Additional Material

Elements in the spotlight: helium

Curriculum relevance

This article can easily be linked to a number of curriculum topics, for example:

- The periodic table
- Electron shells and reactivity
- Spectral lines, emission, and absorption
- Quantum effects
- Alpha decay
- Superconducting electromagnets
- RMS velocity: kinetic theory and the Maxwell Boltzmann distribution
- Escape velocity of the Earth – comparison with He RMS velocity
- Mass spectrometry (for helium leak detectors)
- Particle accelerators
- Binding energy calculation: helium from fusion?

What happens to released helium balloons?

Thought experiment 1

Fill your balloon with helium gas and watch. What happens depends on the material and size of the balloon, the pressure of gas and whether it is tethered. We will tether it for now with a shiny ribbon. If the balloon is latex, then it will rise as far as it can on its tether, but over a few hours, the ribbon will slacken as the gas leaks out of the balloon. Helium atoms are tiny and seep through the pores in the rubber. Metallised plastic, or Mylar, with its smaller pores, will slow the leakage, but the balloon will still deflate over a few days, leaving the balloon as limp litter tied to a glistening ribbon. Where has the helium gone?

Time for some kinetic theory: those atoms of helium have a much lower mass than the molecules in the air surrounding them, yet are at the same temperature (in thermal equilibrium) and so have the same average kinetic energy. This means that they are moving at about three times the speed of the molecules of the air, about 1.3 kilometres per second for the helium, and so they quickly disperse, even to the top of the atmosphere. This speed is just their average; they exchange kinetic energy in collisions with the neighbouring molecules. Some of those collisions will mean that helium atoms at the top of the atmosphere reach the 11 km/s "escape velocity" – the speed needed to escape Earth's gravity. This means that helium from the air leaks into space – it is too light and fast for the Earth's pull to hold it for long and it is lost forever.

Thought experiment 2

Fill your balloon with helium gas and let go (this can be an accident – been there). The balloon rises; the upthrust from the surrounding air is greater than the weight of the balloon. How high will it go? Forever? Maybe the beauty of this idea is what makes memorial balloon releases popular. The truth is less pleasant. As the balloon rises, it moves into thinner air. If enough helium remains trapped, then its pressure has less to battle with against the external air, and the balloon will stretch further. It might burst – the helium escapes and the balloon shell falls. Otherwise, as it rises, the air gets thinner and eventually the balloon will find a balance and rest there. But remember, it's leaky; eventually enough helium will get out for our balloon to again sink as litter to the ground. The story for the helium is the same as before – ultimate destination: space.

But where does our balloon land? The streets? A meadow? A forest? A river? The sea? A bag of plastic or latex with a ribbon, which can cause harm to wildlife; should nature be subjected to this?

Can't we make helium by nuclear fusion?

Won't nuclear fusion for future energy have a by-product of helium? A quick "back of the envelope" calculation can give us the scope for this. ITER – the international fusion project being developed now in the South of France – aims to release energy through fusion of the deuterium and tritium isotopes of hydrogen. Each fusion will release about 17.6 MeV. If the 35GW UK mean electricity consumption was achieved by fusion, working with an efficiency of generation of about 35%, then that would yield about 8 tonnes of helium per year. How far would that go? Not very far; world use in 2014 was 32 000 tonnes.