Atoms, Elements and Isotopes

To achieve consistent communication between chemists around the globe, the International Union of Pure and Applied Chemistry (IUPAC) was formed.

Of the 92 naturally occurring elements in the earth, 25 of these are required for life
- 11 of these are vital for biological systems
  - However, 4 of these, hydrogen, carbon, oxygen and nitrogen make up just under 97% of a human's total body mass. They also constitute 99% of the atoms from which the body is formed.

The quest to discover the composition of matter has spanned for many years. In 440 B.C, the Greek philosopher Empedocles postulated that all matter was a construct from 4 different elements:
- Earth, fire, air and water
  - In 300 B.C this became known as the Aristotelian view of matter (from Aristotle).

In 1643, a pupil of Galileo, Evangelista Torricelli proved that air had a weight and that it was capable of pushing down on liquid mercury
- This lead to the discovery of the barometer and further led to the theory that air and other gases consists of loosely packed particles, too small to be seen
  - Furthermore, during the late 18th and early 19th century a scientist, John Dalton developed his atomic theory
    - That all matter is made of atoms and that they cannot be broken down into anything simpler
    - That all atoms in a particular element are identical to each other and differ to atoms of other elements
- In 1987 JJ Thompson discovered the electron
  - He showed that atoms could be broken down into smaller pieces, known as subatomic particles
  - This lead to the discovery by Ernest Rutherford in 1911, that an atom must contain a central nucleus
  - Niels Bohr used experimental evidence to show that electrons occupy orbits and shells around the nucleus

Atoms can be arranged in different structures known as allotropes
- Both diamonds and graphene are made from carbon atoms
  - The carbon in diamonds is a complex structure consisting of strong covalent bonds
  - The carbon in graphene is arranged in layers being held together with weak bonds

Atoms with the same number of protons and electrons but a different number of neutrons is known as an isotope
- For example, oxygen has 8 protons, 8 electrons and can either have 8, 9 or 10 neutrons
  - This is written as $^{16}\text{O}$, $^{17}\text{O}$ or $^{18}\text{O}$
    - The number is the atomic mass of the atom, therefore, 'normal' oxygen is $^{16}\text{O}$
- Plants can discriminate between the 2 isotopes of CO$_2$ in our atmosphere, $^{12}\text{C}$ (98.9%) and $^{13}\text{C}$ (1.1%)
  - The difference in neutrons is enough to alter the diffusion of CO$_2$ within the plants chloroplast, therefore, $^{12}\text{CO}_2$ is preferred
- Tracers used in metabolic studies also use isotopes such as PTOX tracers which are labelled with $^{13}\text{C}$
- Isotopes can also have severely negative effects
  - D$_2$O compared with H$_2$O, studies show that a 90% replacement to D$_2$O proved fatal to fish and other organisms
  - It impaire the organism's haematopoiesis, inhibited mitosis, muscle and nervous function