Exothermic or endothermic?

Class practical

This is a useful class practical to introduce **energy changes** in chemical reactions. The students measure the **temperature changes** in four reactions, and classify the reactions as **exothermic** or **endothermic**. The experiments can also be used to revise different **types of chemical reaction** and, with some classes, **chemical formulae** and **equations**.

Lesson organisation

There are five solutions and three solids involved. Careful consideration will need to be given as to the most appropriate way to dispense these to the class. Special care should be taken with the magnesium ribbon and magnesium powder and, with some classes, teachers may prefer to dispense these materials directly.

The length of time required for carrying out the actual reactions is around 30 minutes, but this will depend on the nature of the class and how the practical is organised.

Apparatus	Chemicals
Eye protection ***Each group of students will need:*** **Polystyrene cup (expanded polystyrene)** **Beaker (250 cm^3) in which to stand the polystyrene cup for support (Note 1)** **Thermometer (–10°C to 110°C)** **Measuring cylinder (10 cm^3), 2** **Spatula** **Absorbent paper**	Access to the following solutions (all at approx 0.4 M concentration): Copper(II) sulfate Hydrochloric acid Sodium hydrogencarbonate Sodium hydroxide (IRRITANT) Sulfuric acid *Access to the following solids:* Magnesium ribbon, cut into 3 cm lengths Magnesium powder (HIGHLY FLAMMABLE) Citric acid (IRRITANT) **Refer to Health & Safety and Technical notes section below for additional information.**

Health &Safety and Technical notes

Read our standard health &safety guidance

Wear eye protection throughout. At the suggested concentrations, the solutions (except for sodium hydroxide) represent minimal hazards, although it is probably advisable to label them as HARMFUL. If the concentrations are increased then the solutions must be labelled with the correct hazard warning. The solutions could be provided in small (100 cm^3) labelled conical flasks or beakers.

Copper(II) sulfate solution, $CuSO_4$(aq) - see CLEAPSS Hazcard and CLEAPSS Recipe Book.

Dilute hydrochloric acid, HCl(aq) - see CLEAPSS Hazcard and CLEAPSS Recipe Book.

Sodium hydrogencarbonate solution, $NaHCO_3$(aq) - see CLEAPSS Hazcard and CLEAPSS Recipe Book.

Sodium hydroxide, NaOH(aq), (IRRITANT) - see CLEAPSS Hazcard and CLEAPSS Recipe Book.

Dilute sulfuric acid, H_2SO_4(aq) - see CLEAPSS Hazcard and CLEAPSS Recipe Book.

Magnesium ribbon, Mg(s) - see CLEAPSS Hazcard. The teacher may prefer to keep the magnesium ribbon under their immediate control and to dispense on an individual basis.

Magnesium powder, Mg(s), (HIGHLY FLAMMABLE) - see CLEAPSS Hazcard. Small amounts of magnesium powder can be provided in plastic weighing boats or similar. The teacher may prefer to keep the magnesium powder under their immediate control and to dispense on an individual basis.

Citric acid, $HOOCCH_2C(OH)(COOH)CH_2COOH$(s), (IRRITANT) - see CLEAPSS Hazcard. Small amounts of citric acid can be provided in plastic weighing boats or similar.

1 Typical expanded polystyrene cups fit snugly into 250 cm^3 squat form beakers. This provides a more stable reaction vessel and also prevents spillage if the polystyrene cup splits.

Procedure

Reaction of sodium hydroxide solution and dilute hydrochloric acid

a Stand the polystyrene cup in the beaker.

b Use the measuring cylinder to measure out 10 cm^3 of sodium hydroxide solution and pour it into the polystyrene cup.

c Measure the initial temperature of the sodium hydroxide solution and record it in a suitable table.

d Measure out 10 cm^3 of hydrochloric acid and carefully add this to the sodium hydroxide solution in the polystyrene cup. Stir with the thermometer and record the maximum or minimum temperature reached.

e Work out the temperature change and decide if the reaction is exothermic or endothermic.

f Discard the mixture (in the sink with plenty of water). Rinse out and dry the polystyrene cup.

Reaction of sodium hydrogencarbonate solution and citric acid

a Repeat steps a – c of the previous experiment, using sodium hydrogencarbonate solution in place of sodium hydroxide solution.

b Add 4 small (not heaped) spatula measures of citric acid. Stir with the thermometer and record the maximum or minimum temperature reached.

c Work out the temperature change and decide if the reaction is exothermic or endothermic.

d Discard the mixture (in the sink with plenty of water). Rinse out and dry the polystyrene cup.

Reaction of copper(II) sulfate solution and magnesium powder

a Repeat steps a – c of the first experiment, using copper(II) sulfate solution in place of sodium hydroxide solution.

b Add 1 small (not heaped) spatula measure of magnesium powder. Stir with the thermometer and record the maximum or minimum temperature reached.

c Work out the temperature change and decide if the reaction is exothermic or endothermic.

d Discard the mixture (in the sink with plenty of water). Rinse out and dry the polystyrene cup.

Reaction of sulfuric acid and magnesium ribbon

a Repeat steps a – c of the first experiment, using sulfuric acid in place of sodium hydroxide solution.

b Add one 3 cm piece of magnesium ribbon. Stir with the thermometer and record the maximum or minimum temperature reached.

c Work out the temperature change and decide if the reaction is exothermic or endothermic.

d Once all the magnesium ribbon has reacted, discard the mixture (in the sink with plenty of water). Rinse out and dry the polystyrene cup.

Teaching notes

The reactions and types of reaction involved are:

Sodium hydroxide + hydrochloric acid sodium chloride + water (Neutralisation)

$NaOH(aq) + HCl(aq) \;\; NaCl(aq) + H_2O(l)$

Copper(II) sulfate + magnesium magnesium sulfate + copper (Displacement, Redox)

$CuSO_4(aq) + Mg(s) \;\; MgSO_4(aq) + Cu(s)$

Sulfuric acid + magnesium magnesium sulfate + hydrogen (Displacement, Redox)

$H_2SO_4(aq) + Mg(s) \;\; MgSO_4(aq) + H_2(g)$

At this level the neutralisation reaction between sodium hydrogen carbonate and citric acid may be a bit complicated – it may be better to just use the word equation. More able students could use $H^+(aq)$ to represent the acid.

Sodium hydrogencarbonate + citric acid sodium citrate + water + carbon dioxide

$NaHCO_3(aq) + H^+(aq) \;\; Na^+(aq) + H_2O(l) + CO_2(g)$

Health &Safety checked, 2016

Credits

This Practical Chemistry resource was developed by the Nuffield Foundation and the Royal Society of Chemistry.

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