DEMONSTRATION 1.1

BEHAVIOUR OF ELECTRONS: DISCHARGE TUBES

The passing of a high voltage through a number of discharge tubes, each containing a different pressure of gas. The intensity of light emitted from the tube varies with gas pressure.

EQUIPMENT

- set of six discharge tubes on stand
- induction coil with leads

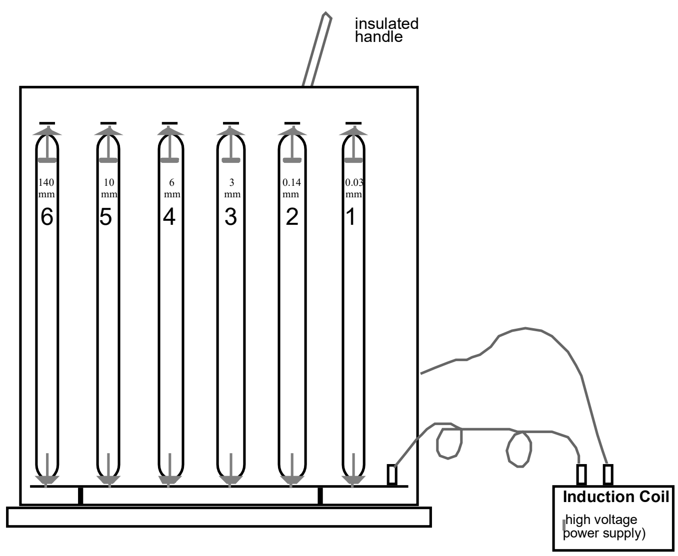
PROCEDURE

- Dim the lights.
- Apply voltage to each tube in turn (keep voltage constant in each case).

CAUTION **Switch off power before shifting the lever!**

RESULTS

At the highest gas pressure only a faint glow is observed in the discharge tube. As the gas pressure is decreased to 10 mmHg pink coloured “streamers” are observed between the plates. At 6 and 3 mmHg the streamers have merged and broadened. A pink glow fills the space between anode and cathode. At 0.14 mmHg one observes vertical striations surrounding the anode. Around the cathode there is a blue glow and between this blue glow and the cathode is a dark space called the *Crookes dark space*. The cathode itself begins to glow with a faint pinkish coloration. At the lowest pressure, the tube is filled entirely with the Crookes dark space. Where the Crookes dark space meets the glass tube, the glass is seen to fluoresce.



As the gas pressure is reduced, the Crookes dark space increases, because there are fewer gas molecules for the electrons to collide with.[1]

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[1]Abbot and Wood, Elementary Physical Science, p 394.

DEMONSTRATION 1.2

BEHAVIOUR OF ELECTRONS: THE “MALTESE CROSS”

A high voltage is applied across a cathode ray tube containing a piece of metal in the shape of a Maltese Cross. The cross stops some electrons from striking the end of the tube, thus creating a shadow of the cross.

EQUIPMENT

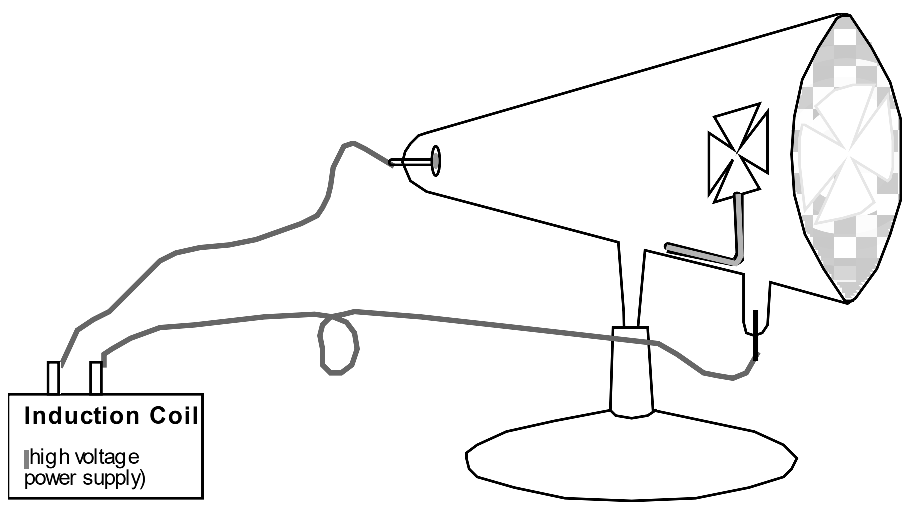
- cathode-ray tube with Maltese Cross
- bar magnet
- induction coil with leads

