Exploding balloons

In this demonstration experiment, mixtures of hydrogen and oxygen gases in party balloons are ignited. Varying the proportions of the two gases alters the vigour of the resulting explosive, exothermic reaction.

Lesson organisation

This is a very noisy demonstration and should be done in a large room (e.g. a school hall) or outdoors so the audience can sit or stand well away from the exploding balloons. Be aware as well that the noise will affect others in the vicinity, including possibly people living near the school.

Apparatus and chemicals

Eye protection
Ear protectors

The teacher will require:
Small balloons, at least 4 (see note 1)
Metre rule
Small candle, wax taper or wooden splint (see note 2)
Cotton thread
Boss, clamp and stand
Matches

Access to cylinders (with regulators and rubber delivery tubing) of hydrogen (Extremely flammable) and oxygen gas (Oxidising agent) (see note 3)

Students will require:
Eye protection

Technical notes

Hydrogen (Extremely flammable) Refer to CLEAPSS® Hazcard 48
Oxygen (Oxidising agent) Refer to CLEAPSS® Hazcard 69

1 Small party balloons are ideal. Do not fill the balloons too far in advance of the lesson.
2 Attach the candle, wax taper or wooden splint to the end of the metre rule with adhesive tape or Blue Tak.
3 Gases generated chemically will not have sufficient pressure to inflate the balloons. Filling the balloons with the different mixtures of gases can be tricky and teachers may prefer to have some balloons which are already filled.
Procedure

**HEALTH & SAFETY:** Wear eye protection throughout. The teacher should also wear ear protection as indicated. Students should be instructed to protect their ears at relevant points in the demonstration.

a. Inflate one of the balloons with air (by mouth) and seal it by tying a knot in the neck. Clamp the knotted end of the balloon to hold it in position. Place the clamp stand on a desk well away from any combustible materials. Check that the ceiling space above the clamp stand is also clear.

b. Light the candle or wax taper and touch the balloon with the candle flame. The balloon will burst with a familiar pop, due solely to the rubber bursting. Extinguish the candle flame.

c. Inflate a second balloon with hydrogen from a cylinder and seal it. This balloon should float in air. Tether it to the clamp stand with a length of cotton thread. Ensure that the students are at least 3 m away.

d. Instruct the students to place their fingers in their ears. The teacher should wear ear protection.

e. Light the candle and, holding the metre rule at arm’s length, touch the candle flame on the balloon. The balloon will explode with a loud bang. Flames from the combustion of the hydrogen with the oxygen in the air can be seen. Extinguish the flame.

f. Inflate the third balloon with a little hydrogen (about one third of the full balloon size) and complete the inflation with air from the mouth. The correct ratio of hydrogen to air for complete combustion is 2:5 but it is preferable to have rather more hydrogen than this so that the balloon will float upwards.

g. Attach the filled balloon to the clamp stand with a cotton thread as before. Ensure that ears are protected and then ignite the balloon as before. The explosion will be louder this time because the fuel (hydrogen) and the oxygen in the air are thoroughly mixed. Again, extinguish the candle flame.

h. Finally, inflate the fourth balloon - first with some hydrogen and then fill it with oxygen from the cylinder. The ideal mixture is two volumes of hydrogen to one volume of oxygen but this may need adjusting in order to ensure that the balloon still floats.

i. Attach the balloon to the clamp stand with thread as before. Wear ear protectors and ensure that members of the audience place their fingers in their ears. Ignite the balloon at arm’s length. There will be a very loud explosion!

Note: Exploding stoichiometric (exactly reacting) mixtures of hydrogen and oxygen on a large scale can shatter glass apparatus and laboratory windows (flying glass may cause injury) and permanently damage the hearing of people in the same room. It is recommended that this reaction is done ONLY on the small scale as described in experiment 70 and experiment 71.
Teaching notes

Hydrogen-air mixtures will explode if they contain between 4 to 75% hydrogen.

The exothermic reaction:
\[ 2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g}) \]
releases 484 kJ of energy from the amounts (reacting masses) shown in the equation.

A good way of presenting the demonstration is to have the balloons tethered in a row some distance apart, prepared shortly before the demonstration. They can then be ignited one-by-one in order of increasing vigour of reaction.

The explosions increase in loudness as the percentage of oxygen in the mixture increases. The class could be asked to predict what would happen if a balloon filled only with oxygen is ‘ignited’. This could then be demonstrated, with suitable theatricality, and the class asked to explain the rather disappointing result. With no fuel (hydrogen) for the oxygen to combine with, the bang is due only to the bursting of the rubber of the balloon, as when filled only with air (or helium).

Reference
This experiment has been reproduced from Practical Chemistry:
http://www.practicalchemistry.org/experiments/intermediate/energy-changes-and-fuels/exploding-balloons,47,EX.html

Useful resources

Hydrogen air reaction:
http://www.jce.divched.org/JCESoft/CCA/CCA4/MAINPT/DH_el/t/H.HTM#Air