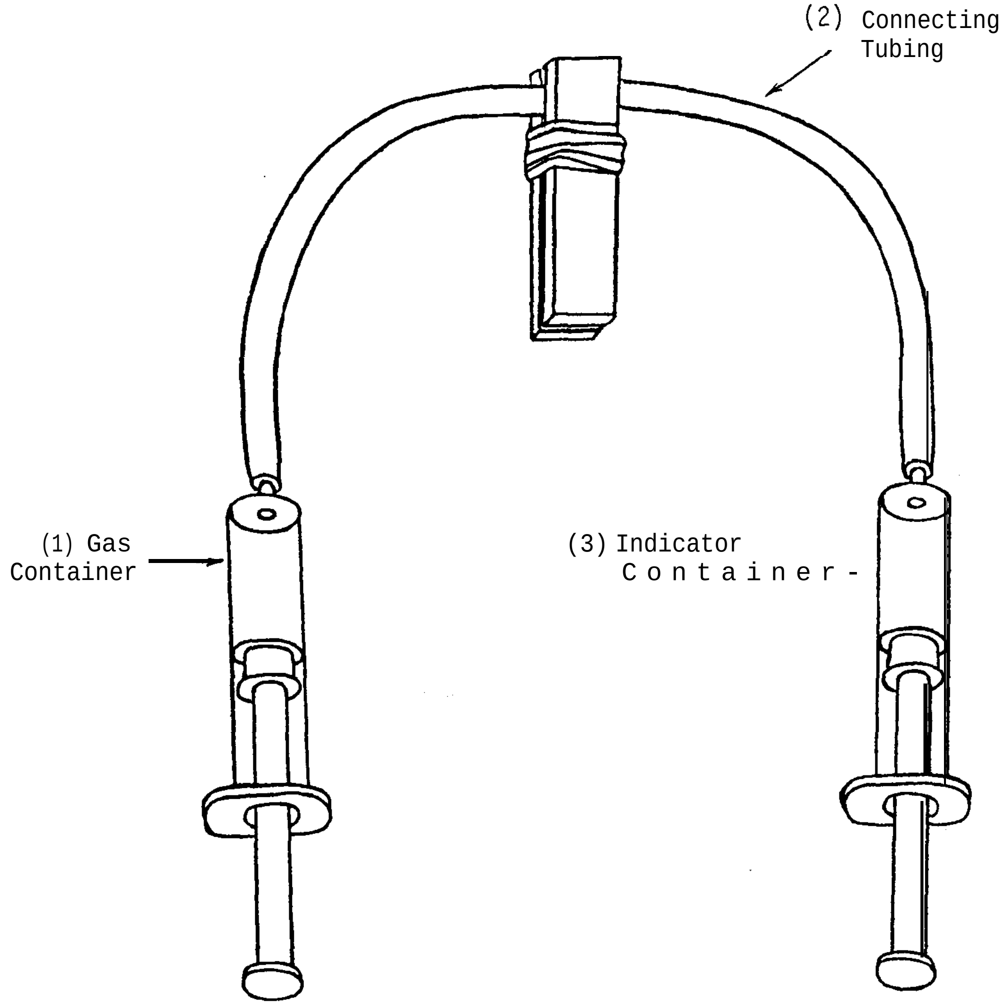
Select a plastic, disposable syringe (A) of a large capacity (35 - 50 ml, for example).

c. Notes

(i) To use this device to study diffusion of liquids, fill the syringe almost completely with cold water. Then, draw a small amount of colored solution into it and let the'syringe stand. Diffusion should be complete after two or three days. Colored solutions which work well include potassium permanganate and copper sulphate.

(ii) This experiment has been adopted from Andrew Farmer, "The Disposable Syringe: Additional Experiment," School Science Review, CLXXVIII (1970), 60.

C2. Gas Diffusion Device *



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Gas Container	1	Plastic Disposable Syringe (A)	Capacity approximately 25 ml
(2) Connecting Tubing	1	Rubber or Plastic Tubing (B)	Approximately 15 cm long, diameter to fit syringe nozzles
	1	Pinch Clamp (C)	IV/A4
(3) Indicator Container	1	Plastic Disposable Syringe (D)	Capacity approximately 25 ml
	--	Indicator Solution (E) (Limewater or Litmus Solution)	Approximately 5 ml

*Adapted from Andrew Farmer, "The Disposable Syringe--A Rival to the Test Tube?," School Science Review, CLXXIV (1969), 35.

b. Construction

(1) Gas Container

Select a plastic, disposable syringe (A) of about 25 ml capacity.

(2) Connecting Tubing

Use a length of flexible tubing (B) to connect the two syringes together. Make a pinch clamp (C) or use another suitable clamp to close the tubing.

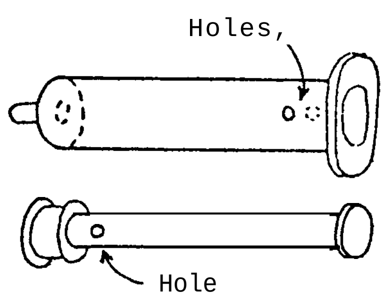
(3) Indicator Container

Select a plastic, disposable syringe (D) with the same capacity as that used for the gas container. Fill it with the indicator solution (E).