PROCEDURE

- Shake the cathode-ray tube gently to make the cross sit upright.
- Connect it to the induction coil as shown.
- Apply voltage across the tube.
- Reverse the polarity to the tube and select the best shadow.

RESULTS

The electron beam will cause the glass of the tube to luminesce. The cross, blocking some of the beam, will cast a shadow.



If the magnet is brought close to the tube the electron beam will be deflected so that the shadow becomes distorted.

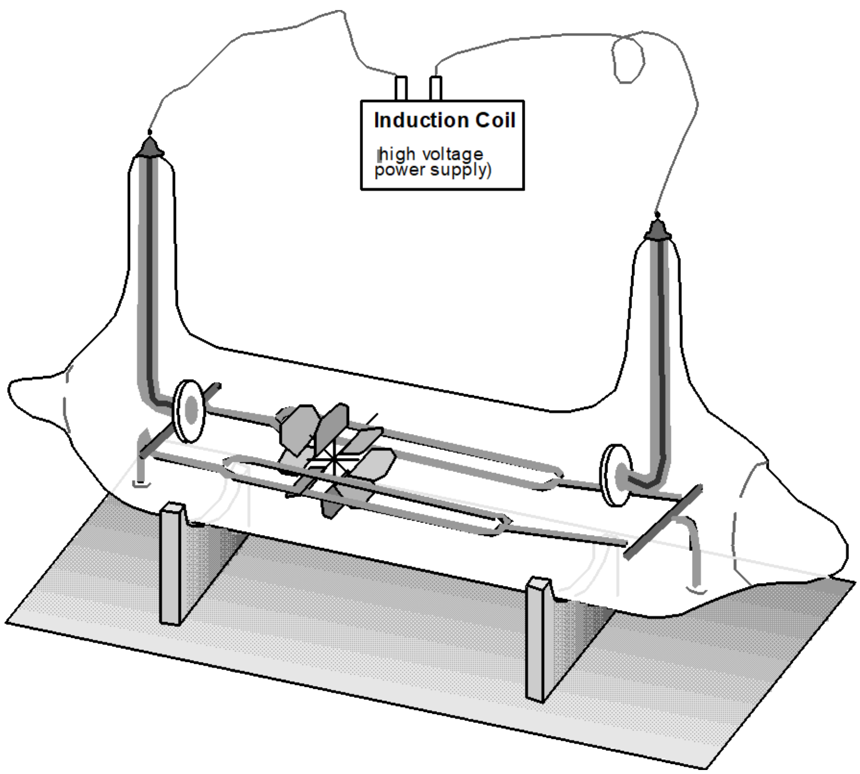
DEMONSTRATION 1.3

BEHAVIOUR OF ELECTRONS: THE “PADDLE WHEEL”

A high voltage is applied across a cathode ray tube containing a paddle wheel on rails. The wheel moves along the rails.

EQUIPMENT

- cathode-ray tube with paddle wheel
- induction coil with leads



PROCEDURE

- Place the Paddle wheel apparatus on level base so that the paddle wheel rests in the centre before you start the demonstration
- Connect the induction coil.
- Gradually increase the voltage across the tube.

