White powder mix-up at the factory

- Your task

Haynes Whiteners,
54 Henshaw House,
Paynes Parade,
St Pringle Bay.
Chief Chemist,
Science Laboratories,
Bunsen Road,
Test Tube Town.
CH4 7PH.
28th September

Dear Sir/Madam,

We are writing to ask your company of chemists to solve a problem we have at the "Haynes Whiteners Factory". The factory makes 4 different white powders. Sometimes there is a mix up and the bags of powders are not labelled. The factory needs to be able to tell the difference between the white powders and identify which is which. Your task is for your company to come up with some simple tests and reactions which might show a difference between the 4 white powders.

We could arrange for your chemists to visit our very simple laboratories to carry out some experiments. The equipment we have available for your use include: beakers, Bunsen burners, test-tubes and holders, Universal indicator and hydrochloric acid. Of course this factory is very proud of its safety record and we would expect you to work within the health and safety laws.

After the laboratory work, your chemists will be asked to explain the tests to our factory workers and answer their questions.

Further, we would expect a report of your findings and recommendations within the week.

Please do not hesitate to contact us if there is anything you are unsure about.

Yours faithfully,

Based on a suggestion by S. Pringle.

Time

70 minutes.

Group size

3.

Equipment & materials

Eye protection.

General
Test-tubes (including pyrex ones), ignition tubes, test-tube racks, test-tube holders, beakers, glass droppers, glass stirring rods, spatulas. Microscope & slides. Bunsen burners, tripods, gauzes, heatproof mats, clampstands. Balances. Powerpack/leads/bulb. Electrolysis cell (as a distractor).

Universal indicator & indicator scales, litmus. Limewater.

Per group
White powders (solids should be powdered so that they are roughly of equal particle size). Choose 4

powders (approximately 10 g of each) from the list: magnesium oxide, sodium chloride, zinc oxide, ammonium chloride, sugar, citric acid, calcium carbonate, wax. (Students are told what the 4 powders are.) Hydrochloric acid (1 mol dm^{-3}) – 50 cm^3, sodium hydroxide (1 mol dm^{-3}) –50 cm^3.

Health & Safety notes

This is an open-ended problem solving activity, so the guidance given here is necessarily incomplete. Teachers need to be particularly vigilant, and a higher degree of supervision is needed than in activities which have more closed outcomes. Students must be encouraged to take a responsible attitude towards safety, both their own and that of others. In planning an activity students should always include safety as a factor to be considered. Plans should be checked by the teacher before implementing them.

You must always comply with your employer's procedures and in some cases may decide that a particular activity is inappropriate in your situation. Further information on Health and Safety should be obtained from reputable sources such as CLEAPSS [*http://science.cleapss.org.uk/*] in England, Wales and Northern Ireland and, in Scotland, SSERC [*https://www.sserc.org.uk/*].

Eye protection should be worn – goggles (BS EN166 3 when handling the sodium hydroxide) rather than safety glasses.

Zinc oxide, ZnO is very TOXIC to aquatic life.

Ammonium chloride, NH4Cl (s) is harmful if swallowed and an eye irritant. When it sublimes, do not inhale the vapour. Sodium hydroxide solution, 1 mol dm^{-3} NaOH (aq), is CORROSIVE to skin and eyes. Hydrochloric acid, 1 mol dm^{-3} HCl (aq), is of low hazard.

Dispoal: Solutions produced from zinc oxide should be kept for disposal. (It may be easier to precipitate as the carbonate, filter and store the solid).

It is the responsibility of the teacher to carry out a suitable risk assessment.

Curriculum links

Physical and chemical changes, chemical reactions.

Possible approaches

Experiment is designed to make students think about how chemicals differ – physically and chemically. Tell students at start of lesson that they will need to ask permission if an "unusual test" is required. Students are in competition with other companies for the business. Companies will be penalised for breaking health and safety laws, *eg* not wearing eye protection, untidy work.

Possible tests

eg Appearance, include under microscope. Adding water, adding universal indicator. Heating. Effects of adding acid/alkali. Weighing – density.

Conduction of electricity. Magnetic. (Distracters have been included.) ($CaCO_3$ gives off CO_2 when acid is added. $CaCO_3$ does not dissolve in water. Ammonium chloride sublimes on heating. Citric acid melts on heating to give an orange liquid. Ammonium chloride and citric acid turn indicator red.)

Suggested write-up

Students write a report for the factory boss. All the tests and results must be written up clearly with a conclusion of the easiest way(s) of identifying which powder is which. Also students will need a name for their company. The boss will be looking for an eye-catching and accurate presentation. Students might elect a representative from their group to present their findings – *eg* a POSTER – at end of the lesson.

- For an "unlabelled bags in the bakery" experiment:- use sodium hydrogencarbonate (sodium bicarbonate), sodium chloride, sugar and citric acid.

Credits

Health & safety checked May 2018

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