HYDROGEN BALLOONS

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Description:
Hydrogen is the lightest element of the period table and was once used to fill airships such as the Hindenburg. As most students can tell you, one of the problems with filling airships with hydrogen is the small defect in which they occasionally catch fire and spectacularly explode. Hydrogen can be produced in the laboratory in a number of ways – in this demonstration the oxidising agent aluminium is used with sodium hydroxide and water to produce hydrogen gas to fill a balloon. This reaction is an exothermic reaction that produces a lot of heat; when the balloon is burnt another exothermic reaction occurs, in which hydrogen and oxygen is combined to form water, releasing a large amount of heat/light and sound energy!

Time: 15 min

Short and sweet: Aluminium and sodium hydroxide produce hydrogen.
Keywords: hydrogen, balloon, aluminium, foil, sodium hydroxide, water, explosion, combustion, density, gas, oxidising, exothermic
Subject areas: chemistry, physics

MATERIALS AND METHOD

Materials:

- 1 cup cold water
- 1 tablespoon sodium hydroxide or 6M sodium hydroxide solution or solid sodium hydroxide based drain cleaner such as Draino®
- 300mm x 300mm of aluminium foil
- Round balloons
- 500-700mL conical flask or 750 mL wine bottle
- Large beaker or plastic bucket ¼ filled with water
- Metre ruler
- Lighting taper and matches
- Sellotape or masking tape

Method:

1. Dissolve sodium hydroxide in water and place in conical flask. Place the conical flask in the beaker – this will act as a water bath to slow the reaction.
2. Add aluminium foil to the conical flask.
3. Stretch a balloon over the neck of the conical flask.
4. The balloon will inflate with hydrogen over the next few minutes.
5. Let balloon float away.
6. Alternately, the balloon can be set on fire by taping it to a metre ruler. Tape a lighting taper to a second metre ruler, and light it. Dim the lights and use the taper to burn the balloon setting fire to the hydrogen.

   Ensure that the hydrogen producing reaction is slow – test it on the day prior to demonstration to ensure that there is not a rapid inflation of the balloon due to a rapid exothermic reaction which will fill the balloon with hot sodium hydroxide vapours – this will a) make the balloon to heavy to float and b) create a dangerously corrosive balloon!

SAFETY/DISPOSAL

- The reaction is a rapid exothermic reaction. Ensure that the flask is in a water bath and in a fume hood – there is potential for rapid filling of the balloon which would also involve hot NaOH vapours that are corrosive.
- Hydrogen gas is very explosive (the point of this demonstration!). Ensure that it is not able to come into contact with a naked flame.
- The residue of the experiment is able to be washed down the sink with excess water – Aluminium powder and sodium hydroxide is often used as a drain unblocking mix.
- Sodium hydroxide is corrosive – care must be taken with its use.
- After lighting the balloon, the fireball is very quick and will travel up towards the ceiling. Ensure that the ceiling cannot catch alight because of spider webs, debris or holes, or ceiling tile construction.

EDUCATIONAL CONCEPTS & REACTIONS/ANALYSIS

- Aluminium is highly reactive and so reacts with oxygen to form a protective coating of aluminium oxide. This is dissolved by the sodium hydroxide.
  $Al_2O_3 + 2NaOH + 3H_2O \rightarrow 2Na^+ + 2\,[Al(OH)_4]^-$

  The exposed aluminium surface can then react with water to form hydrogen.
  $2\,Al + 6\,H_2O \rightarrow 2\,Al(OH)_3 + 3H_2$

  This surface layer of aluminium hydroxide then is dissolved by the sodium hydroxide to expose another surface of aluminium which can react with H_2O.
  $Al(OH)_3 + NaOH \rightarrow Na^+ + [Al(OH)_4]^-$

- Hydrogen burns completely in oxygen to produce water
  $H_2 + ½\,O_2 \rightarrow H_2O$ or $2H_2 + O_2 \rightarrow 2H_2O$

HOW THE DEMONSTRATION COULD BE USED

- Chemistry – properties of hydrogen (light, flammable, reactive)
- Chemistry – stoichiometry and Le Chatelier's Principle – how much Al/NaOH/H_2O is needed to make x amount of H. How much H_2O is made from burning H?
- Chemistry - exothermic reactions – how much heat is produced when the H is produced?

INVESTIGATIONS/VARIATIONS

- What is the effect of different brands/weights of aluminium foil on rate of reaction?
- What is the effect of different strengths of NaOH on rate of reaction? Amount of water added?