RESULTS

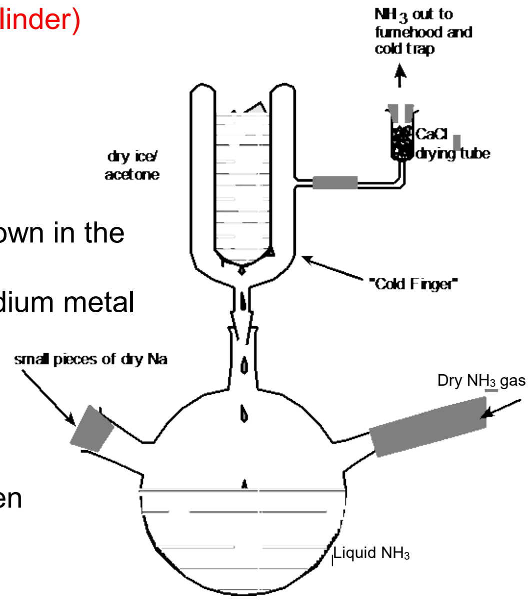
As the voltage increases the wheel begins to rotate and move along its track. This indicates that cathode rays consist of a stream of fast moving electrons which possess momentum and therefore mass. As the voltage increases the cathode ray's average momentum increases and the paddle wheel turns faster.

Reversing the polarity will cause the wheel to turn and move in the opposite direction.

DEMONSTRATION 1.4

THE SOLVATION OF ELECTRONS

This demonstration shows the colour of electrons when they are solvated in ammonia and demonstrates Le Chatelier's principle.



REAGENTS

- ammonia gas, NH_3 (from cylinder)
- sodium iodide, NaI
- dry ice, solid CO_2/acetone
- calcium chloride, $CaCl_2$
- sodium metal, Na

PROCEDURE

- Set up the apparatus as shown in the diagram.
- Cut a clean edge on the sodium metal
- Add sodium and observe the colour.
- Add small amounts of sodium iodide.

RESULTS

An intense blue colour can be seen throughout the frosted flask.
Add NaI to quench the colour.

$$Na(s) \rightarrow Na^+ + e^-_{NH_3}$$

Where $e^-_{NH_3}$ represents an electron trapped or solvated in ammonia.

When sodium ions are added, Le Chatelier's principle applies, e.g.

$$Na^+ + e^-_{NH_3} \rightarrow Na(s)$$

When Na forms, the solvated electron and colour disappear.

High Risk Demonstration:

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

DEMONSTRATION 1.5

CONDUCTIVITY OF SOLIDS

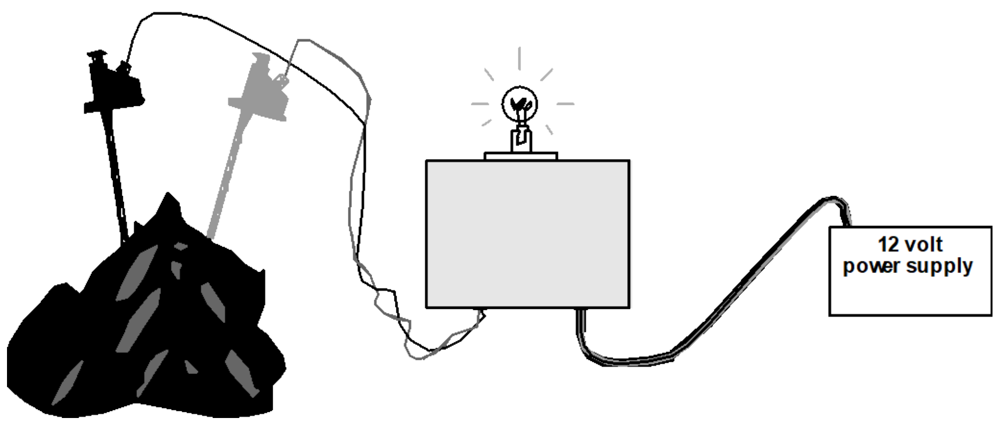
A voltage is applied across a number of different metals and non-metals to test their electrical conduction.

EQUIPMENT

- 6 V lamp wired to two probes
- variable power supply
- a selection of metals, e.g. copper, zinc, magnesium etc., and some solid non-metals, e.g. sulfur, graphite

PROCEDURE

- Set the power supply to 6 volts and connect it to the lamp/probes arrangement.
- Touch the probes across each sample.



graphite

RESULTS Metals will conduct. The non-metals will not conduct electricity except graphite which only conducts parallel to its cleavage planes.

