DEMONSTRATION 3.1

THE SOLUBILITY OF AMMONIA IN WATER "THE AMMONIA FOUNTAIN"

The partial vacuum created in a flask by ammonia gas dissolving in water creates a fountain when water is sucked into the flask.

EQUIPMENT

- Ammonia gas Cylinder
- Hose
- 1 L round bottom flask
- Glass tubing with a stop cock at one end and a rubber bung at the other
- Boss head and retort ring
- Wash Bottle
- Retort Stand

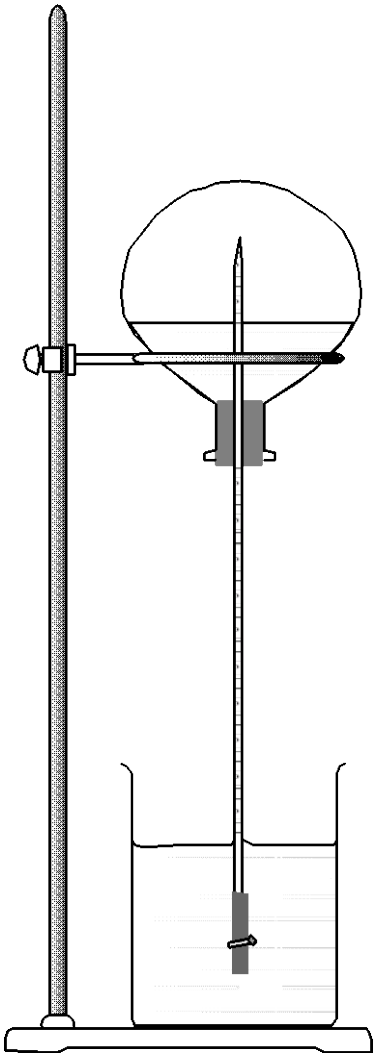
REAGENTS

- ammonia gas
- phenolphthalein
- deionised water

CAUTION **Examine the flask to ensure there are no cracks so the flask will withstand the partial vacuum.**

PREPARATION

- Fill the beaker with water and place it on the foot of the retort stand.
- Add some phenolphthalein to the water.
- Attach a hose to the outlet of the ammonia gas cylinder.
- Working in the fume hood invert the round bottom flask and insert the hose. Turn the Ammonia gas cylinder on and pass a stream of ammonia gas into the round bottom flask. Gently swirl the hose around the flask for a minute to allow sufficient ammonia gas to fill the flask.
- Close the ammonia cylinder. Stopper the round bottom flask using the glass tubing assembly.
- Clamp the flask upside down on to the retort stand as shown in the figure. Keep the flask inverted such that the stop cock end of the glass tubing is immersed in the beaker of water.
- Raise the flask such that the glass tubing is no longer in the water. Open the stop cock and squeeze sufficient water from the wash bottle into the tubing such that a stream of water jets from the other end. Close the stop cock and lower the flask to the original position. With the glass tubing immersed in the beaker of water turn on the stop cock to draw



in a small amount of the liquid up through the tubing into the inverted round bottom flask. Close the stop cock after about 30seconds and leave the set up on the demo tray.

PROCEDURE

- Open the stop cock.

RESULTS

As ammonia dissolves in the water a partial vacuum is created. This causes the water level in the long glass tube to rise until it overflows into the inverted flask. As more water flows from the beaker into the flask, more ammonia will dissolve, and the rate at which the water rises in the tube increases dramatically. This produces a fountain effect in the inverted flask.

$NH_3(g) + H_2O \Phi NH_3(aq)$

$NH_3(aq) + H_2O(l) \Phi NH_4^+(aq) + OH^-(aq)$

As ammonia dissolves in the water, it forms a basic solution that causes the phenolphthalein indicator to turn a pink/magenta colour.

High Risk Demonstration:

- **Refer to HIRAC**
- **Take Extra Caution**

DEMONSTRATION 3.2

CONDUCTIVITY OF SOLUTIONS

Different solutions are tested for their conductivity.

