**Q19.** Explain, with the help of a nuclear reaction in each of the following cases, how the neutron to proton ratio changes during (I) alpha-decay (II) beta-decay.

Answer: We know that in alpha decay, mass number reduces by 4 units; atomic number reduces by 2 units. In beta decay atomic number increased by 1 unit but there is no change in mass number.
Number of Neutrons = Mass number – Number of proton (atomic number)

(I) $^{238}_{92}\mathrm{U} \longrightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He}$

Neutron to proton ratio before $\alpha-$decay $= \frac{238-92}{92} = \frac{146}{92}$ =1.58

Neutron to proton ratio after $\alpha-$decay $= \frac{234-90}{90} = \frac{144}{90}$ =1.6

Thus the neutron to proton ratio increases in an $\alpha-$decay.

(II) $^{210}_{83}\mathrm{Bi} \longrightarrow {}^{210}_{84}\mathrm{Po} + {}_{-1}^{0}\mathrm{e}$

Neutron to proton ratio before $\beta-$decay $= \frac{210-83}{83} = \frac{127}{83} = 1.53$

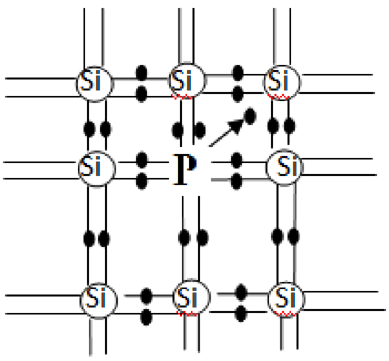
Neutron to proton ratio after $\beta-$decay $= \frac{210-84}{84} = \frac{126}{84} = 1.5$

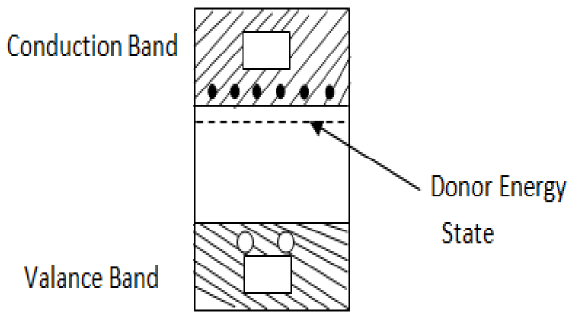
Thus the neutron to proton ratio decreases in a $\beta-$decay.

**Q20.** What is an intrinsic semiconductor? How can this material be converted into (I) N-type (II) P-type extrinsic semiconductor? Explain with the help of energy band diagrams.

Answer: The naturally occurring pure semiconductor (without doping) where conductivity depends only on electrons thermally excited from valence band to conduction band is called an intrinsic semiconductor.

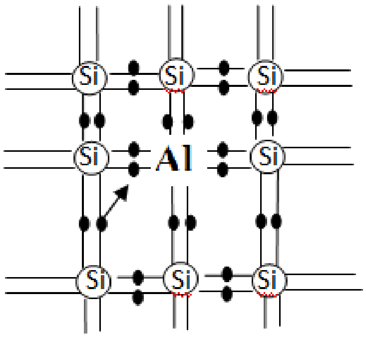
**N-type semiconductor :**In N-type semiconductor charge carrier is negative charge type i.e electron**,** when we dope silicon(Si), which has four valence electrons, with a controlled amount of penta-valent atoms like phosphorus atoms (P), which has five valence electrons, the atoms of the impurity element P will substitute the Si atoms.

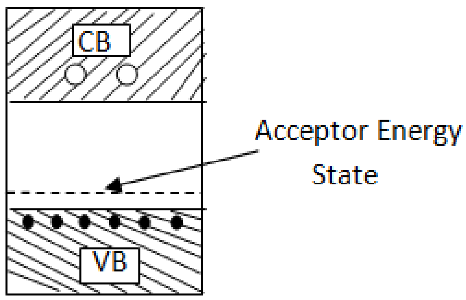


Out of five valence electrons of Phosphorus ( P) four electrons forms covalent bonding with Silicon (Si) atom, while the fifth electron of Phosphorus is free to move. The penta-valent atoms are called the donor atoms because they donate electrons to the host crystal also since the free charge carrier is electron hence this *Extrinsic semi-conductor* is called n-type. On giving up their fifth electron, the donor atoms become positively charged. However, the material remains electrically neutral as a whole.