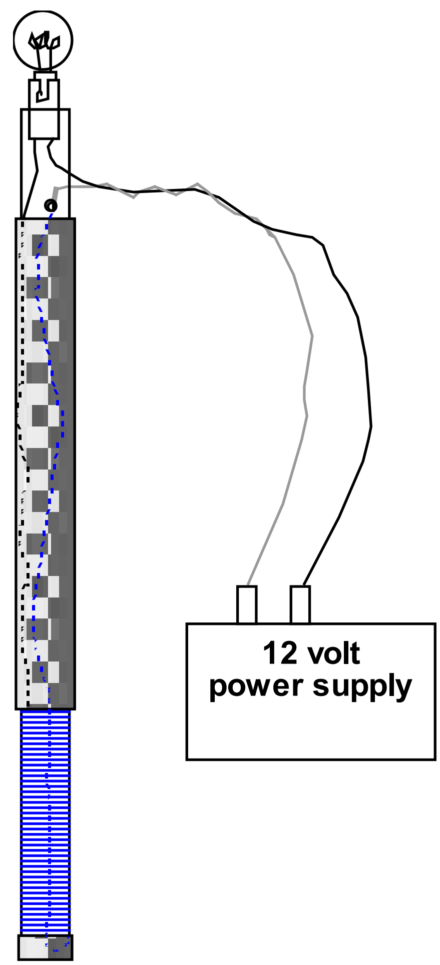
DEMONSTRATION 1.6

CONDUCTIVITY AT LOW TEMPERATURES

A perspex rod, to which a light bulb is attached, is lowered into liquid nitrogen to illustrate that the conductivity of metals increases at lower temperatures.

EQUIPMENT

- perspex rod with a coil of thin copper wire
- 6 volt lamp with terminals (refer to diagram).
- variable power supply and leads
- Dewar flask on a plastic tray
- liquid nitrogen



PROCEDURE

- Dim the lights.
- Connect the lamp & wire coil arrangement to the power supply and set the voltage so that the lamp just glows red.
- Lower the perspex rod into the liquid nitrogen until the wire coil is fully immersed.
- Do not leave the probe in the liquid nitrogen longer than is necessary to observe the effect of the lower temperature.

RESULTS

The light bulb, which was glowing dimly, begins to shine brightly.

CAUTION !

Liquid nitrogen boils at -196˚C and can cause frostbite.

High Risk Demonstration:

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

DEMONSTRATION 1.7

CONDUCTIVITY OF MOLTEN IONIC SOLIDS

To illustrate that molten salts conduct electricity, a crucible containing a solid is heated until the solid melts and the conductivity of the salt is tested.

EQUIPMENT

- 6 volt lamp wired in series with one long probe
- alligator clip attached to the free wire of the circuit
- nickel crucible
- 6 volt power supply
- insulating mat with hole for crucible
- bunsen burner
- digital thermometer & high/low temperature probe (optional)

REAGENTS

- a salt of low melting point

e.g. copper nitrate-3-water, $Cu(NO_3)_2 \cdot 3H_2O$, $T_m = 115^\circ C$
silver nitrate, $AgNO_3$, $T_m = 209^\circ C$
potassium nitrate, KNO_3, $T_m = 338^\circ C$
sodium hydroxide, $NaOH$, $T_m = 322^\circ C$