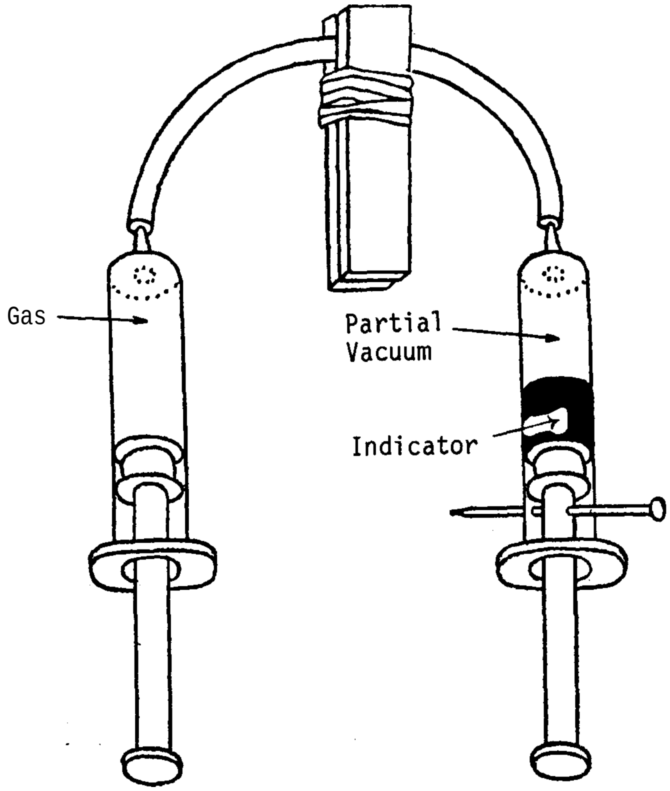
c. Notes

(i) Place an indicator solution (e.g., limewater) in the indicator container. A gas (e.g., CO_2) is collected in the gas container syringe and the two syringes are connected by the tubing. When the clamp is released, the gas will diffuse until it reaches the indicator solution and causes a reaction (white precipitate when CO_2 meets limewater). The time taken for the gas to diffuse may be measured.

(ii) A slight modification of the indicator container will allow a comparison of gas diffusion rates in air and in a partial vacuum. This is done by making two holes opposite each other near the mouth of the syringe barrel with a hand drill or heated nail. Then one hole is made in the plunger, as shown. The holes should be made so that a nail can be pushed through the barrel and plunger.

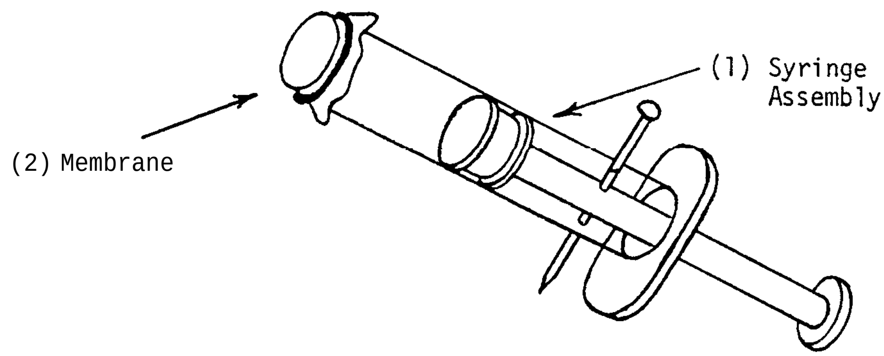


To repeat the above experiment with a partial vacuum, the nail is removed from the indicator syringe and several ml of indicator solution are drawn into the syringe. Then the tubing, closed by the clamp, is attached to the syringe. With the clamp in place the plunger is pulled back, to create a partial vacuum, and the nail is pushed through the syringe barrel and plunger to hold the plunger in position. Gas is collected in the other syringe and allowed to diffuse to the indicator solution, and the time taken is compared to the results of the first experiment.



D. OXIDATION APPARATUS

Dl. Oxidation Indicator: Membrane Type *

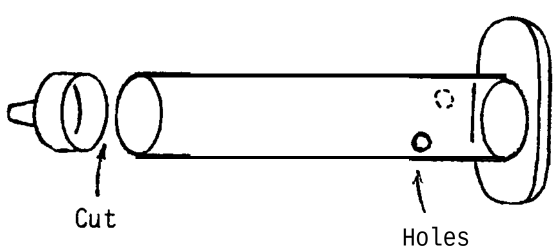


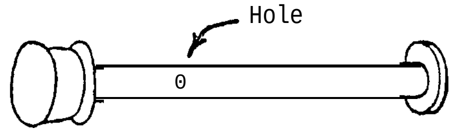
a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Syringe Assembly	1	Plastic Disposable Syringe (A)	Capacity 25-50 ml
	1	Nail (B)	Approximately 0.2 cm diameter, 4 cm long
(2) Membrane	1	Thin Sheet Rubber (C)	Approximately 5 cm x 5 cm
	1	Rubber Band or Thin Wire (D)	--

b. Construction

(1) Syringe Assembly





Take a medium to large capacity (25 - 50 ml) plastic, disposable syringe (A). Cut off the end of the barrel near the nozzle. Then, with a hand drill or hot nail, make two holes approximately 0.3 cm in diameter opposite each other near the mouth of the barrel.

In the same fashion, make one hole in the stem of the plunger, near the plug, as shown.

*Adapted from Paul D. Merrick, Experiments with Plastic Syringes, (San Leandro, California: Educational Science Consultants, 1968), p 6.

Insert the plunger into the syringe barrel, and push the nail (B) through the holes in the barrel and plunger to fix the plunger in position.

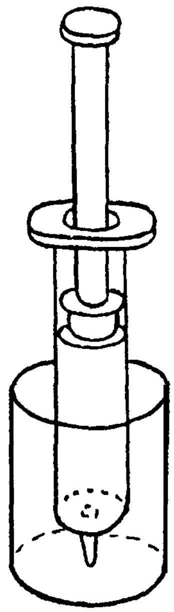
(2) Membrane

Cut a 5 cm x 5 cm square of thin sheet rubber (C) (from a toy balloon, for example). Stretch it over the open end of the syringe barrel and secure it in place with a rubber band (D) or length of thin wire.

