CHAPTER 14

Nuclear Physics

MAIN TOPICS

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- Atom
- Nucleus
- Atomic Number and Mass Number
- Isotopes
- Radioactivity
- Half life

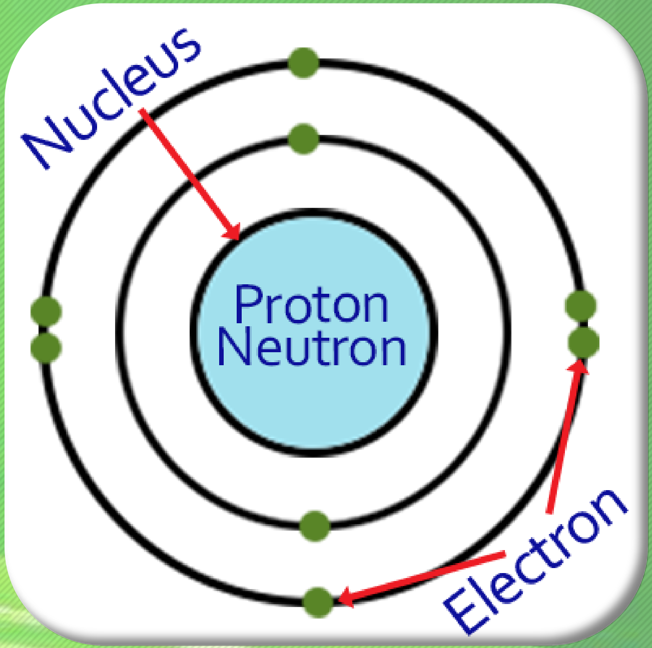
ATOM

CHAPTER 14

Atom is the fundamental building block of matter. Atom consists of three nucleons

- Proton
- Neutron
- Electron

Proton and Neutron are found in nucleus. While electrons revolves around the nucleus in certain shells



NUCLEUS

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- Nucleus is the core of the atom.
- The nucleus is a very small as compare to the atom.
- Its size is ≈1 fm (1 fm = 10^{-15} m).
- 10,000 times smaller than the size of an atom.

NUCLEONS

Proton:

The proton has a positive electrical charge. It is found in nucleus.

Neutron:

The neutron is neutral. It is also found in nucleus. It is slightly heavier than proton.

Electron:

The electron has a negative electrical charge, which is equal on proton. It is revolves around nucleus. It is 1840 times lighter than proton.

NUCLEONS

Charge on proton	$+1.6\times10^{-19}$C
Charge on electron	-1.6×10^{-19}C
mass of proton	1.672×10^{-27}Kg
mass of neutron	1.674×10^{-27}Kg
mass of electron	9.11×10^{-31}Kg

ATOMIC & MASS NUMBER

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Atomic Number:

Atomic Number is the number of proton in the atom. It is denoted by Z.

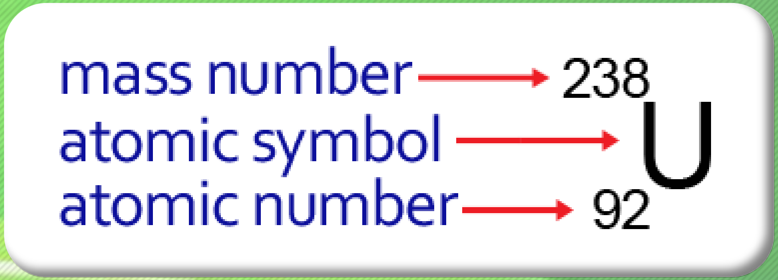
Mass Number:

Mass Number is the sum of number of proton and number of neutron in the atom. It is denoted by A.

$$A = P + N$$

$$A = Z + N$$

number of neutron $N = A - Z$



ANSWER CHECK

How many neutrons are there in $^{245}_{94}Pu$

A. 94

B. 151

C. 245

D. 339

ANSWER CHECK

How many neutrons are there in ${}^{245}_{94}Pu$

A. 94

B. 151

C. 245

D. 339

Explanation:

N = A- Z

N = 245 – 94 = 151

ANSWER CHECK

How many electrons are there in $^{245}_{94}Pu$

A. 94

B. 151

C. 245

D. 339

ANSWER CHECK

How many electrons are there in $^{245}_{94}Pu$

A. 94

B. 151

C. 245

D. 339

Explanation:

Z = P = e = 94

ISOTOPES

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Atoms which have same atomic number but different mass number are called isotopes.

In other words, isotopes have same number of protons in their nucleus but different number of neutrons.

Example:

Isotopes of hydrogen

Protium ($^{1}_{1}H$)

Deuterium ($^{2}_{1}H$)

Tritium ($^{3}_{1}H$)

RADIOACTIVITY

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Radioactivity is the spontaneous process in which some isotopes of an element emit invisible radiation.

- Radiation are emitted from nucleus.
- All isotopes do not emit radiation. Only isotopes with unstable nucleus are radioactive
- Energy is lost during radioactive emission.
- These radiation can penetrate the opaque material.

