M. Sc. (Physics)

II Semester

M3PHY01-CT09: Atomic and Molecular Physics

Introduction to Atomic Spectra: H. E. Lathile

Fundamentals of Molecular Spectroscopy: C.N. Banwell and E.M. McCash

Charles Kittel: Spectroscopy

Gupta and Kumar: Spectroscopy

UNIT - I

General Introduction

Physics of atoms and molecules:- Long history of discoveries both experimental and theoretical.

Whether matter is continuous or composed of discrete particles :- Greek philosophers

Anaxagoras (500-428 BC)
Empedocles (484-424 BC)
Leucippus (circa 450 BC)
Democritus (460-370 BC)

Argued that the universe consists of empty space and of indivisible particles, the atoms, differing from each other in form, position and arrangement.

Greek - 'atomos' (atom) → 'indivisible'.

Atomic hypothesis → rejected by Aristotle (384-322 BC)

Supported continuity of matter.

In modern times → question re-opened.

Exp. gas laws → Boyle in 1662

↓ interpretation of these laws in terms of

Kinetic model → Bernoulli → 1738

Kinetic theory of gases (19th century)

↳ Clausius, Maxwell and Boltzmann

↓ physical properties of gases by assuming that:

1. Gas consists of large number of particles called "molecules" → elastic collisions with each other and wall of container.
2. Molecules of a particular substance are all identical → are small compared to with the distances that separate them.
3. Temp. of gas ∝ average kinetic energy of the molecules.

Spectroscopy → field of experimental and theoretical research

↓

Contributed much to our knowledge concerning the physical nature of things → not only on Our earth but of the sun, interstellar space and of the distant stars

Year 1666 → Sir Isaac Newton

↓

Different colored rays of light when allowed to pass through a prism → refracted at different angles.

Sunlight → hole in a diaphragm → prism

Beautiful band of color.

↓

Spectrum

A narrow slit as a secondary source of light → Fraunhofer and Wollaston

↓

The dark absorption lines of the sun's spectrum

↳ Labeled eight of the most prominent lines by first eight letters of the alphabet.

These lines → Fraunhofer lines

* Laws of chemical combination → Interpreted by making hypotheses about the atomic nature of matter.

1801 → Proust → Law of definite proportions

→ about chemical elements combine to form a given compound. The proportion by weight of each element is always the same.

1807 → J. Dalton → Law of multiple proportions.

→ Two elements combine in different ways, to form different compounds, then for a fixed weight of one element, the weights of the other element are in the ratio of small integers.

Dalton (1808) → hypothesis → elements are composed of discrete atoms.

↓

for a given element → these atoms are all identical and each has the same weight.

Compounds → atoms of different elements combine in simple ratio.

Gay-Lussac (1808) → Two gases combine to form a third, the volumes are in the ratio of simple integers.

Avogadro (811) → first to make a clear distinction between atoms, the discrete particle of the elements and molecules

↳ Discrete particles composed of two or more atoms bound together.

Atomic explanation of Chemistry → not fully accepted until late in the 19th century.

↓

Chemists tended to ignore evidence from Kinetic theory.

Random motion of small particles suspended in a fluid → Brown (1827)

↓

Could be explained by Kinetic theory of gases

↓

This motion → due to collisions of the molecules of the fluid with the suspended particles → proved by Einstein (1905).

From the chemical laws the relative weights of atoms can be established.

Dalton → proposed a scale in which hydrogen was given the atomic weight 1.

Another scale → Oxygen atomic weight 16.
(Chemical scale)

↓

On this scale → atomic hydrogen was given weight 1.008

Mole → Quantity of a substance weighing μ grams, where μ → atomic (molecular) weight of that substance

Avogadro's Number → Number of atoms (or molecules) in one mole of any substance.
(N_A)

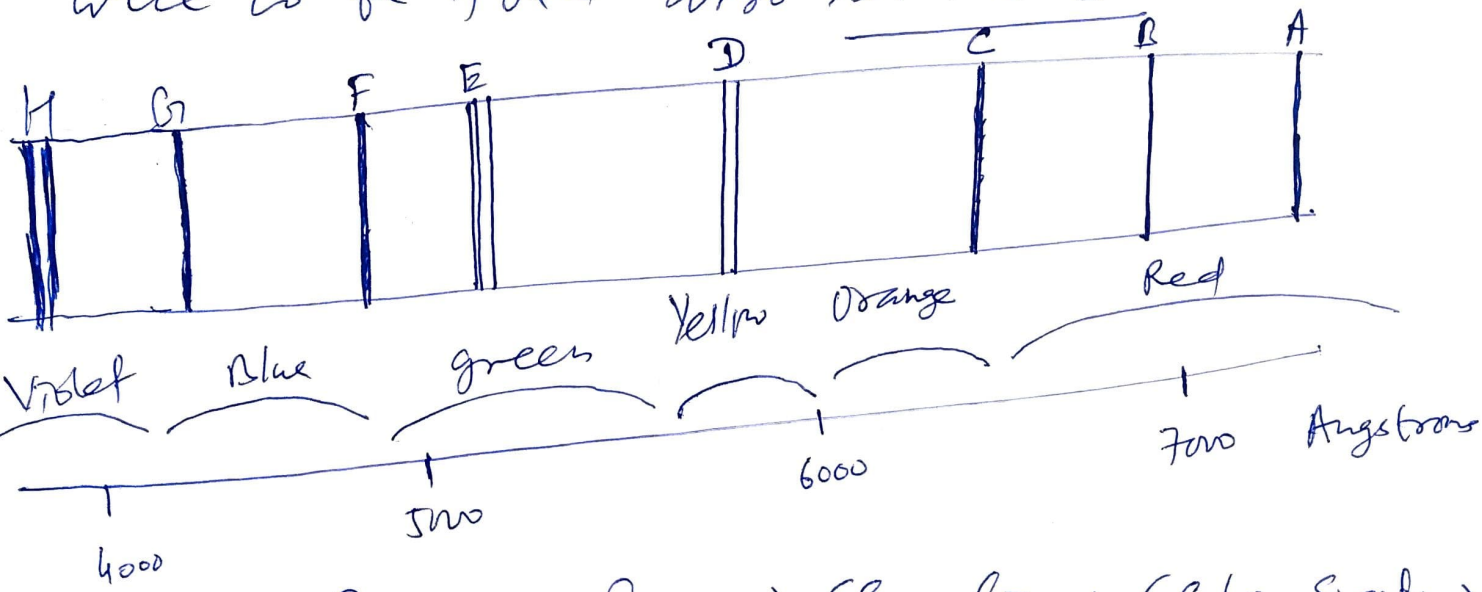
Perrin (1908) $N_A = 6.02214 \times 10^{23}$ mole^{-1}

Kirchhoff's Law :- Took long to explain the Fraunhofer lines.

Foucault :→ when light from a very powerful arc → allowed to pass through a sodium flame just infront of a spectroscope → Two black lines appeared in exactly the same position of the spectrum as the two D lines of the spectrum of Sun

↓

Many of the elements found on the earth were to be found also in the Sun.



Prominent Fraunhofer lines (Solar Spectrum)

Kirchoff theory → Sun is surrounded by layers of gases acting as absorbing screens for the bright lines emitted from the hot surfaces beneath.