C. Notes

(i) This simple device will give a visual indication that oxidation is taking place. For example, if wet steel wool or a piece of cotton soaked in alkaline pyrogallol [Note (i) XII/D41 is inserted into the barrel of the syringe and the plunger fixed in place with the nail , as the material reacts with the oxygen in the air the pressure inside the syringe will gradually be lowered. This can be seen since the rubber sheet will be pulled further and further into the syringe.

D2. Oxidation Indicator: Displacement Type *



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Syringe	1	Plastic Disposable Syringe (A)	Capacity approximately 35 ml
(2) Beaker	1	Jar or Beaker (B)	To support syringe

b. Construction

(1) Syringe

Select a plastic, disposable syringe (A) of medium to large capacity (35 - 50 ml). No modifications are necessary.

(2) Beaker

Choose a small glass jar (B), beaker, or other container that will support the syringe, as shown.

c. Notes

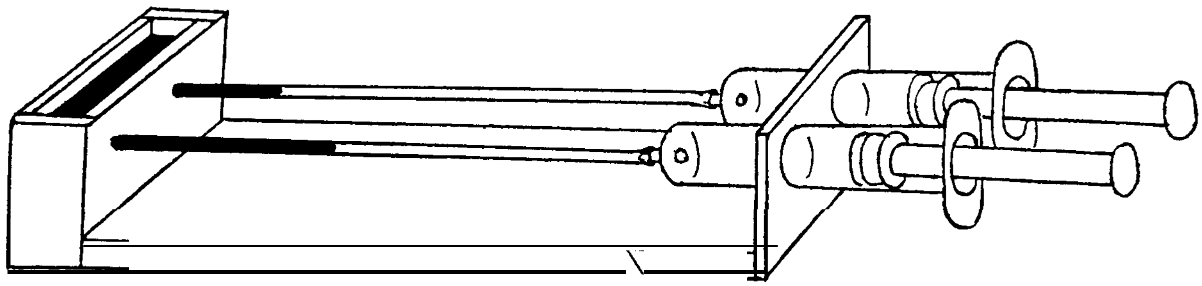
(i) Place a portion of wet steel wool (it may have to be washed in vinegar to remove the anti-rust coating) in the syringe barrel and position the plunger

*Adapted from Paul D. Merrick, Experiments with Plastic Syringes, (San Leandro, California: Educational Science Consultants, 1968}, p 2.

so that some predetermined air volume is trapped in the syringe. Place the syringe into a small amount of water in the beaker so that the nozzle is under water. As the steel wool reacts with the oxygen in the air, pressure inside the syringe will drop and water will be drawn up into the syringe barrel. Dyeing the water with non-fast vegetable dye will make the visual display more evident.

Cotton wool or other absorbent material soaked with alkaline pyrogallol [Note (i) XII/D4] may be substituted for the wet steel wool.

D3. Oxidation Rate Indicator *



(1) Indicator

a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Indicator	1	Respirometer	BIOL/VIII/Dl(l)

b. Construction

(1) Indicator

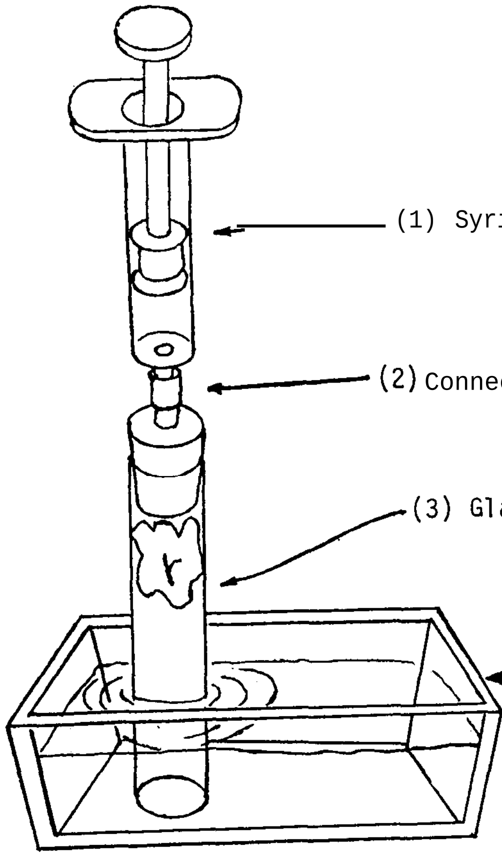
Construct this item according to directions given for the Respirometer, BIOL/VIII/Dl(l).

c.Notes

(i) Begin operation of this device by fastening the plastic tubing to the reservoir and to the nozzles of the syringes. Fill the reservoir with water which has been colored with non-fast vegetable dye. Items which react with oxygen in the air, including wet steel wool, white phosphorus, or alkaline pyrogallol (soaked cotton wool), are placed in the barrel of one syringe, where they react, removing oxygen from the trapped air. This results in a lowering of pressure which causes the colored water to be drawn from the reservoir into the clear tubing. The second syringe serves as a control, containing only air. The rate of the reaction can be judged from the speed with which the water column moves toward the syringe.

*Adapted from Paul D. Merrick Experiments with Plastic Syringes, (San Leandro, California: Educational Science Consultants, 1968), p 11.

