Energy

Student Notes

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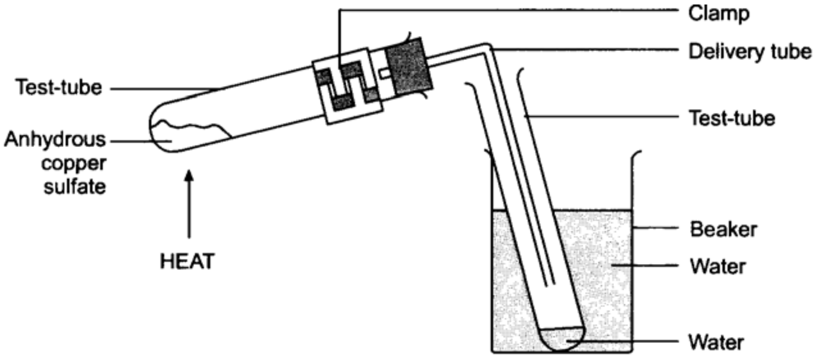
Activity 1: Heating copper(II) sulfate

Introduction

In this experiment the water of crystallisation is removed from hydrated blue copper(II)sulfate. After cooling the anhydrous copper(II) sulfate formed is then rehydrated with the same water.



What to record

Record any observations when the water was poured back onto the white copper(II)sulfate.

What to do

1. Set up the apparatus as shown.
2. Heat the blue copper(II) sulfate until it has turned white.
3. Act quickly to prevent suck back. Lift the clamp stand so that the delivery tube does not reach into the water in the test-tube.
4. Allow the anhydrous copper(II) sulfate to cool.
5. Hold the tube containing anhydrous copper(II) sulfate in one hand and pour the condensed water onto the powder.

Safety

Wear eye protection.

Questions

1. Why is one test-tube placed in a beaker of cold water?

2. What do the following words mean (*a*) hydrated, (*b*) anhydrous, (*c*) product, (*d*) condensed and (*e*) reaction?

3. The reaction

Hydrated copper(II) sulfate + heat anhydrous copper(II) sulfate + water is called a reversible reaction. Why?

4. Anhydrous copper(II) sulfate could be used as a fuel for heating ('just add water to get the heat'). Explain why it would not be a very economical fuel.

Activity 4: Exothermic or endothermic?

This practical introduces the idea of energy changes in chemical reactions. You will measure the temperature changes in four reactions, and classify the reactions as exothermic or endothermic.

You will then decide what type of reaction is occurring in each case and write a balanced equation.

Procedure

HEALTH & SAFETY: Wear eye protection throughout.

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.

Activity 5: Measuring heat energy of fuels

The combustion of alcohols is exothermic and in this experiment the energy released from burning a known mass of alcohol is used to heat a known amount of water. A comparison of various alcohols as fuels can be made by calculating the quantity of energy transferred to the water.

Apparatus

All students will need access to:

Balances (2 or 3 d.p.)

Each student or pair of students will need:

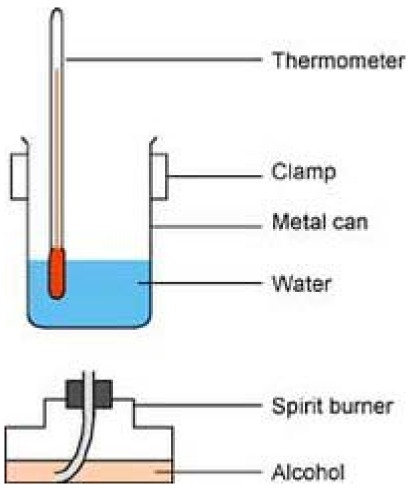
Eye protection for each student
Clamp, stand and boss
Metal can (such as a copper calorimeter) or conical flask (250 cm^3)
Measuring cylinder (100 cm^3)
Spirit burner with cap or small crucible with wide lid (see note 1 to 4 and alternative method in teaching notes)
Stirring thermometer (0-110 °C)
Glass rod
Heat resistant mat

Access to

Matches or Bunsen burner

All students will need access to:

Alcohols in labelled spirit burners (or in dropper bottles if using crucibles) (see note 5):
Methanol (**Highly flammable, Toxic**)
Ethanol (**Highly flammable**)
or Industrial Denatured Alcohol (IDA) (**Highly flammable, Harmful**)
Propan-1-ol (**Highly flammable, Irritant**)
Butan-1-ol (**Flammable, Harmful**)



Procedure

HEALTH & SAFETY: Wear eye protection

a) Clamp the metal can (or flask) at a suitable height to allow room for the spirit burner to be placed below. Allow a gap of around 2-5 cm between the base of the flask/can and the top of the spirit burner. This gap may need to be adjusted depending on the height of the flame.
b) Using the measuring cylinder, fill the metal can with 100 cm^3 of water.
c) Using the thermometer, measure and record the initial temperature of the water.
d) Weigh the spirit burner (and cap) containing the alcohol and record the initial mass and name of the alcohol in a suitable table.
e) Place the spirit burner on the heat-resistant mat under the metal can, remove the cap, and light the wick.
f) Allow the alcohol to heat the water so the temperature rises *by* about 40°C. Use a glass rod or the thermometer to stir the water gently whilst the alcohol burns.
g) Replace the cap on the spirit burner to extinguish the flame.
h) Record the final temperature of the water using the thermometer. Work out the temperature change.
i) Reweigh the spirit burner and cap. Work out the mass of alcohol used.
j) Repeat the experiment for different alcohols using 100 cm^3 of fresh cold water each time.
k) If time allows repeat the experiment for each alcohol at least twice.

Notes

Using the measurements that you have recorded work out the temperature change and the mass of alcohol burned for each alcohol.

The energy transferred to the water from the burning alcohol can be calculated using the equation $q = mc\Delta T$

where q = energy transferred (in J), m = mass of water (in g) c = specific heat capacity of water (in J/[g°C]) and ΔT = temp change (in °C or K).

Assume that 1 cm^3 of water has a mass of 1 g.
Assume that the specific heat capacity of water, c = 4.18 J/(g°C) or c = 4.18 J g^{-1} K^{-1} (i.e. 4.18 J are required for every 1 °C rise in temperature per g of water).

Which fuel (alcohol) provides the most energy per gram of fuel burned?

The experimental results are often much less than values given in data books, or predicted using models and the energies needed to break the bonds. Explain why this occurs.

Additional work: Investigate methods of reducing heat loss to the environment and thus discuss how the experiment could be improved.

Diagnostic Test

1 Which reactions, in solution, are quicker, ionic or covalent? **(1)**

2 In each of the following test tube reactions how could you tell if a chemical reaction had occurred?

a) Silver nitrate solution and hydrochloric acid are added together.

b) Magnesium metal is added to hydrochloric acid.

c) Water is added to quicklime (calcium oxide). **(3)**

3 The rate of a chemical reaction increases when the temperature of the system is raised. Why is this? **(2)**

4 What is meant by the 'activation energy' of a reaction? **(2)**

5 What is meant by the terms 'exothermic' and 'endothermic'? **(2)**

6 Some reactions are affected by catalysts.

a) Explain what a catalyst is and give an example. **(2)**

b) Describe briefly how catalysts are believed to work. **(2)**

7 a) What does the symbol ΔH represent?

b) What do you understand by 'ΔH is negative'.

c) Would ΔH be positive or negative for the reaction in Question 2(c)? **(3)**

8 a) More energy is released when strong bonds are formed than when weaker bonds are made. TRUE or FALSE? **(1)**

b) So long as particles collide, they will react together. TRUE or FALSE? Explain your answer. **(2)**

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