EQUIPMENT

- 6 volt lamp wired to two strips of copper (or graphite electrodes)
- variable power supply and leads
- several 250 mL beakers
- wash bottle with distilled water

REAGENTS

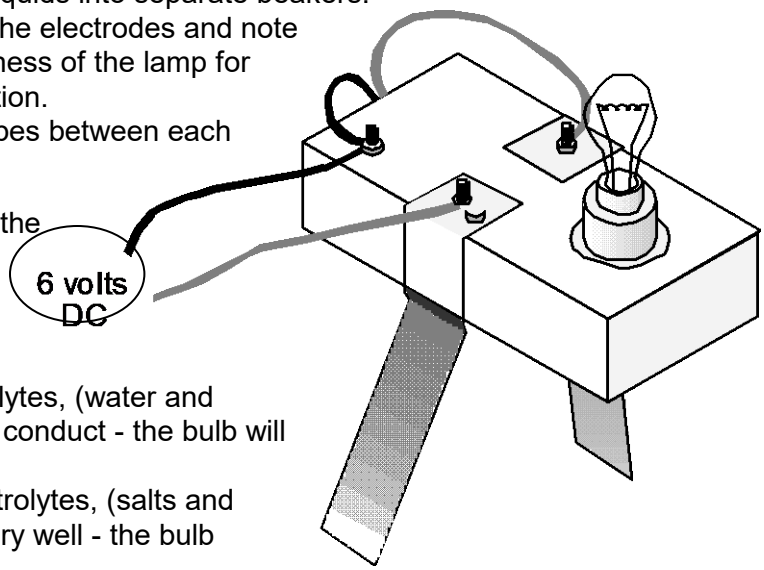
- copper(II) sulfate-5-water, $CuSO_4 \cdot 5H_2O$(0.5M) [8gm/100mL]
- sodium chloride, NaCl (0.5M) [3g/100mL]
- sucrose (0.5M) [17g/100mL]
- hydrochloric acid, HCl (1 M, 250 mL)
- acetic acid, CH_3COOH (17 M, 250 mL)
- ammonia, NH_3 (3 M, 250 mL)

PREPARATION

- Prepare saturated aqueous solutions of the salts and sucrose.
- Provide the solutions, acids and bases in labelled reagent bottles as well as the distilled water.
- Provide one beaker for each liquid.

PROCEDURE

- Pour the liquids into separate beakers.
- Immerse the electrodes and note the brightness of the lamp for each solution.
- Rinse probes between each test.



RESULTS

The intensity of the bulb is proportional to the conductivity of the solution.
The non-electrolytes, (water and sucrose) do not conduct - the bulb will not glow.
The strong electrolytes, (salts and HCl) conduct very well - the bulb glows brightly.
The weak electrolytes, (acetic acid and the ammonia solution) conduct poorly - the bulb glows weakly.

High Risk Demonstration:

- **Refer to HIRAC**
- **Set up in Red Tray**

DEMONSTRATION 3.3

IMMISCIBLE LIQUIDS AND SOLUBILITY

Illustrating that polar solids are soluble in polar solvents and non-polar solids in non-polar solvents.

EQUIPMENT

- Petri dishes

REAGENTS

- Toluene

- Iodine, I_2 (a few crystals)
- Potassium Permanganate (few crystals)
- water

CAUTION **The organochlorine solvent is carcinogenic.**

PROCEDURE

- Place some water in a small Petri dish.
- Add Toluene, to form a small pool.
- Add a few crystals of potassium permanganate, $KMnO_4$.
- Note whether the colour develops in the water or Toluene.
- Repeat the demonstration but add a few crystals of iodine, I_2, instead of potassium permanganate.