D4. Stoichiometry Device *



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Syringe	1	Plastic Disposable Syringe (A)	Capacity 10 ml or more
(2) Connecting Tube	1	Rubber or Plastic Tubing (B)	To fit syringe
	1	Glass Tubing (C)	0.5 cm diameter, 2 cm long
(3) Glass Tube	1	Glass Tubing (D)	2-3 cm diameter, 10 cm long
	1	l-Hole Stopper (E)	To fit large tubing
	--	Cotton (Cotton Wool) (F)	--
(4) Water Container	1	Pan or Tray (G)	Capacity approximately 1 liter

*From Paul D. Merrick, Experiments with Plastic Syringes, (San Leandro, California: Educational Science Consultants, 1968), p 19.

b. Construction

(1) Syringe

Select as many plastic, disposable syringes (A) of the same capacity (approximately 10 ml) as desired.

(2) Connecting Tubing

Connect the short rubber or plastic tubing (B) to the syringe nozzle. Connect the free end of the rubber or plastic tube to the short piece of glass tubing (C).

(3) Glass Tubing

Seal one end of a large diameter glass tube (D) with a one-hole stopper (E) and insert the glass tube (C) into the hole in the stopper.

Push a small wad of cotton (F) (cotton wool) into position near the top of the glass tube, below the stopper.

(4) Water Container

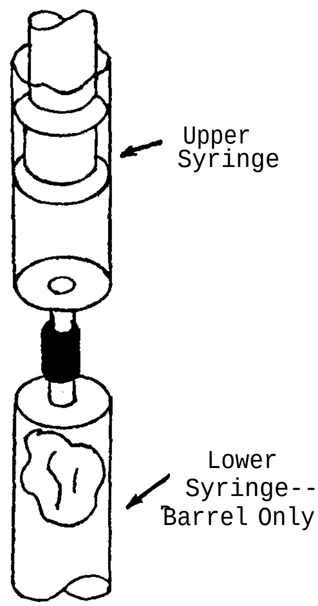
For the water container, use a pan, tray, jar, or beaker (G) into which the desired number of syringe assemblies can be filled.

c. Notes

(i) An alkaline pyrogallol solution must be prepared for use with this apparatus. Put 10 g powdered pyrogallol [1, 2, 3 -- trihydroxybenzene, $C_6H_3(OH)_3$] and 2 g sodium hydroxide (NaOH) pellets into a small flask or test tube. Add about 30 ml H_2O. Tightly cap the container and shake it until all the solid dissolves. Avoid stirring the container to introduce air, as the alkaline solution will rapidly absorb oxygen and become useless for the experiment.

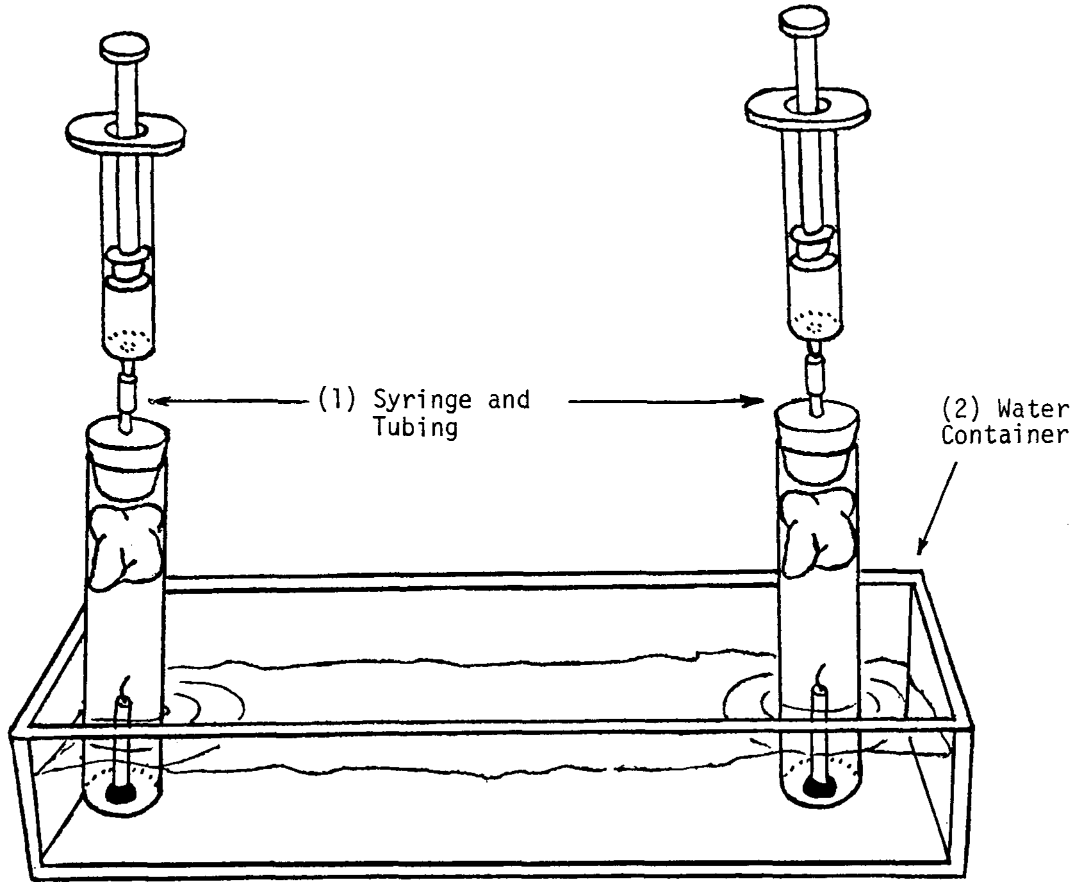
(ii) For experimentation in stoichiometry, several of these syringe assemblies need to be set up. Each should have an identical amount of the pyrogallol solution (or other reducing agent) in the syringe. Place all the devices open end down in the water container. Inject varying amounts of the pyrogallol (for example, 0.5, 1, 1.5 . . . 10 ml) into the glass tube where it will be absorbed in the cotton. The pyrogallol will then react with the oxygen in the air in the tube, and continue to react until either the pyrogallol or oxygen is consumed. As oxygen is removed from the air, pressure in the tube will fall, and water will be drawn up into it from the trough. The height of the water in the tube then becomes a measure of the amount of oxygen consumed, and will be seen to be proportional to the amount of pyrogallol used, until the upper limit is reached.

