

# PAM1014 Introduction to Radiation Physics

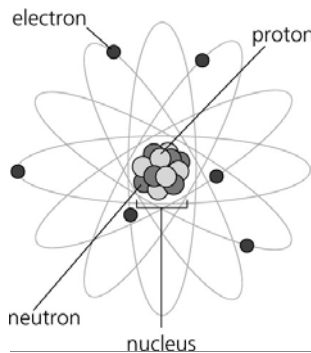
## "Basic Atomic Theory"

## Objectives

- Introduce
  - Atoms and Molecules
  - Isotopes
  - The periodic Table
  - Electronic Energy Levels
  - Atomic excitation & de-excitation
  - Ionisation
  - Molecules

## Atoms

- The basic building blocks of matter
- Composed of THREE particles
  - Electrons
  - Protons
  - Neutrons
- Bohr Model



## Constituents of Atoms

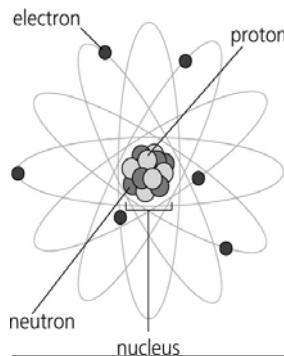
Constituent	Symbol	Charge	Mass
electron	$e^-$	-1	$9.1 \times 10^{-31} \text{ kg}$
proton	p	+1	$1836 \times m_e$
neutron	n	0	$1839 \times m_e$

$m_e$  = Electron rest mass.

$e$  = Electron Charge =  $1.6 \times 10^{-19} \text{ C}$

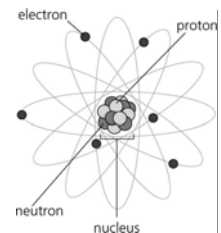
## Atoms

- Nucleus
  - Dense central region
  - Contains neutrons and protons.
  - Contains most of the mass of an atom

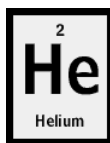


## Atoms

- Atomic Number (Z)
  - The number of protons
  - OR the number of electrons
- Atomic Mass Number (A)
  - The total number of protons PLUS the total number of neutrons
- Electrically Neutral
  - Since  $N^{\circ} \text{ electrons} = N^{\circ} \text{ protons}$



## Elements



- A substance that cannot be divided or changed into other chemical substances by any ordinary chemical technique.
- The smallest unit of this kind of chemical substances is an atom.
- An element is a class of substances that contain the same number of protons in all its atoms.
- They all have names and abbreviations

## Isotopes

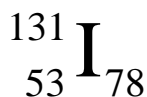
- All atoms of an element have the same number of protons
- The number of neutrons can vary.
- Atoms with the same number of protons and differing numbers of neutrons are called ISOTOPES.
- Isotopes of an element
  - Have the same Atomic Number
  - Have different Atomic Mass Number

## Isotopes

- Chemical Symbol
  - X = Atom "X"
  - A = Mass Number
  - Z = Atomic Number
  - N = Number of Neutrons



- For example



## Isotopes

- Some Isotopes are unstable.
  - The nucleus of unstable atoms do not hold together well.
  - Radioactive decay is the process whereby the nucleus of unstable isotopes release fast moving particles and energy.

## Periodic Table

- Elements have properties that repeat themselves with variation of N° of electrons (Atomic Number)
- Elements can be arranged periodically to show this repeated variation.

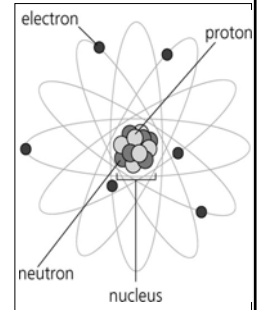
## Periodic Table

## Periodic Table

The periodic table shows elements arranged in rows (periods) and columns (groups). The groups are labeled 1A through 8A, and the periods are labeled 1 through 7. The lanthanide and actinide series are shown at the bottom.

