BALLOON IN A BOTTLE: WEATHER BALLOON MASTER CLASS

The following materials and tools will be required:

MATERIALS AND TOOLS

Two-litre empty plastic bottle
500ml empty plastic bottle
Blow-up balloons
Scissors

This activity should be carried out under adult supervision

ACTIVITY STEPS

STEP 1

Cut a small hole at the bottom of the small plastic bottle.

STEP 2

Fold the mouth of the balloons over the top of the bottles so that the balloons are inside the bottles.

STEP 3

Try blowing up both balloons in each of the bottles. Do you think the balloon in the big bottle or the balloon in the small bottle will blow up easier?

THE IMPORTANCE OF WEATHER BALLOONS

A weather balloon carries equipment that collects information concerning atmospheric pressure, temperature, relative humidity, and wind speed by means of a battery-powered telemetry instrument or 'radiosonde', which transmits these parameters by radio to a ground receiver.

The further the air balloon reaches, the more it expands and eventually explodes due to lower air pressure at higher altitudes. A parachute recovery system is put in place to allow for a safe landing of the transmitter, which is eventually recovered so that the information can be retrieved and any damages to the radiosonde can be repaired so that it can be reused for future flight.

When launching professional rockets, it is important to confirm that the wind above the ground – also known as the vertical wind profile – is within safe limits for the flight, doing so as close to launch time as possible. This can be achieved with the use of weather balloons.

At ground level, the Earth's atmospheric pressure is much stronger that it is when a balloon reaches a higher altitude where the atmosphere is much thinner. If a balloon were completely filled with helium from the start, as the pressure in the atmosphere drops, the balloon would attempt to expand to equalise the pressure, which would in turn cause it to pop.

The higher the weather balloon travels, the more it expands. This is because the air pressure decreases as the balloon climbs higher into the atmosphere. The latex or neoprene weather balloon is highly flexible and has the ability to expand from 2 metres to 8 metres wide, but it will eventually break when the balloon reaches an altitude where the air pressure is only a few thousandths of a fraction of what is found on the Earth's surface.

This activity demonstrates that the particles inside the walls of the balloon create enough air pressure to force the rubber of the balloon to expand and the balloon to inflate. The collision of these air particles with the walls creates a high-pressure environment inside the balloon relative to the atmospheric pressure around it. This is relative to a weather balloon before launch.

When the balloon is placed inside the bottle, it does not inflate, since the bottle is already filled with air particles with no escape route. This demonstrates that the higher the atmospheric pressure, the more space the air particles consume.

When a hole is cut into the bottle, the air particles in the bottle have an exit. These particles are pushed out as the balloon fills the space inside, resulting in room for the balloon to inflate. This is relative to a weather balloon at high altitude, whereby there are less air particles within the atmosphere and so the weather balloon expands further.

Ahead of launch Skyrora will release weather balloons with telemetry devices attached to analyse the windspeeds at certain altitudes. From that data, it can be determined whether our rockets are able to complete low risk launch through such wind speeds. This enables Skyrora to assess weather conditions more accurately and therefore choose an appropriate launch window.

LESSON PLAN

The key objective of this experiment is to explain how air pressure works. Blowing up a balloon involves forcing additional air particles from your lungs into the balloon. These particles hit the inside walls of the balloon creating enough air pressure to force the rubber of the balloon to expand and the balloon to inflate.

The collision of these air particles with the walls creates a high-pressure environment inside the balloon relative to the atmospheric pressure around it. Therefore, when a balloon is released, the high-pressure air flows out of the balloon to the low-pressure air surrounding it.

When a balloon is placed inside the bottle it will not inflate as the bottle is already filled with air particles with no escape route. This is a great demonstration that air takes up space. The air inside the bottle compresses a little but not enough to permit the balloon the inflate.

When you cut a hole in a bottle, the air molecules in the bottle have an exit. They are pushed out as a balloon fills the space inside, resulting in room for the balloon to inflate.

If the hole in the bottle is then covered, the balloon stays inflated even when the air source (mouth) is removed. This is because the high-pressure in the balloon pushes outward harder than the low-pressure air in the bottle. The air in the balloon pushes out against the walls, keeping it inflated. When the hole is unplugged, air flows back into the bottle. The air pressure in the bottle increases and collapses the balloon.

Key Questions:

- Why did one balloon inflate and the other not?
  If there is no change in air pressure, the balloon will not deflate (or inflate further)
- Why does air take up space?
  Air takes up space because it is made of particles: since it has mass, it also has volume
- Why is it impossible to inflate a balloon inside a bottle?
  The bottle is already filled with air particles with no escape route
- What is meant by atmospheric pressure?
  The force exerted on a surface by the air above it as gravity pulls it to Earth

Extensions:
Inflate the balloon in the bottle again and cover the hole in the bottle with your finger, pouring water into the balloon while keeping your finger over the hole. Hold the bottle over a sink before you remove your finger: watch out for that stream of water gushing out of the bottle top!