(iii) If glass tubes are not available, syringe barrels may be substituted. A short piece of plastic or rubber tubing is used to connect the upper syringe and lower syringe barrel, which is used in an inverted position.



E. ANALYTICAL APPARATUS

El. Air Composition Device *



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Syringe and Tubing	2	Stoichiometry Device (A)	XII/D4, Components (l), (2), and (3)
(2) Water Container	1	Pan or Tray (B)	Approximately 1 liter
	--	Limewater (C)	--
	2	Modeling Clay (D) (Plasticine)	Small wads
	2	Candles (E)	Approximately 0.5 cm diameter, 5 cm long

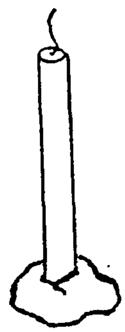
*From Paul D. Merrick, Experiments with Plastic Syringes, (San Leandro, California: Educational Science Consultants, 1968), p 20.

b. Construction

(1) Syringe and Tubing

Prepare two syringe and tubing (A) assemblies, as described for the Stoichiometry Device (XII/D4).

(2) Water Container



Support each candle (E) in a small wad of modeling clay (D), about 5 - 10 cm apart on the bottom of the pan or tray (B). The clay wad must be smaller than the diameter of the glass tube used.

Pour sufficient limewater (C) into the pan or tray to cover the wad of clay and 1 cm or so of the candles.

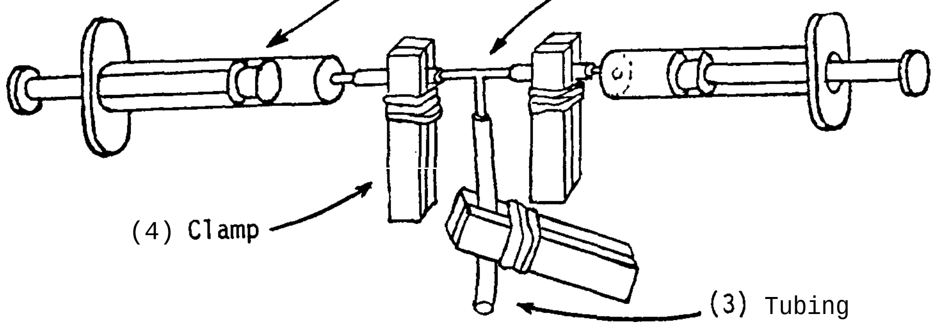
c. Notes

(i) To investigate the proportion of oxygen in the air, an alkaline pyrogallol solution, prepared according to instructions in XII/D4, is required. Each syringe should contain an equal amount of the pyrogallol solution (5 ml, for example).

(ii) When the syringe assemblies, with alkaline pyrogallol solution in each syringe, and the candles in the limewater have been prepared, light one candle. After a few seconds, place one of the syringe assemblies over each candle. Allow them to stand for about five minutes after the burning candle goes out to allow the limewater to remove CO_2 from the air in its tube. At this time, limewater will have risen into the tube to compensate for the lost CO_2. Mark this level of limewater with a wax pencil or felt-tipped marker.

Using a syringe pump (see XII/A2), remove air from the other tube until the limewater rises to the same level in the second tube as it had in the first. Mark this level, also. Now, inject alkaline pyrogallol from the syringes onto the cotton wads. This will react with the oxygen in the air, and remove all of it if enough pyrogallol is used. The water level in each tube will have risen. The amount of rise in the first tube (the one containing the candle) will be compared to the amount of rise in the second tube. Also, the change in trapped air volume in both tubes should be noticed. By doing this, it will be found from the first tube that the burning candle removes only about 25% of the oxygen in the air, while the change in volume in the second tube will show that air is about 21% oxygen.

E2. Gas Reaction Chamber *



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Syringe	2	Plastic Disposable Syringe (A)	Capacity 50 ml
(2) "T" Tube	1	Glass "T" Tube (B)	Approximately 0.5 dm diameter
(3) Tubing	3	Rubber Tubing (C)	To fit syringe nozzle, approximately 8 cm long
(4) Clamp	3	Pinch Clamp (D)	IV/A4

b. Construction

(1) Syringe

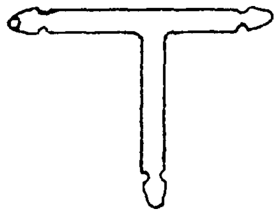
Select two 50 ml plastic, disposable syringes (A). Secure the syringes in a horizontal position by appropriate supports.

(2) "T" Tube

Use a glass or metal "T" tube (B) with three outlets. If available, a three-way valve (stopcock) may be substituted for the clamps and "T" tube.

*Adapted from Nuffield O-Level Chemistry, Collected Experiments, (London:Longmans/ Penguin Books, 1967), p 237.

(3) Tubing



Connect the two syringes to the "T" tube with two short pieces of rubber tubing (C). Use a third piece of tubing (C) to connect the apparatus to a source of gas.