**P-type semi-conductor:** When Silicon atom Si (intrinsic semiconductor) is dopped with in controlled amount by trivalent atoms like Aluminium (Al) , Indium (In) or boron (B) atom, 3 valance electron of trivalent atom say Aluminium ( Al) forms covalent bond with neighboring Silicon atom however due to deficiency of electron 1 incomplete covalent bond with Silicon atom remains.




This is completed by taking an electron from one of the Si-Si bonds, thus completing the Al-Si bond. This makes it ionized (negatively charged), and creates a hole or an electron deficiency in the covalently bonded electron system in the crystal as shown in the figure. The trivalent atoms are called *acceptor atoms* and this *extrinsic semi-conductor* is known as *p-type semi-conductor* as charge carrier is hole.

**Q21.** Why is the mass of a nucleus always less than the sum of the masses of its constituents, neutrons and protons? If the total number of neutrons and protons in a nuclear reaction is conserved, how then is the energy absorbed or evolved in the reaction? Explain.

Answer: Energy is required to hold positively charged proton together in nucleus. In a nucleus, the protons and neutrons come closer to a distance of $10^{-14}$ m. The energy required for the purpose is spent by the nucleons at the expense of their masses. The difference is mass converted to energy, so mass of the nucleus formed is less than the sum of the masses of the individual nucleons.

Here proton number and neutron number are conserved in a nuclear reaction; the total rest mass of neutrons and protons is the same on either side of a reaction. However total binding energy of nuclei on the left side need not be the same as that on the right hand side. The difference in these binding energies appears as energy released or absorbed in a nuclear reaction.

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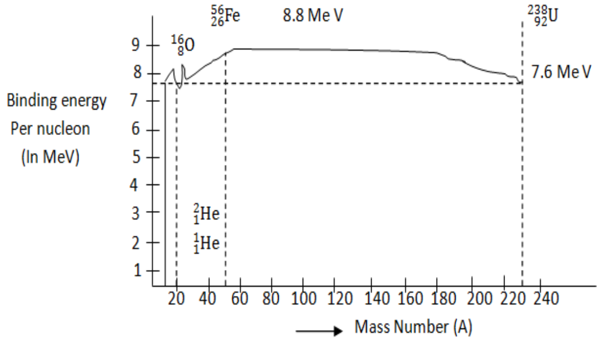
**Or,**

Draw a graph showing the variation of binding energy per nucleon with mass number for different nuclei.

Explain, with the help of this graph, the release of energy by the process of nuclear fusion.

Answer: **Binding Energy Curve:** The variation of average binding energy (B.E) per nucleon with mass number A is shown in the fig.




The above graphical presentation suggests:

(I) Average B.E. per nucleon for light nuclei like $^{1}_{1}$He and $^{2}_{1}$He is small (2 to 3 MeV).

(II) For mass number 2 to 20, the peaks are sharply defined. So that $^{4}_{2}$He, $^{12}_{6}$C, $^{16}_{8}$O, $^{20}_{10}$Ne etc have more stability than the nuclei in their neighborhood.

(III) From the graph most stable nucleus (e.g. $^{56}_{26}$Fe ) having intermediate mass number 56 has **maximum** Binding energy as 8.8 Me V/N.

(IV) The B.E. /nucleons decreases gradually after mass number $^{56}_{26}$Fe to $^{238}_{92}$U. The heavy nuclei are relatively less stable.

(V) Binding energy per nucleons is small for both light and heavy nuclei.
When **light nuclei fuse (nuclear fusion)** to form a heavy nucleus, high value of binding energy is released. Similarly when a **heavy nucleus splits (nuclear fission)** into lighter nuclei**, high** value of binding energy is released**.**

**Q22.** Define the term modulation. Name three different types of modulation used for a message signal using a sinusoidal continuous carrier wave. Explain the meaning of any of these.

