Diffusion of gases – a safer alternative to bromine

This experiment can be safely conducted by following the instructions; we recommend that any persons unfamiliar with the safety procedures required to handle toxic gases please consult an experienced colleague. Do not attempt this practical if you are not experienced, or have the help of an experienced chemist.

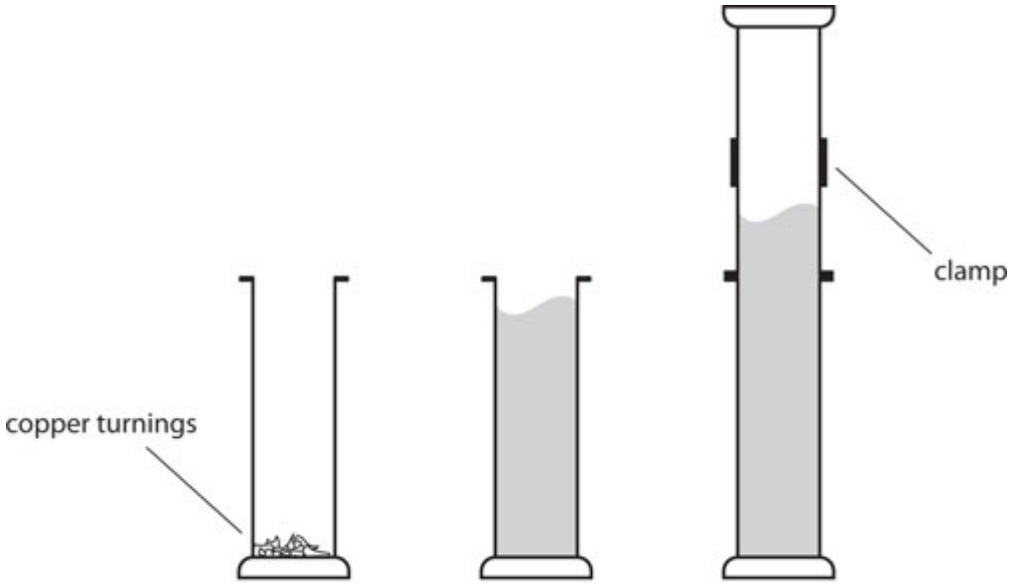
Diffusion into air

Bromine (**VERY TOXIC** and **CORROSIVE**) (see SSERC or CLEAPSS Hazcard) has caused a number of accidents to both teachers and technicians, with serious burns to the skin or breathing difficulties. Bromine is not banned but if it is to be used, it should be done by an experienced teacher or a knowledgeable colleague should be in the vicinity to provide assistance in case of an accident. Any person handling bromine for the first time, or who does not handle it regularly, should receive training from an experienced colleague.

Nitrogen dioxide (**VERY TOXIC** and **CORROSIVE**) is a heavy, brown gas. Despite the similar hazard warnings, there is a lower risk of serious corrosion injury with nitrogen dioxide than bromine but it does have the added problem with regard to respiratory toxicity that symptoms can be delayed, sometimes by up to three days.

A known volume of concentrated nitric acid (**CORROSIVE**) is added to an excess of copper turnings to produce enough nitrogen dioxide so that a gas jar of known volume is nearly filled. Another gas jar of air is placed over a gas jar of nitrogen dioxide. Over the next 20 minutes, the brown gas diffuses into the upper jar.

Procedure



a Using water and a 250 ml measuring cylinder, establish the volume of the gas jar. Do not use this wet gas jar for the following demonstration.
b Using a retort stand, boss and clamp, adjust the fitting of a dry inverted gas jar over another dry gas jar of the same size and set it to one side.
c In a fume cupboard, place at least 1 g, but no more than 2 g, of copper turnings in the gas jar (fig i). Knowing that 8 ml of concentrated nitric acid produces 1000 cm^3 of nitrogen dioxide at room temperature and pressure, estimate the volume of acid needed to just fill the gas jar with gas. Wearing eye protection and suitable gloves, place 1 ml less than the estimated volume of nitric acid (**CORROSIVE** and **OXIDISING AGENT**) in a 10 ml measuring cylinder. Empty the contents of the measuring cylinder into the gas jar with copper and watch the brown gas rise (fig ii).
d Once the reaction stops, it is possible to place a lid on the gas jar and carry out the rest of the demonstration in the open laboratory. Invert the second jar over the jar containing the gas and remove the lid from the lower jar (containing the nitrogen dioxide) Clamp this jar into position with care (fig iii). Diffusion takes place in 20 minutes.

Controls and hints

Wear goggles (EN 166 3) when handling concentrated nitric acid. Gloves are not required when an automatic pipettor is used.

Disposal

If possible, move the gas jars to a fume cupboard. Add water to each gas jar and pour the contents down a foul-water drain, adding more water. Unreacted copper turnings can be dried and reused. If there is no fume cupboard in the room, carefully insert gas-jar lids to cover both jars. Seal with sellotape and remove to a fume cupboard.

Extension

The demonstration can be performed along with a similar set up using bromine to show that gases diffuse at different rates. To fill a 1 litre gas jar, use no more than 2 ml of liquid bromine. Adjust the volume of bromine liquid to the capacity of the gas jar that is available. It takes time for bromine to vaporise. Use a fume cupboard, wear goggles or a face shield and nitrile or latex chemical-resistant gloves. A bucket of 1 M sodium thiosulfate solution should be available in case bromine splashes onto the skin or is spilled.

Reference

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Credits

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