(4) Clamp

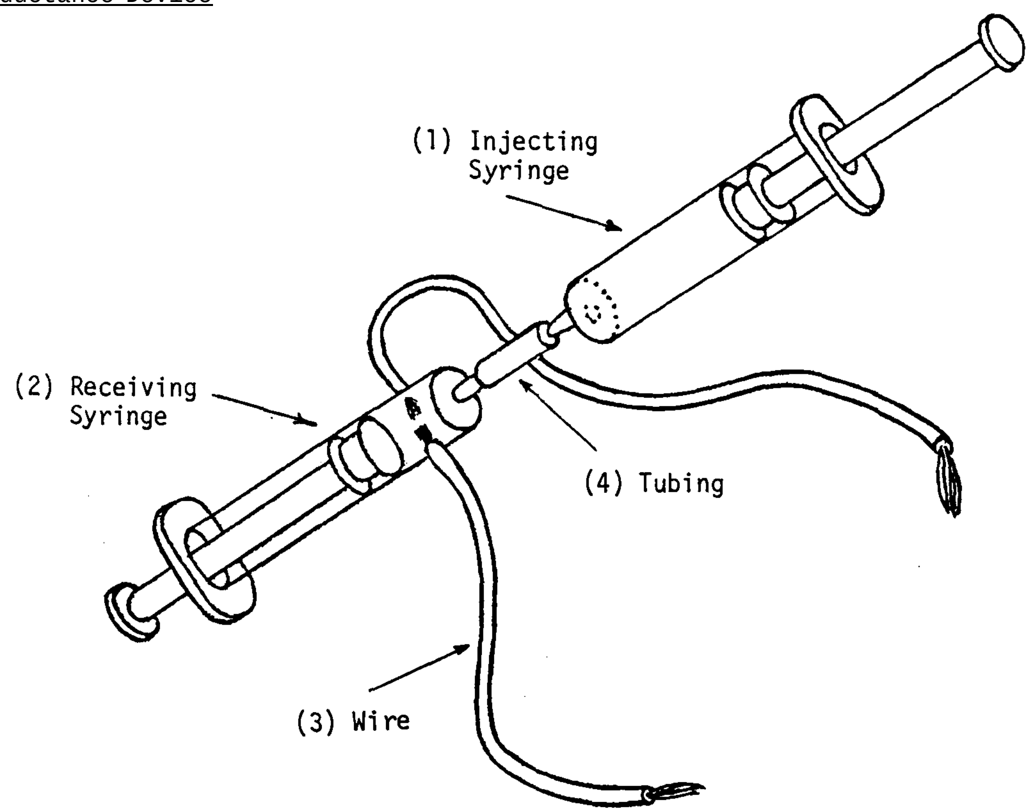
Use three pinch clamps (0)or other suitable clamps to close each section of tubing.

C.Notes

(i) To determine the number of gram-molecules of hydrogen chloride that react with one gram-molecule of ammonia, set up the apparatus as shown in the main illustration. Using the correct combination of open and closed clamps, fill one syringe with dry amnonia gas, empty it, and repeat one or two more times to "flush" the syringe. Follow the same procedure with the other syringe using dry hydrogen chloride. Then, fill the first syringe with 40 cc of the dry ammonia and fill the second with 50 cc of the dry hydrogen chloride. With the two syringes open to each other but closed to the atmosphere , inject the hydrogen chloride into the syringe of ammonia. The two gases will react, forming ammonium chloride. That about 10 cc of hydrogen chloride remains unreacted is shown by passing the gas over damp indicator paper. Thus, 40 cc of amnonia reacts with 40 cc of hydrogen chloride.

F. CONDUCTANCE APPARATUS

F1. Conductance Device *



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Injecting Syringe	1	Plastic Disposable Syringe (A)	Capacity approximately 35 ml
(2) Receiving Syringe	1	Plastic Disposable Syringe (B)	Capacity approximately 35 ml
(3) Wire	2	Insulated Wire (C)	Approximately 0.3 cm diameter, 50 cm long
(4) Tubing	1	Plastic or Rubber Tubing (D)	To fit syringe nozzles, 2 cm long

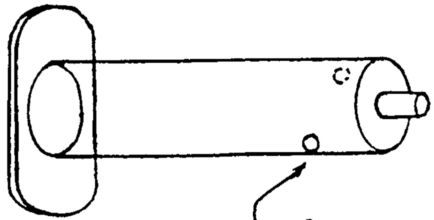
b. Construction

(1) Injecting Syringe

Use a 35 ml plastic, disposable syringe (A), with no modifications, for this component.

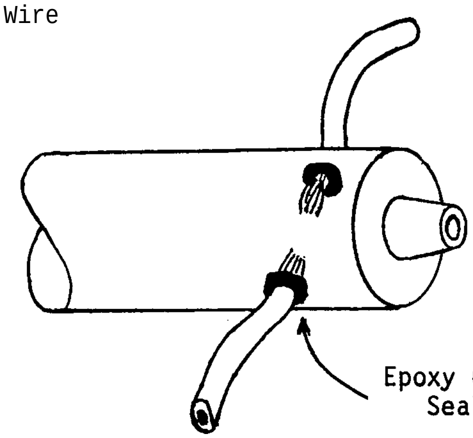
*Adapted from Andrew Farmer, "The Disposable Syringe--A Rival to the Test Tube?," School Science Review, CLXXIV (1969), 32-34,

(2) Receiving Syringe



Take a 35 ml plastic, disposable syringe (B) and with a hand drill or hot wire make two holes, approximately 0.2 cm in diameter, opposite each other near the base of the barrel.