## The Bohr Model

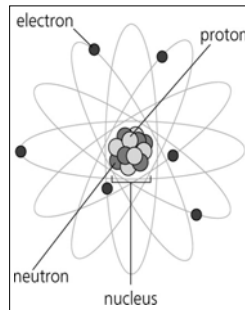
- Not completely correct
- Approximation to the planetary model
- Mathematically gravitational force similar to Coulomb forces



- Strength of Coulomb forces much larger than gravitational
- +ve and -ve charges cause attractive and repulsive interactions.

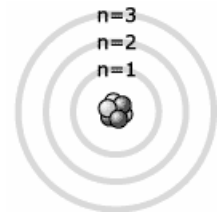
## The Bohr Model

- Not to scale!
- Nuclear radius ~100,000 times smaller than atomic radius.
- More accurate theory of the atom requires "Quantum Mechanics"



## Quantized Orbits

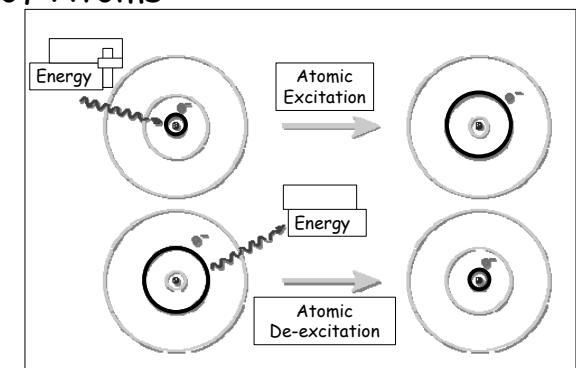
- The energy of the orbiting electrons as depicted in Bohr model is restricted to certain discrete values.
- The energy is therefore "quantized"
  - Only certain orbits with certain radii are possible
  - Orbits in between discrete value not possible



## Excitation & De-excitation of Atoms

- If atoms absorb energy, electrons are excited into higher energy levels
- Atoms release this energy if electrons drop back to lower levels

## Excitation & De-excitation of Atoms



## Excitation & De-excitation of Atoms

- Energy of the emitted or absorbed light (photon) is exactly equal to the energy difference between the two orbits.

## Ionisation

- Much of normal matter is "electrically neutral"
  - N<sup>o</sup> of electrons = N<sup>o</sup> of protons
- In presence of energy sources, atoms and molecules can gain OR lose electrons
  - therefore gain a net electrical charge.

## Ionisation

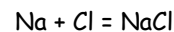
- Definition:
  - Gain or Loss of electrons
- Loss of an electron
  - Atom becomes positively charged ion
    - e.g. H<sup>+</sup>, He<sup>+</sup>, Fe<sup>2+</sup>
- Gain of an electron
  - Atom becomes negatively charged ion
    - F<sup>-</sup>, Cl<sup>-</sup>, S<sup>2-</sup>

## Combination of Atoms

- Atoms of various elements may combine to form structures called molecules

### Example

- An atom of sodium (Na) can combine with an atom of chlorine (Cl) to form sodium chloride (NaCl)



- Smallest particle of an element is an atom
- Smallest particle of a compound is a molecule

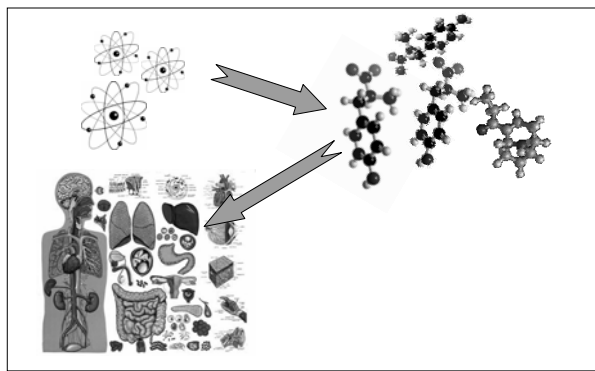
## Combination of Atoms

- Over 100 elements are known
  - Most are rare
- ~95% of the Earth & it's atmosphere consist of only a dozen elements

## Combination of Atoms

- Nitrogen, Oxygen, Carbon and Hydrogen compose over 95% of the human body
- 80% of the human body is water

## Composition of Matter



## Summary

- Atoms and Molecules
- Isotopes
- The periodic Table
- Electronic Energy Levels
- Atomic excitation & de-excitation
- Ionisation
- Molecules