1 STRUCTURE OF THE ATOM

LECTURE 1

Content

In this lecture we will discuss the evidence that existed pre-1900 that matter is not continuously divisible into smaller and smaller units, and that there in fact exists a fundamental 'building block' known as the **atom**.

We will then look at two classic experiments, Thomson's measurement of the specific charge of the electron and Millikan's oil drop experiment, that atoms contain yet smaller particles (**electrons**) that carry the fundamental unit of electric charge.

Outcomes

At the end of this lecture you will:

- know the evidence for the existence of atoms and subatomic particles (electrons)
- be able to describe experiments to measure the charge and the specific charge of the electron
- be able to calculate these quantities from typical experimental data

LECTURE 1 SUMMARY

- matter is made of atoms
- atoms contain smaller, lighter particles called electrons
- electrons carry the fundamental unit charge, $e = 1.6 \times 10^{-19}$C
- electric charge is quantised in units of e
- Thomson's apparatus may be used to measure the ratio e/m
- Millikan's oil drop experiment may be used to measure e

LECTURE 2

Content

In this lecture we will look at **collisions** and **scattering** of particles. Collisions provide the standard tool for probing atomic and molecular structure. We will discuss total collisional cross-sections, and elastic and inelastic scattering.

We will then examine the famous **Rutherford Scattering** experiment (which you may be familiar with from Lab 2) and the evidence it provides for the structure of the atom being a massive positively charged nucleus surrounded by negatively charged electrons.

Outcomes

By the end of this lecture you will:

- know the definition of the total collisional cross section
- know and be able to use the Beer-Lambert Law
- be able to qualitatively explain data from electron and positron scattering experiments
- describe the Franck-Hertz experiment and use data from it to calculate the wavelength of spectral lines
- describe experimental evidence for the concentration of mass and positive charge in the nucleus of the atom, i.e. the Rutherford experiment

LECTURE 2 SUMMARY

- the collisional cross section is a measure of the interaction probability of a projectile and a target.
- it is related, but not equivalent to the size of the particles
- the Beer-Lambert law describes attenuation due to scattering
- scattering can be elastic or inelastic
- particle scattering is a powerful tool in physics
- the Franck-Hertz experiment uses inelastic scattering to demonstrate quantisation of energy levels
- Rutherford scattering demonstrates the concentration of mass and positive charge in the nucleus of the atom

LECTURE 3

Content

In this lecture we will examine particle scattering in more detail. We will consider the relation between *total* and *differential* cross section, and then move on to a *quantum* treatment of scattering, where the incoming particles must be treated as waves.

Outcomes

At the end of this lecture you will:

- know the difference between total and differential cross section
- be able to calculate the total cross-section from the form of the differential cross section
- appreciate the importance of a quantum description of scattering
- describe scattering events in terms of incoming plane waves and outgoing spherical waves

LECTURE 3 SUMMARY

- the total cross section σ_T does not contain information about the *direction* of scattering, for this we need the differential cross section, $\frac{d\sigma}{d\Omega}$.
- These are related by $\sigma_T = \int \frac{d\sigma}{d\Omega}(\theta, \phi) d\Omega$
- the wave nature of the scattering particles is important, leading to a quantum treatment being necessary
- a quantum description of scattering is made using incoming plane waves and outgoing spherical waves