RESULTS When Toluene is added to the water it is immiscible. When crystals of potassium permanganate are added to the system, a deep colour appears in the water showing its high solubility in water. This is an example of a polar substance dissolving in a polar solvent. However, the iodine preferentially dissolves in the cleaning fluid to give a violet solution. Iodine is a non–polar substance which dissolves in a non–polar solvent.

DEMONSTRATION 3.4

THE SEMI-PERMEABLE MEMBRANE

A porous pot with a semi-permeable membrane is filled with sucrose solution and sealed with a rubber bung with a glass tube attached to it so that some of the sucrose solution rises up the tube. The pot is then immersed in water and the sucrose level in the tube rises due to osmosis.

EQUIPMENT

- porous pot with rubber bung
- 1.5 to 2 L beaker, depending on the size of the pot
- glass tubing, 5 mm diameter

REAGENTS

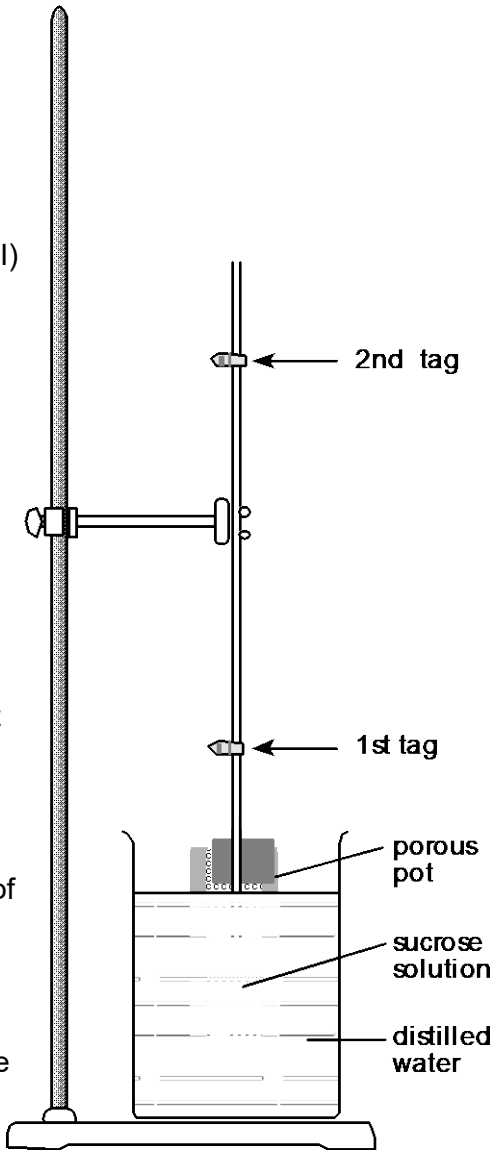
- sucrose, $C_{12}H_{22}O_{11}$ (saturated, 500 mL)
- copper(II) sulfate-5-water, $CuSO_4 \cdot 5H_2O$ (125 g)
- potassium hexacyanoferrate(II)-3-water, $K_4[Fe(CN)_6] \cdot 3H_2O$ (211g)
- blue food dye
- vaseline
- deionised water

PREPARATION

- Prepare 500 mL of 1 M copper(II) sulfate solution by dissolving 125 g $CuSO_4 \cdot 5H_2O$ in water.
- Prepare 500 mL of 1 M potassium hexacyanoferrate(II) solution by dissolving 211 g $K_4[Fe(CN)_6] \cdot 3H_2O$ (or 184 g of the anhydrous compound) in water.
- Prepare 500 mL of saturated sugar solution by dissolving 1 kg $C_{12}H_{22}O_{11}$ in boiling water.
- Colour it with blue food dye.
- The preparation should be completed between 24 and 6 hours before the lecture.

Prepare a semi-permeable membrane inside the wall of the pot as follows:

- Fill the pot with 1 M aqueous copper sulfate solution. Take care that it does not spill over and contaminate the outside of the pot.
- Place some 1 M potassium hexacyanoferrate(II) solution into the beaker.
- Carefully lower the pot into the solution and add further potassium



hexacyanoferrate(II) solution to the beaker until it reaches almost to the rim of the pot.