(3) Wire



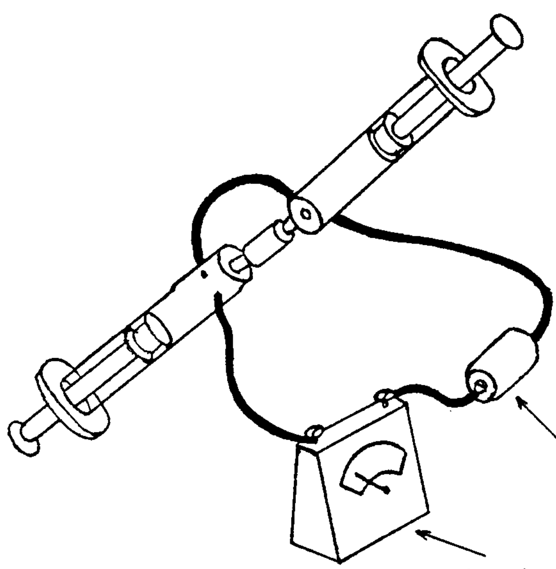
Remove about 1.0 cm of insulation from each end of both wires (C). Insert one bare end of each wire through the holes in the syringe barrel (B). Seal the holes with epoxy glue, taking care to see that no epoxy covers the bare wire inside the syringe barrel.

(4) Tubing

Connect the two syringes together with a short piece of plastic or rubber tubing (D).

c. Notes

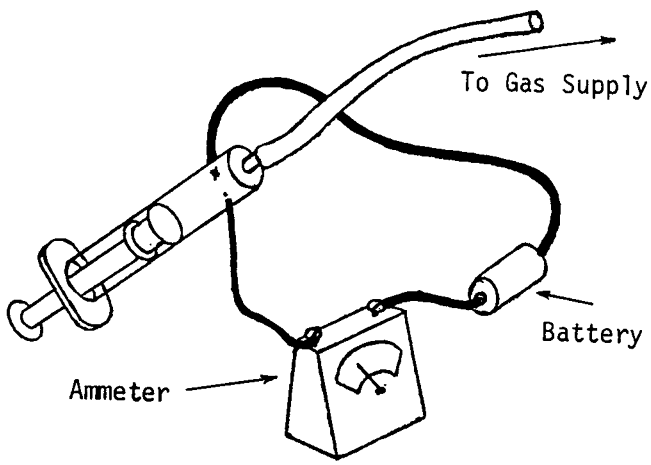
(i) This apparatus may be used to investigate the variation of conductance as two solutions are mixed. The wires are connected in series to a 1.5 volt cell and an ammeter as shown. One liquid is placed in the receiving syringe, another in the injecting syringe, and the current is measured on the ammeter. Then the solution in the injecting syringe is gradually fed into the receiving syringe, and any changes in the current are noted. Conductance, the reciprocal of resistance, may be calculated from the



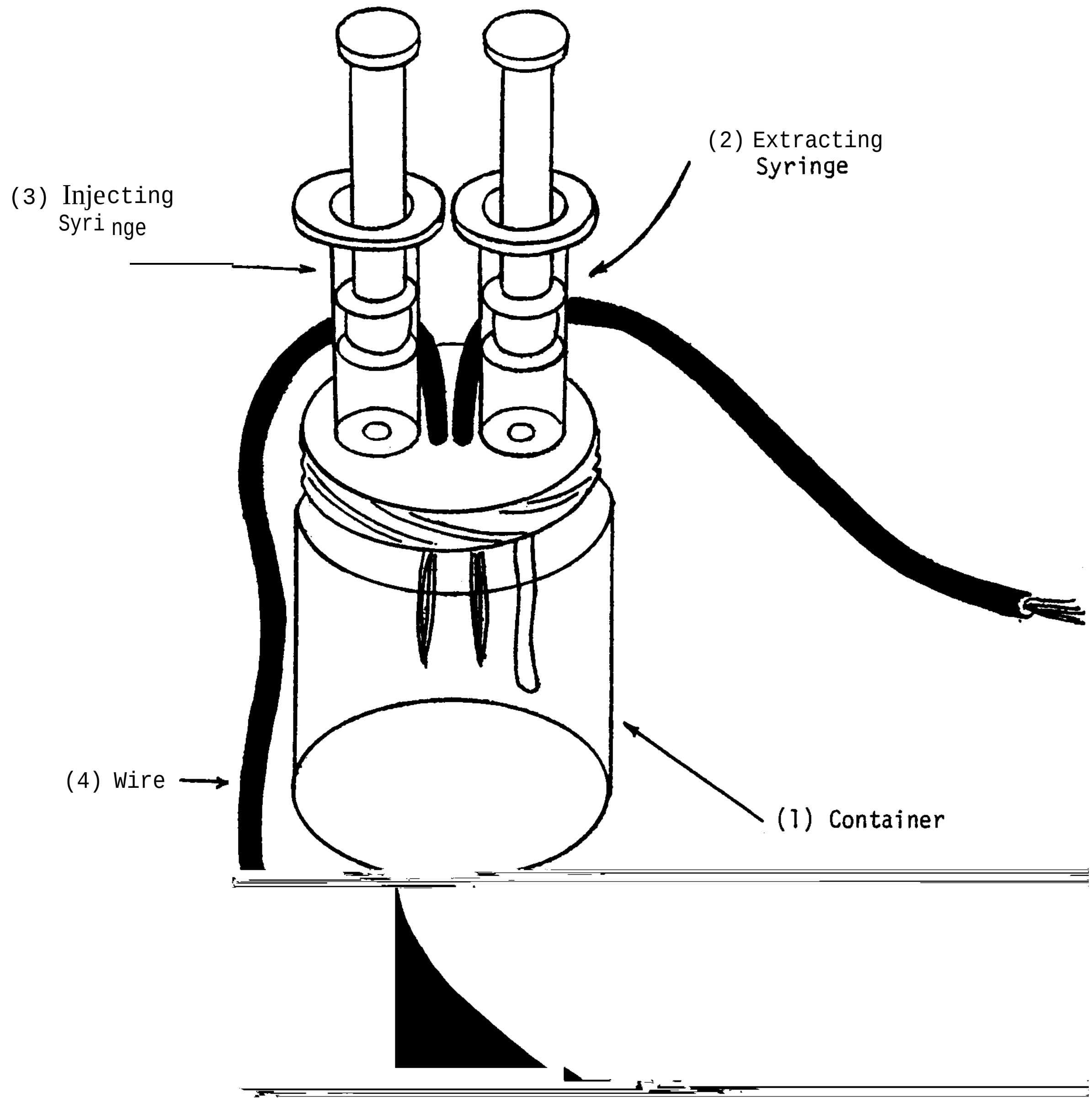
current and voltage: $R = \frac{E}{I}$ mhos $= \frac{1}{R}$

