Law of Conservation of Mass

• matter is neither created nor destroyed though it may change forms in the course of a chemical reaction

History of Atomic Structure

Dalton’s Atomic Theory

• very small indivisible particles
• atoms of a given element are identical - same mass & chemical properties
• compound = 2+ elements combined in fixed proportions
• accounts for experimentally based laws - conservation of mass

Crookes’ Vacuum Tubes, Cathode Rays

• discharge tube - long glass tube, electrode at each end, gas at low pressure
• rays from cathode to anode = cathode rays
• straight lines - maltese cross - sharp shadow in glow at end of tube

Stoney’s Name

• named the particles of electricity electrons - adopted & replaced cathode rays

Thomson’s Charge, e/m Ratio

• showed cathode rays were attracted to positive plate - ⊴ negative
• measured e/m ratio using the fact that they are deflected by magnetic fields
• same e/m no matter what gas/electrode materials - ⊴ in all matter

Millikan’s Oil Drop Experiment
• voltage applied to fine mist of electrically charged oil drops - causes upward force
• adjusted until it balances gravity
• charge on electron measured accurately

Thomson’s Plum Pudding Model
• knew majority of mass was positively charged
• positive spheres in which negatively charged electrons are embedded

Rutherford’s Gold Foil
• Geiger & Marsden
• fire α-particles at thin gold foil
• large no. not deflected - essentially empty space
• many deflected at small angles
• some deflected at large angles - passed close to positive charge
• few rebounded - collided directly with a small, dense nucleus of positive charge
• model: mostly empty space, small dense nucleus at centre, electrons moving around to balance charge

Bohr’s Model
• electrons arranged in a series of concentric circular orbits of increasing distance from the nucleus
• orbits had characteristic energy - \( \therefore \) called energy levels

Rutherford’s Protons
• bombarded elements with α-particles
• same particle was given out
• identical to hydrogen nucleus
• concluded these are the positive charge in the nucleus of an atom

Chadwick’s Neutron
• bombarded beryllium with α-particles
• the α-particles displaced the beryllium neutrons
• the beryllium neutrons hit and displaced paraffin wax protons
• protons detected

**Properties of Electrons, Protons, Neutrons**

<table>
<thead>
<tr>
<th>Particle</th>
<th>Relative Mass</th>
<th>Relative Charge</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electron</td>
<td>1/1836</td>
<td>-1</td>
<td>Outside nucleus</td>
</tr>
<tr>
<td>Proton</td>
<td>1</td>
<td>+1</td>
<td>In nucleus</td>
</tr>
<tr>
<td>Neutron</td>
<td>1</td>
<td>0</td>
<td>In nucleus</td>
</tr>
</tbody>
</table>

**Atomic Number (Z)**

• number of protons in the nucleus of an atom of that element
• gives: no. of protons, no. of electrons, position in the periodic table

**Mass Number (A)**

• sum of the no. of protons and neutrons in the nucleus of an atom of the element

**Isotopes (hydrogen and carbon)**

• same no. of protons but different no. of neutrons
• Hydrogen: $^1$H / protium, deuterium, tritium
• Carbon: $^{12}$C, $^{13}$C, $^{14}$C
• chemical properties depend on no. and arrangement of electrons
• same chemical properties
• physical properties are slightly different due to difference in mass

**Relative Atomic Mass ($A_r$)**
• The relative atomic mass of an element is the average mass of the isotopes of that element, as they occur naturally, taking abundances into account and expressed on a scale relative to \(1/12\) of the mass of an atom of \(^{12}\text{C}\).

Calculations: Relative Atomic Masses

Silicon has the isotopic composition:

- silicon-28 = 92.2%
- silicon-29 = 4.7%
- silicon-30 = 3.1%

• \(A_r = (0.922 \times 28) + (0.047 \times 29) + (0.031 \times 30) = 28.11\) amu

Spectrometer (use and processes)

Processes

- Vaporisation - non-gaseous samples are vaporised
- Ionisation - high-energy electrons bombard atoms to form positive ions
- Acceleration - by an electric field
- Separation - ions are deflected sideways as they move through a magnetic field (lighter ions are deflected more than heavier ions)
- Detection - electric current is produced on striking & detected - current \(\propto\) no. of ions of that particular type

Principle

• positively charged ions are deflected in circular paths according to their mass/charge ratio and are therefore separated

Uses

• carbon dating
• organic pollutants in water
• identifying unknown samples