- Ensure that the solutions do not mix through splashing or spilling. It is recommended to prepare several pots at the same time, in case of failure.
- After two or three hours a semi-permeable membrane should have formed inside the wall of the pot.
- Discard the solutions and rinse the pot(s) well with water. Cut a piece of glass tubing, about 1.5 m long.
- Bore a hole in the rubber bung to fit the tubing.
- After cooling fill one of the prepared pots with the saturated sucrose solution.
- Seal the pot with the bung.
- Insert the tube. Ensure that there is no air trapped beneath the bung: on pushing it home, some sucrose solution should appear in the tube.
- Rinse off any spilled solution and allow to dry.
- Make an air-tight seal with vaseline around the rim of the pot and the base of the tubing.

PROCEDURE

- Tag the initial level of solution in the tubing.
- Write date and time on it.
- Fill a large beaker with water and carefully lower the pot and tube assembly into the water.
- Set up this assembly and provide blank tags.
- Note and tag the liquid-level at the end of the lecture.
- Present the same pot the next lecture and note the new level.

RESULTS

The liquid level in the tube inside the pot will increase due to osmotic pressure across the semi-permeable membrane.

Note: The associated rise of the level in the tube is dependent, not only on the osmotic pressure, but also on temperature variations and the effectiveness of membrane and seal.

DEMONSTRATION 3.5

THE "CHEMICAL GARDEN"

The chemical garden illustrates the dynamic formation of solid phases controlled by osmosis and diffusion in a system far from equilibrium.

EQUIPMENT

- 500mL beaker
- nickel spoon

REAGENTS

- 300 mL of sodium silicate ("Waterglass") solution (27 % solution)
- copper(II) sulfate-5-water, $CuSO_4 \cdot 5H_2O$ (a few crystals)
- cobalt(II) chloride-6-water, $CoCl_2 \cdot 6H_2O$ (a few crystals)
- nickel(II) sulfate-6-water, $NiSO_4 \cdot 6H_2O$ (a few crystals)
- Iron(ll) sulphate, $Fe(SO_4).7H_2O$(a few crystals)
- Iron (lll) sulphate, $Fe_2(SO_4)_3$
- Copper (ll) chloride, $CuCl_2.2H_2O$ (a few crystals)
- Iron (lll) Nitrate, $Fe(NO)_3.9H_2O$
- Deionised water (100 mL)

PREPARATION

- Using the beaker, dilute 300mL of 27% Waterglass with 100 mL water.
- Set up the beaker with the solution.
- Provide the nickel spoon and the salts in their original storage containers.

PROCEDURE

At the beginning of the lecture, sprinkle the dry crystals of the chosen transition metal salts into the silicate solution in such way that a random mixture of them covers the bottom of the vessel.

RESULTS

During the next hour a multi-coloured crop of slender, crystalline strands will grow upwards generating a "coral reef" of silicates. The metal ions from the salts combine with silicate ions and form membranes of insoluble silicates around the crystals. The inside of the membrane contains a more concentrated salt solution than the outside, some water passes inward by osmosis, ultimately causing breaks in the membrane and formation of more membrane surface as the salt solutions contact fresh sodium silicate.

DEMONSTRATION 3.6

OSMOSIS AND EGG MEMBRANES

Two raw eggs, with shells removed, are placed in separate solutions of water, sucrose and dye to illustrate that osmosis can occur in either direction through a semi-permeable membrane.