PREPARATION

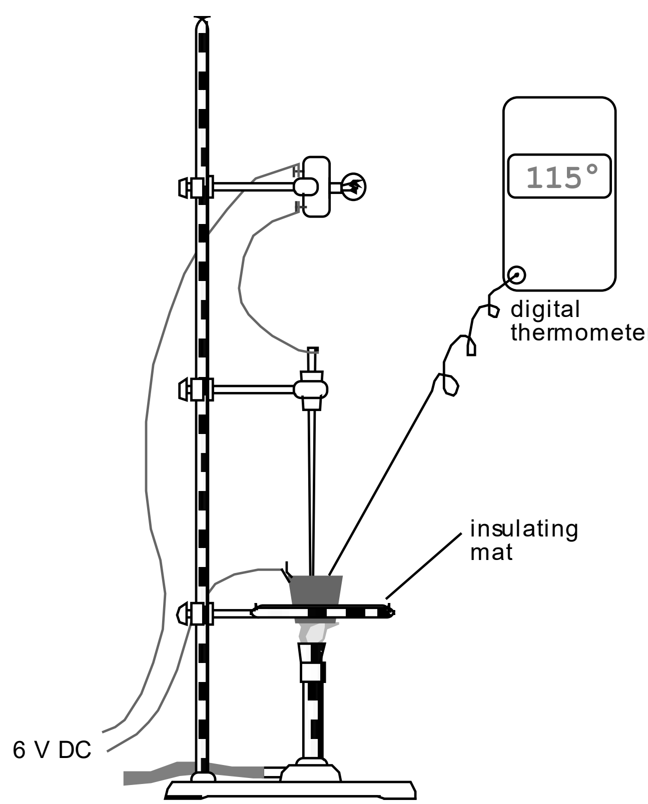
- Assemble the apparatus as in the diagram below.
- Using cork or rubber tubing, insulate the probe against the clamp.
- Place the digital thermometer in the view of the video camera.

PROCEDURE

- Set voltage selector to 6 volt.
- Place some salt into the crucible and heat till molten.
- Dim the lights.
- Place the temperature probe into the melt without touching the bottom and observe the temperature, then dip the probe (connected to the lamp) into the melt.

RESULTS

Once molten the salt will become a conductor and the lamp will glow.



DEMONSTRATION 1.8

SURFACE TENSION OF WATER

Detergents reduce the surface tension of water.

EQUIPMENT

- large beaker
- light box

REAGENTS

- powdered sulfur (2 g)
- detergent concentrate

PROCEDURE

- Fill the beaker with water and sprinkle enough sulfur to lightly cover the surface.
- Touch the surface of the water with a clean, dry finger.
- Touch the surface of the water with a detergent coated finger.

RESULTS

When touched with a clean finger the sulfur will remain afloat. When touched with a detergent coated finger the sulfur powder will sink to the bottom of the beaker.

DEMONSTRATION 1.9

INCOMPATIBLE-LIKE OIL AND WATER

Oil and water don't mix. Or do they? The concept of surface and interfacial tension and surfactants are illustrated. A droplet of mineral oil and a droplet of olive oil are placed on top of a water surface. The mineral oil forms a lens; the olive oil forms a thin layer. They can both be dispersed by adding a surfactant.

EQUIPMENT

- Two crystallization dishes filled with water
- Two plastic 1mL pipettes
- one spatula
- A video camera or viewer to facilitate the observation from a distance

REAGENTS

- Mineral oil
- Olive oil
- Dish washing liquid

PROCEDURE

- Using a pipette, carefully deposit a droplet of mineral oil on the surface of one dish full of water. The droplet will float on top of the water surface like a lens, compact and rounded..
- Do the same with olive oil. The droplet spreads entirely on the surface of the water and becomes almost invisible, as viewed from the top.
- Add a little detergent to both dishes and stir briefly until the oil disappears in a foam..

RESULTS

The surface tension of water is very high due to the high intermolecular forces in water, so water tries to reduce its surface area as much as possible, for example by being covered by an oil layer. But interfacial tension is also important and can oppose the spreading of the oil.

The phenomenon of spreading is dominated by surface tension terms (γwater, γmineal , γolive) and an interfacial tension term (γwater/mineral , γwater/olive) through the spreading parameter S:

$S = \gamma_{water} – (\gamma_{water/oil} + \gamma_{oil})$.

If S is positive, then the oil spreads over the water, otherwise not.

The sum of the surface tension of olive oil γolive and the interfacial tension of water and olive oil γwater/olive is smaller than the surface tension of water, so olive oil spreads in a film and covers entirely water. This does not happen with the mineral oil, because in this case the spreading parameter is negative, and the oil remains concentrated in a droplet.

Both oils can be “solubilised” in water by adding a small amount of soap, which forms micelles around the oil, and breaks up both oil droplet and oil film.

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