...represented by the symbol ^1_1H.

Next in the periodic table after the hydrogen element is the helium element. Its nucleus contains two protons and two neutrons. This means for helium $A = 4$ and $Z = 2$; and hence helium is represented as ^4_2He. We now take the example of uranium - a heavy element of the periodic table. The charge number Z of uranium is 92 while its mass number A is 235. This is represented as $^{235}_{92}U$. It has 92 protons while the number of neutrons N is given by the equation $N = A - Z = 235 - 92 = 143$. In this way the number of protons and neutrons in atoms of all the elements of the periodic table can be determined. It has been observed that the number of neutrons and protons in the initial light elements of the periodic table is almost equal but in the later heavy elements the number of neutrons is greater than the number of protons in the nucleus.

21.2 ISOTOPES

Isotopes are such nuclei of an element that have the same charge number Z, but have different mass number A, that is in the nucleus of such an element the number of protons is the same, but the number of neutrons is different. Helium, for example has two isotopes. These are symbolically represented as ^3_2He and ^4_2He. As the charge number of helium is 2, therefore, there are two protons in the helium nucleus. The neutron number of the first isotope is, according to Eq. 21.1 is $3 - 2 = 1$ and that in the second isotope ^4_2He, the number of neutron is $4 - 2 = 2$. Hydrogen has three isotopes represented by ^1_1H, ^2_1H, ^3_1H. Its first isotope is called ordinary hydrogen or protium. There is only one proton in its nucleus. The second isotope of hydrogen is called deuterium. It has one proton and one neutron in its nucleus. Its nucleus is called deuteron. The third isotope of hydrogen has two neutrons and one proton in its nucleus and it is called tritium. The isotopes of hydrogen are shown in Figs. 21.1 (a,b,c).

The chemical properties of all the isotopes of an element are alike, as the chemical properties of an element depend only upon the number of electrons around the nucleus, that is upon the charge number Z, which for all the isotopes of an element is the same. It is, therefore, not possible to separate the isotopes of an element by chemical methods. Physical methods are found to be successful for this purpose. A

(a) ^1_1H (Protium)

(b) ^2_1H (Deuterium)

(c) ^3_1H (Tritium)

Fig. 21.1

Do You Know?

Both Xenon and caesium each have 36 isotopes.

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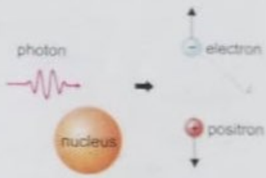
Pair Production

In the previous sections you have studied that a low energy photon interacting with a metal is usually completely absorbed with the emission of electron (Photoelectric effect) and a high energy photon such as that of X-rays is scattered by an atomic electron transferring a part of its energy to the electron (Compton effect). A third kind of interaction of very high energy photon such as that of γ-rays with matter is pair production in which photon energy is changed into an electron-positron pair. A positron is a particle having mass and charge equal to that of electron but the charge being of opposite nature i.e. positive. The creation of two particles with equal and opposite charges is essential for charge conservation in the universe. The positron is also known as antiparticle of electron or anti-electron. The interaction usually takes place in the electric field in the vicinity of a heavy nucleus as shown in the Fig.19.10 so that there is a particle to take up recoil energy and momentum is conserved.



Pair Production

Fig. 19.10

In the process, radiant energy is converted into matter in accordance with Einstein's equation $E = mc^2$, and hence, is also known as materialization of energy. For an electron or positron, the rest mass energy = $m_oc^2 = 0.51$ MeV. Thus to create the two particles 2 x 0.51 MeV or 1.02 MeV energy is required. For photons of energy greater than 1.02 MeV, the probability of pair production occurrence increases as the energy increases and the surplus energy is carried off by the two particles in the form of kinetic energy. The process can be represented by the equation

$$\text{Energy of photon} = \begin{bmatrix}\text{Energy required} \\ \text{for pair production}\end{bmatrix} + \begin{bmatrix}\text{Kinetic energy} \\ \text{of the particles}\end{bmatrix}$$

$$hf = 2m_oc^2 + K.E.(e^-) + K.E.(e^+) \quad \cdots\cdots\cdots \quad (19.16)$$

19.6 ANNIHILATION OF MATTER

It is converse of pair production. When a positron comes close to an electron they annihilate or destroy each other. The matter of two particles changes into electromagnetic energy producing two photons in the γ-rays range.

$$e^- + e^+ \longrightarrow \gamma + \gamma$$

The two photons are ... in opposite

NOT Gate

It performs the operation of inversion or complementation. That is why it is also known as inverter. It changes a logic level to its opposite level, i.e., it changes 1 to 0 and 0 to 1. The symbolic representation of NOT gate is shown in Fig. 18.37. Whenever a bar is placed on any variable, it shows that the value of the variable has been inverted. For example $\overline{1} = 0$ and $\overline{0} = 1$. The "bubble" (o) in Fig.18.37 indicates operation of inversion. Its truth table is given in Table 18.4. The mathematical notation for NOT operation is $X = \overline{A}$