TYPES OF RADIATIONS

There are three types of radioactive radiation.

- Alpha (α) rays
- Beta (β) rays
- Gamma (γ) rays

ALPHA (α) RAYS

- Alpha rays (α) (also called alpha particles) are helium nucleus ($^{4}_{2}He$). It has two protons and 2 neutrons.
- Alpha particle have positive charge.
- Alpha rays can be stopped easily by a few pieces of paper due to its large mass and double positive charge
- Alpha rays are deflected in presence of electrical or magnetic field
- Alpha particles damage to the surface of living tissues.

ALPHA (α) RAYS

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Transmutation:

Change of one element to the an other by radioactive decay.

Alpha particle production is followed by transmutation.

$$^{238}_{92}U \rightarrow {}^{4}_{2}He + {}^{234}_{90}Th$$

ANSWER CHECK

What is atomic number of an atom when it emits an alpha particle.

A. 2 more

B. 2 less

C. 4 more

D. 4 less

ANSWER CHECK

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What is atomic number of an atom when it emits an alpha particle.

A. 2 more

B. 2 less

C. 4 more

D. 4 less

Explanation:

Alpha rays is helium nucleus ($^{4}_{2}He$), which is emitted from nucleus leaving it 2 proton short

BETA (β) RAYS

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- Beta rays (β) (also called beta particles) are electron (β^-) or positrons (β^+).

Positron:

Positron are anti particle of electrons. They have same mass as that of electron but opposite (positive charge)

- Beta particles can have two different charges.
  - (β^-) has negative charge.
  - (β^+) has positive charge

BETA (β) RAYS

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- Beta rays can be stopped by thin layer of aluminum or tin
- Beta rays are deflected in presence of electrical or magnetic field
- Beta particles cause severe damage to the surface of living tissues, even killing the living cells.
- If beta rays are stopped they are ordinary electrons

BETA (β) RAYS

Transmutation for (β^-):

A neutron changes to proton

$$^{234}_{90}\mathrm{Th} \rightarrow {}^{234}_{91}\mathrm{Pa} + {}^{0}_{-1}\mathrm{e}$$

Transmutation for (β^+):

A proton changes to neutron

$$^{22}_{11}\mathrm{Na} \rightarrow {}^{0}_{1}\mathrm{e} + {}^{22}_{10}\mathrm{Ne}$$

ANSWER CHECK

After emission of one radioactive particle, the atomic number of the resulting atom is increased. Which particle is it

A. α-particle

B. β^{+}-particle

C. β^{-}-particle

D. γ-particle

ANSWER CHECK

After emission of one radioactive particle, the atomic number of the resulting atom is increased. Which particle is it

A. α-particle

B. β^{+}-particle

C. β^{-}-particle

D. γ-particle

GAMMA (γ) RAYS

- Gamma rays (γ) (also called gamma particles) are high energy, high frequency photons.
- Gamma particles have no charges.
- Gamma rays have more penetrating power than α or β rays because they have no charge or mass. They can be stopped by 4m layer of lead.
- Gamma rays are not deflected in presence of electrical or magnetic field.

GAMMA (γ) RAYS

- Gamma particles are more dangerous than for living tissues. They can cause cell damage, skin burns or cancer.

Transmutation:

Gamma rays are emitted when an atom emits alpha rays.

$$^{238}_{92}U \rightarrow ^{4}_{2}He + ^{234}_{90}Th + 2^{0}_{0}\gamma$$

HALF LIFE

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The time required for half of an original material to go under radioactive decay.

- Half life depends upon the type of nuclei. It may vary from a split second to billion years.
- It does not depend upon the quantity of the matter.

HALF LIFE

Example:

In a given quantity, N_o Nuclei of a certain atom are present. Its half life is T.

- When time t = 0, then radioactive nuclei present

$$N = N_o.$$

- When time t = T, then radioactive 50% nuclei will be present.

$$N = \frac{N_o}{2}$$

HALF LIFE

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- When time t = 2T, then 25% nuclei will be present.

$$N = \frac{N_o}{4}$$

- When time t = 3T, then 12.5% nuclei will be present.

$$N = \frac{N_o}{8}$$

- When time t = 4T, then 6.25% nuclei will be present.

$$N = \frac{N_o}{16}$$

ANSWER CHECK

80 Nuclei of a radio active elements are present. How many of them are present after 4 half lives.

A. 0

B. 5

C. 10

D. 20

ANSWER CHECK

80 Nuclei of a radio active elements are present. How many of them are present after 4 half lives.

A. 0

B. 5

C. 10

D. 20

Explanation:

Nuclei present after first half life = 40. After second 20. After third 10. After fourth 5.

ANSWER CHECK

7g of a radio active elements are present now, which was earlier 224 g. How many half lives have passed.

A. 8

B. 7

C. 6

D. 5

ANSWER CHECK

CHAPTER 14

7g of a radio active elements are present now, which was earlier 224 g. How many half lives have passed.

A. 8
B. 7
C. 6
D. 5