EQUIPMENT

- 4 x 1 L beakers
- stirring rod
- paper towels

REAGENTS

- 4 raw eggs
- sugar, $C_{12}H_{22}O_{11}$ (85 g)
- deionised water (1.6 L)
- hydrochloric acid, HCl (10 M, 400 mL)
- blue or green food dye

PREPARATION

- Peel off the outer shells of the eggs by rolling them in a half-full Petri dish of hydrochloric acid (400 mL) for a short time.
- Blot dry with the paper towels. The eggs should now be encased only in their membranes.
- It is most important to **not cook the eggs** in the hydrochloric acid at this point!
- Prepare a 20% sugar solution by dissolving 85 g of sugar in 400 mL of water.
- Pour 400 mL deionised water into three of the 1 L beakers and pour 400 mL sugar solution into the remaining beaker.

PROCEDURE

- Place one of the eggs in the beaker of sugar solution and another in one of the beakers of water.
- Add the food dye to one of the remaining beakers and stir.
- Place two eggs in this beaker.
- Leave the eggs for one day. The eggs in water may burst if left longer.
- Remove the eggs from the coloured solution, keep one for reference and place one in a beaker of distilled water.

High Risk Demonstration:

- **Refer to HIRAC**

RESULTS

The egg in the sugar solution will shrink. The eggs in the water beakers will expand, and the interior of the eggs in the coloured solution will become coloured. The coloured egg loses its colour to the deionised water.

An egg has an outer shell made mainly out of calcium carbonate and this shell is lined with a membrane that is permeable to water. When the eggs are soaked in hydrochloric acid, the acid dissolves the shell.

$CaCO_3(s) + 2H^+(aq) \zeta Ca^{2+}(aq) + H_2O(l) + CO_2(g)$

The eggs will undergo changes in their weight due to osmosis. Water will flow through the egg's membrane from a region of low solute concentration to a region of high solute concentration. When the decalcified egg is placed in water, water flows into the egg. The sugar solution is more concentrated than the contents of the egg, and the sugar molecules are too large to pass through the membrane, so that when the decalcified egg is placed in sugar solution, water will flow out of the egg. The same principle applies to the solution containing dye. The dye will flow from the solution to the egg. When the coloured egg is placed in clean water, the dye will flow from the egg (more concentrated) to the water.

DEMONSTRATION 3.7

THE COAGULATION OF IRON(III) OXIDE

EQUIPMENT
- 1 beaker
- 1 stirring rod

REAGENTS
- aqueous solution of iron(III) chloride, $FeCl_3$
- aqueous solution of aluminium sulfate, $Al_2(SO_4)_3$ (a few drops)

PROCEDURE
- Add iron(III) chloride to boiling water to obtain a red, hydrous colloidal solution of iron(III) oxide.
- Add a few drops of aluminium sulfate (0.1M NaOH)

RESULTS The suspended particles rapidly coagulate into a dark red-brown gelatinous precipitate of iron(III) hydroxide.

$Fe^{3+}(aq) + 3OH^-(aq)$ ζ $Fe(OH)_3(s)$

DEMONSTRATION 3.8

THE TYNDALL EFFECT

Light transmitted by a colloidal suspension imitates the colours of a sunset.

EQUIPMENT
- piece of cardboard, 30 cm x 30 cm
- 500 mL beaker
- stoppered 10 mL measuring cylinder
- stirring rod
- torch

REAGENTS

- sodium thiosulfate-5-water, $Na_2S_2O_3 \cdot 5H_2O$ (10 g)
- hydrochloric acid, HCl (1 M, 10 mL)
- deionised water

PREPARATION
- Cut a hole in the centre of the cardboard the same diameter as the bottom of the beaker.
- Place the cardboard on the overhead projector.
- Place 10 mL of hydrochloric acid into a stoppered measuring cylinder.
- Dissolve 10 g of sodium thiosulfate in 500 mL of water.
- Place it in the beaker and set it over the hole in the cardboard.

PROCEDURE
- Switch on the overhead projector.
- Darken the lecture theatre.
- Add hydrochloric acid to the sodium thiosulfate solution and stir.

RESULTS During the next minute or so the light transmitted by the liquid will change very gradually from pale blue to orange-yellow, then to reddish-gold as the colloid particles form.