

LESSON 7

Balloons.

Balloons can be inflated with different gases. Some gases (e.g. helium) make balloons rise in the air, and others (e.g. carbon dioxide) make them fall. Why?

Get your pupil to put some materials in order of lightness or heaviness, by watching them rise or fall in a jug of water. Children are good at this, and you might soon have a steel bolt on the extreme left, next to it a rubber, then water itself in the middle, then a candle stub, and on the extreme right, a cork.

It is like that with gases too. Carbon dioxide sinks in air because it is heavier stuff than air. Helium rises because it is lighter stuff than air.

Here comes a nice surprise. A gas will be lighter stuff than air if its molecular weight is less than air's molecular weight (which is 29 u). So you can easily work out which gases could be used for flying balloons and airships!

Q1. The atomic weight of helium is 4 u. What is its molecular weight? *[The same, 4 u, because helium has a 1-atom molecule.]*

Q2. Why does a helium balloon rise? *[Its molecular weight is less than 29 u.]*

Q3. Will a hydrogen balloon rise or fall? *[It will rise, because the molecular weight of hydrogen is less than 29 u.]*

Q4. If you released two similar balloons at the same time, one filled with helium, the other filled with hydrogen, which would win the upward race? *[The hydrogen balloon, because H_2 weighs only 2 u but He weighs 4 u.]*

Q5. Work out the molecular weight of propane gas, formula C_3H_8 .
 $[(12+12+12)u + (1+1+1+1+1+1+1+1)u = 44 u.]$

Q6. Will a propane balloon rise or fall in the air. *[Answer by experiment!]*

Propane – pure enough for the purpose – is sold in cylinders for campers. There is no danger in inflating a balloon with it, away from flames in a well ventilated room. Let your pupil see that it drops in air.

Q7. Think of a reason why a balloon drops slowly in air even when it is filled with air. *[The weight of the rubber and string pulls it down.]*

Inflate a similar balloon, to a similar size, with air. Then drop the two balloons simultaneously. The propane balloon will hit the ground first. Your pupil will see from this that propane is a heavier gas than air without anything being said.

Q8. If propane and CO_2 balloons were simultaneously dropped from a second floor window, which would hit the ground first? *[It would be a tie.]*

Notes for Parents

Children have an implicit understanding of “heavy stuff” and “light stuff” (from playing in the bath as infants?) Don’t risk spoiling the fun by talking about “weight per unit volume” (density). It would be too soon for him/her.

About 80% of air is N_2 molecules, and the molecular weight of nitrogen is 28 u. However, about 20% of air is O_2 molecules, and the molecular weight of oxygen is 32 u. These figures lead to the 29 u given in this lesson for the molecular weight of air, but don’t spell this out. Your pupil has enough to think about.

The balloon races of Q4 and Q8 start a new thread of science at a nice early age, but it’s important not to get ahead of the pupil’s thinking and substitute confusion for interest. Here is a suggested chronology.

At primary level, children accept that heavy gases have heavy molecules, and have fun predicting the results of races in which balloons are filled to the same size with different gases..

In secondary school, students learn that the rival balloons contain equal numbers of molecules – for no immediately obvious reason! It is one of the delights of physical science. It is an encouragement to further study. And it fully explains our balloon races: for example, since the equal-sized balloons in Q8 hold equal numbers of molecules, and C_3H_8 and CO_2 molecules weigh the same, the balloons will weigh the same and drop at the same rate.

Much later, students find that laws which hold for planets and snooker balls can also be applied to the moving molecules of gases, and that equal numbers of molecules in equal volumes of gases is no longer a mystery. It is a consequence of Newtonian mechanics.