Answer:

**Modulation:** It is the process in which some characteristic such as amplitude, frequency or phase angle of a high frequency carrier wave is changed in accordance with the instantaneous value of the low frequency modulating signal.

A sinusoidal carrier wave can be modulated in three ways:

(I) Amplitude modulation
(II) Frequency modulation
(III) Phase modulation

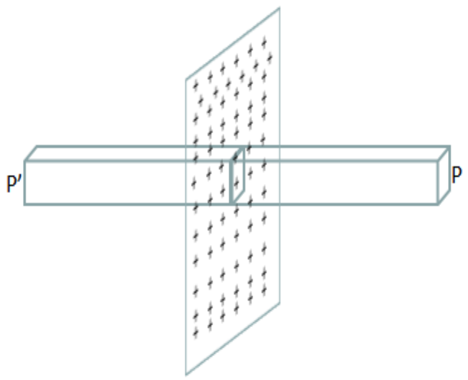
**Amplitude Modulation (AM):** In AM process the modulating frequency wave is superimposed on high frequency carrier wave such that the frequency of the modulated wave remains the same as that of the carrier wave but its **amplitude** is modified in accordance with that of modulating frequency wave.

**Frequency Modulation (FM):** In FM process the modulating frequency wave is superimposed on high frequency carrier wave such that the amplitude of the modulated wave remains the same as that of the carrier wave but its **frequency** is modified in accordance with that of the audio frequency wave.

**Q23.** What is electric flux? Write its S.I. units. Using Gauss's theorem, deduce an expression for the electric field at a point due to a uniformly charged infinite plane sheet.
Answer: The electric flux through a given surface area is the total number of electric lines of force passing normally through this area. It is defined as the dot product of intensity and area, scalar quanity.

$$\Delta\varphi = \vec{E} . \overrightarrow{\Delta S}$$

The SI unit of electric flux = $Vm^{-1}$x $m^2$ = Vm. [Since E = V/d , intensity is potential gradient unit of E=V/m]
**Intensity at a point near an infinitely charged insulating plate:**




Given : $\sigma$ = surface density of charge i.e. charge per unit surface area
$\varepsilon$ = permittivity of the surrounding medium
P is the given point close to the surface of the charged plate.
Let E be the intensity at P ?

Let us imagine a point P' opposite to P and at the same distance at P.

Let us imagine a rectangular box passing through the points P & P'. This closed surface is our Gaussian surface and is known as pill box.

Since the lines of force are emitted normally from the surface they are parallel to the two vertical and two horizontal faces of the Gaussian surface and hence flux through this faces will be zero. The lines of force are perpendicular to the two end faces only.

Hence the total flux through the Gaussian surface

$$\phi = 0 + 0 + 0 + 0 + EA + EA = 2EA \rightarrow (1)$$

Applying Gauss's theorem the flux through the Gaussian surface

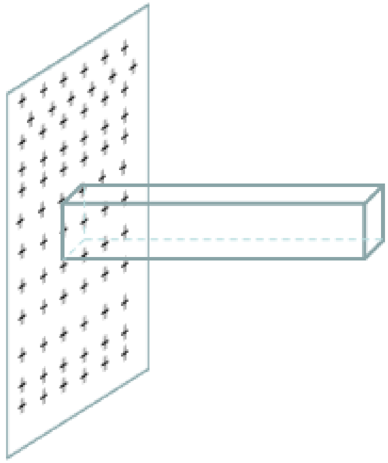
$$\phi = \frac{\text{charged enclosed}}{\text{permittivity}} = \frac{\sigma A}{\varepsilon} \rightarrow (2)$$

From equation (1) and (2)

$$2EA = \frac{\sigma A}{\varepsilon}$$

$$E = \frac{\sigma}{2\varepsilon} \rightarrow (3)$$

**Intensity at a point near an infinitely long charged conducting plate**



Since lines of force can not exist inside a conductor we get lines of force only in the side of the charged face.

$$\phi = 0 + 0 + 0 + 0 + EA = EA \rightarrow (1)$$

$$\phi = \frac{\sigma A}{\varepsilon} \rightarrow (2)$$

$$EA = \frac{\sigma A}{\varepsilon}$$

$$E = \frac{\sigma}{\varepsilon}$$