NOT gate

Fig. 18.37

Table 18.4

A	Output
0	1
1	0

18.14 OTHER LOGIC GATES

NOR Gate

In NOR gate the output of OR gate is inverted. Its symbol is shown in Fig. 18.38 and its truth table is given in Table 18.5. The mathematical notation for NOR operation is

$$X = \overline{A + B}$$

NOR gate

Fig. 18.38

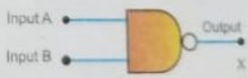
Table 18.5

A	B	Output
0	0	1
0	1	0
1	0	0
1	1	0

NAND Gate

In NAND gate the output of an AND gate is inverted. Its symbol is shown in Fig. 18.39. The bubble in this figure shows that the output of AND gate is inverted. The truth table implemented by it is shown in Table 18.6. The mathematical notation for NAND operation is

$$X = \overline{A . B}$$



NAND gate

Fig. 18.39

Table 18.6

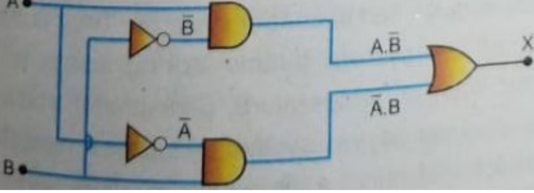
A	B	Output
0	0	1
0	1	1
1	0	1
1	1	0

Exclusive OR Gate(XOR)

Consider a Boolean function X of two variables A and B such that

$$X = A\overline{B} + \overline{A}B$$

The first term of the function X is obtained by ANDing the variable A with NOT of B. The second term is NOT of A ANDed with B. The function X is obtained by ORing these two terms. It can be constructed by combining AND, OR and NOT gates according to tho scheme shown in Fig. 18.40(a). The



18.4 TRANSISTORS

A transistor consists of a single crystal of germanium or silicon which is grown in such a way that it has three regions (Figs. 18.14 & 18.15).

In Fig. 18.14 the central region is p type which is sandwiched between two n type regions. It is known as n-p-n transistor. In Fig. 18.15, the n type central region is sandwiched between two p type regions. It forms a p-n-p transistor. The central region is known as base and the other two regions are called emitter and collector. Usually the base is very thin, of the order of 10^{-6} m. The emitter and collector have greater concentration of impurity. The collector is comparatively larger than the emitter. The emitter has greater concentration of impurity as compared to the collector.

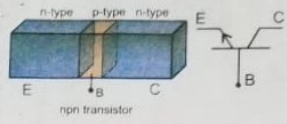


Fig. 18.14

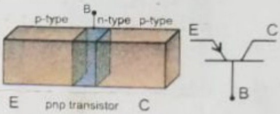


Fig. 18.15

It can be seen in Figs. 18.14 and 18.15 that a transistor is a combination of two back to back p-n junctions: emitter-base junction and collector-base junction.

For normal operation of the transistor, batteries V_{BB} and V_{CC} are connected in such a way that its emitter-base junction is forward biased and its collector base junction is reverse biased. V_{CC} is of much higher value than V_{BB}. Fig. 18.16 shows the biasing arrangement for n-p-n transistor when the transistor has been represented by its symbolic form. Fig. 18.17 shows the same for a p-n-p transistor.

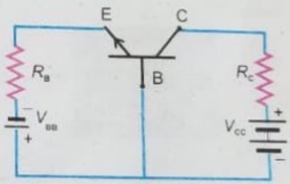


Fig. 18.15

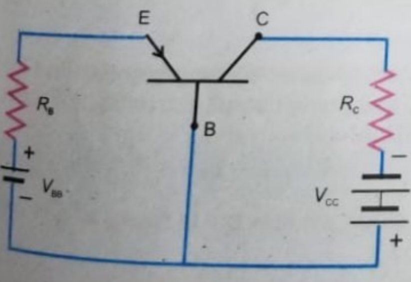


Fig. 18.17

...ay be noted that polarities of the biasing batteries V_{BB} and
are opposit...

...se Lag and Phase Lead

...actice, the phase difference between two alternating ...tities is more important than their absolute phases. Fig ... shows two waveforms 1 (green) and 2 (red). The phase ...s of the waveform 1 at the points A, B, C, D and E have ... shown above the axis and those of waveform 2 below the ... At the point B, the phase of 1 is $\pi/2$ and that of 2 is 0. ...arly it can be seen that at each point the phase of ...form 2 is less than the phase of waveform 1 by an angle of ... We say that A.C. 2 is lagging behind A.C. 1 by an angle of π ... means that at each instant, the phase of AC. 2 is less than ...hase of A.C. 1 by $\pi/2$. Similarly it can be seen in Fig. 16.5. ...he phase at each point of the waveform of A C. 2 is greater ...that of waveform 1 by an angle $\pi/2$. In this case, it is said ...C. 2 is leading the A C. 1 by $\pi/2$. It means at each instant ...e, the phase of A.C. 2 is greater than that of 1 by $\pi/2$.

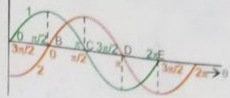


Fig. 16.4

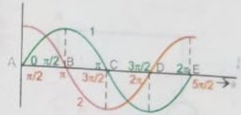


Fig. 16.5

...tor Representation of an Alternating Quantity

...nusoidally alternating voltage or current can be ...ically represented by a counter clockwise rotating ...r provided it satisfies the following conditions.

Its length on a certain scale represents the peak or rms value of the alternating quantity.

It is in the horizontal position at the instant when the alternating quantity is zero and is increasing positively.

The angular frequency of the rotating vector is the same as the angular frequency ω of the alternating quantity.

...6. (a) shows a sinusoidal voltage waveform leading an ...ating current waveform by $\pi/2$. The same fact has been ...n vectorially in Fig.16.6 (b). Here vector **OI** represents ...eak or rms value of the current which is taken as the ...nce quantity. Similarly **OV** represents the rms or peak ... of the alternating voltage which is leading the current by ...oth vectors are supposed to be rotating in the counter

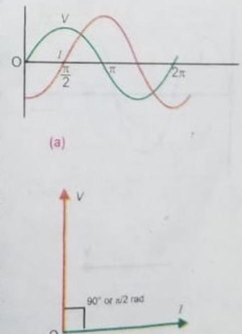


Fig. 16.6