The methane rocket

Introduction

A strong plastic bottle is filled with a 2 : 1 ratio of oxygen to methane and the mixture ignited with the bottle standing on a suitable 'launch pad'. The mixture ignites with a loud bang and the bottle flies several metres.

Equipment

Apparatus

- Eye protection
- Ear protection
- A carbonated soft drink bottle of between 300 cm^3 and 500 cm^3 capacity.
- A rubber bung to fit the bottle.
- A large trough or washing up bowl
- Measuring cylinder, 500 cm^3
- Rubber tubing to fit the gas tap

Chemicals

- Oxygen cylinder or other source of oxygen

Health, safety and technical notes

- Read our standard health and safety guidance here https://rsc.li/3Fsq2Y8
- Both demonstrator and audience should wear eye protection.
- The demonstrator should wear ear protectors and the audience should be advised to cover their ears.
- Do not use a larger bottle than specified and use each bottle for one demonstration only.
- Your employer's risk assessment should be consulted before carrying out this activity.

Procedure

1. Select a suitable place to fire the bottle – a corridor might be a better choice than a laboratory.
2. Prepare a launch pad – open a fairly heavy paperback book in the middle and place it, covers down, on a table, rest the bottle in the centre.
3. Fill a plastic carbonated drinks bottle of between 300 cm^3 and 500 cm^3 capacity with water and pour the water into a measuring cylinder to determine its total volume.
4. Pour one-third of the bottle's volume of water back into the bottle and mark the level with a waterproof pen.
5. Completely fill the bottle and invert it in a trough or washing-up bowl of water.
6. Place the end of a rubber tube connected to the gas tap under the neck of the bottle and fill the bottle to the marked level with methane (natural gas) from the gas tap.
7. Fill the rest of the bottle with oxygen from the chosen source. The bottle now contains a 2 : 1 mixture of oxygen and methane by volume. This is the stoichiometric mixture.
8. Stopper the bottle with a rubber bung and place the bottle on the launch pad. Check the aiming of the rocket and ensure that none of the audience is near the flight path.
9. Wear eye and ear protection and advise the audience to cover their ears.
10. Remove the bung and ignite the gas mixture by applying a lighted splint to the neck of the bottle. The rocket will take off with a loud bang and fly for several metres.

11. If a second flight is to be done, use a new bottle.

Notes

- Remember to turn your gas sources on for a few seconds to allow air in the tube to be displaced before starting to fill the bottle.
- After firing, the rocket can be recovered and shown to the audience to point out that it is covered on the inside by condensation – droplets of water formed in the reaction.
- The reaction is:
- $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$ $\Delta H = -890$ kJ mol^{-1}
- The gases react in a 2 : 1 ratio, and the reaction is strongly exothermic.
- Note that there are three moles of gas on both sides of the equation, so all the force that propels the rocket comes from the expansion of the gases as they are heated by the energy given out by the reaction, rather than by the production of extra molecules of gas.
- Please note: You can get students to balance the equation and try to work out for themselves what the ratio should be, then fill the bottle and launch.
- The best bang will be from a stoichiometric mix.