(ii) Solutions which may be tested in this apparatus include water in the receiving syringe and salt solution or HCl solution in the injecting syringe; dilute H_2SO_4 in the receiving syringe and $Ba(OH)_2$ solution in the injecting syringe; and dilute HCl in the receiving syringe with NaOH in the injecting syringe.

(iii) This device, with one modification, may also be used to investigate the variation of conductance as a gas is bubbled into a solution. The injecting syringe is removed and replaced with a section of plastic or rubber tubing that connects the remaining syringe to a gas source. For example, the syringe is filled with a limewater solution, and the current is noted on the ammeter. Then CO_2 is passed through the limewater, and the change in current as well as the change in color of the solution can be seen. Phenolphthalein can also be added to the limewater initially, and the color change from red to clear will indicate the neutralization has occurred.



F2. Constant Volume Conductance Device



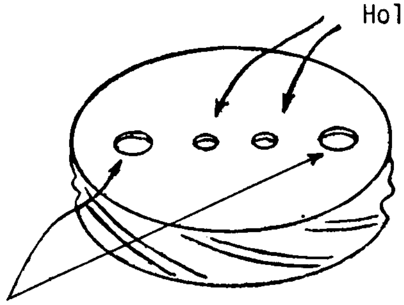
a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Container	1	Jar with Lid (A)	Capacity approximately 200-250 ml
(2) Extracting Syringe	1	Plastic Disposable Syringe (B)	Capacity approximately 20 ml
	1	Rubber or Plastic Tubing (C)	Diameter to fit syringe nozzle; length, about 1 cm shorter than jar height

(3) Injecting Syringe	1	Plastic Disposable Syringe (D)	Capacity approximately 20 ml
(4) Wire	2	Insulated Wire (E)	Diameter 0.3 cm, 50 cm long

b. Construction

(1) Container



Puncture four holes in the jar lid (A). Make the two outside holes about 0.5 cm in diameter to accommodate the syringe (B,D) nozzles. Make the two inner holes about 1 - 2 cm apart and 0.4 cm in diameter, to accommodate the insulated wire (E).

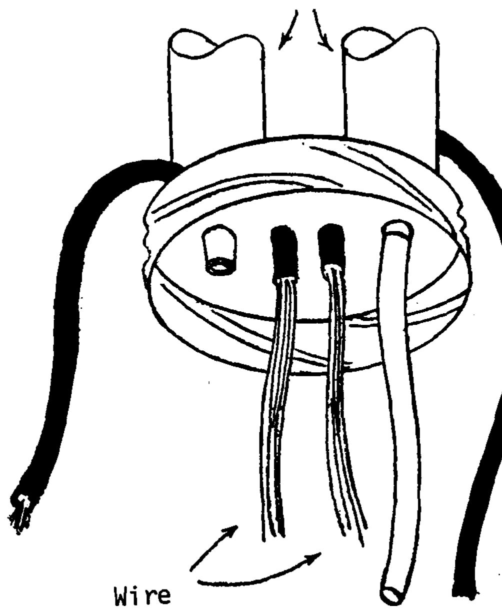
(2) Extracting Syringe

Push the nozzle of a plastic, disposable syringe (B) through one of the outer holes in the jar lid. Attach the rubber or plastic tubing (C) to the syringe nozzle from the inside of the lid.

(3) Injecting Syringe

Push the nozzle of a second plastic, disposable syringe (D) through the other outer hole in the jar lid.

(4) Wire



Strip 5 - 7 cm of insulation from one end of each wire (E). Push each stripped end of wire through the inner holes in the jar lid, from the outside of the lid. Allow about 8 - 9 cm of each wire to extend from the inside of the lid.

C. Notes

(i) In order to use this apparatus to investigate variations in the conductance of a solution as its composition (but not its volume) is changed, the wires from the container must be connected, in series, to a 1.5 volt battery and an ammeter. [See diagram, Note (i), XII/Fl.] A solution, such as water, is placed in the container. A second solution (concentrated salt solution, for example) is placed in the injecting syringe and the lid placed on the jar. Current is measured; then a measured amount of solution from the injecting syringe is added to the container, the solution mixed well, and volume of solution equal to that added to the container is withdrawn with the extracting syringe so that the electrode depth is unchanged. Current is again measured, and conductance calculated as described in Note (i), XII/Fl.

(ii) This equipment is adopted from Andrew Farmer, "The Disposable Syringe--A Rival to the Test Tube?," School Science Review, CLXXIV (1969), 34-35.