KVS ZIET CHANDIGARH

तत् त्वं पूषन् अपावृणु
केन्द्रीय विद्यालय संगठन

STUDY MATERIAL PHYSICS
CLASS XII

2023-24

INDEX

ITS ALSO INCLUDES MIND MAP & SQP CHAPTERWISE

PHYSICS Class XII (Code No.42) (2023-24)

Senior Secondary stage of school education is a stage of transition from general education to discipline-based focus on curriculum. The present updated syllabus keeps in view the rigor and depth of disciplinary approach as well as the comprehension level of learners. Due care has also been taken that the syllabus is comparable to the international standards. Salient features of the syllabus include:

- Emphasis on basic conceptual understanding of the content.
- Emphasis on use of SI units, symbols, nomenclature of physical quantities and formulations as per international standards.
- Providing logical sequencing of units of the subject matter and proper placement of concepts with their linkage for better learning.
- Reducing the curriculum load by eliminating overlapping of concepts/content within the discipline and other disciplines.
- Promotion of process-skills, problem-solving abilities and applications of Physics concepts.

Besides, the syllabus also attempts to

- Strengthen the concepts developed at the secondary stage to provide firm foundation for further learning in the subject.
- Expose the learners to different processes used in Physics-related industrial and technological applications.
- Develop process-skills and experimental, observational, manipulative, decision making and investigatory skills in the learners.
- Promote problem solving abilities and creative thinking in learners.
- Develop conceptual competence in the learners and make them realize and appreciate the interface of Physics with other disciplines

CLASS XII (2023-24)

PHYSICS (THEORY)

Time: 3 hrs. **Max Marks: 70**

		No. of Periods	Marks
Unit–I	**Electrostatics**	26	16
	Chapter–1: Electric Charges and Fields		
	Chapter–2: Electrostatic Potential and Capacitance		
Unit-II	**Current Electricity**	18	
	Chapter–3: Current Electricity		
Unit-III	**Magnetic Effects of Current and Magnetism**	25	17
	Chapter–4: Moving Charges and Magnetism		
	Chapter–5: Magnetism and Matter		
Unit-IV	**Electromagnetic Induction and Alternating Currents**	24	
	Chapter–6: Electromagnetic Induction		
	Chapter–7: Alternating Current		
Unit–V	**Electromagnetic Waves**	04	18
	Chapter–8: Electromagnetic Waves		
Unit–VI	**Optics**	30	
	Chapter–9: Ray Optics and Optical Instruments		
	Chapter–10: Wave Optics		
Unit–VII	**Dual Nature of Radiation and Matter**	8	12
	Chapter–11: Dual Nature of Radiation and Matter		
Unit–VIII	**Atoms and Nuclei**	15	
	Chapter–12: Atoms		
	Chapter–13: Nuclei		
Unit–IX	**Electronic Devices**	10	7
	Chapter–14: Semiconductor Electronics: Materials, Devices and Simple Circuits		
Total		**160**	**70**

CHAPTER 12

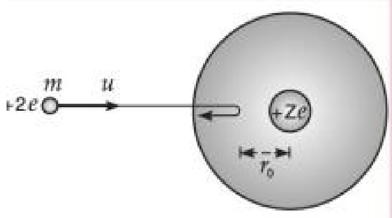
ATOMS

KEY FEATURES

Thomson's atom model. In a sphere, the positive charge is uniformly distributed over its whole volume and the electrons are embedded in it. The oscillations of electrons about their equilibrium positions give rise to radiation of definite frequency.

Rutherford's atom model. Practically, entire macs of the atom and all its positive charge are concentrated in a small central core, while the electrons revolve around it. The central positive and massive core is called nucleus.

Distance of closest approach. The minimum distance from the nucleus, when an energetic a-particle travels directly towards the center of the nucleus is called the distance of closest approach. It gives an estimate of the size of the nucleus.



Mathematically- = ____ ____

where the letters have their usual meanings.

Bohr's atom model. It was introduced, as Rutherford atom model could not account for stability of the atom and the line spectra of the hydrogen atom. Bohr's atom model is based on following postulates-

1. Electrons revolve round the nucleus in certain fixed orbits, called stationery orbits.
2. The stationary orbits are those, in which angular momentum of electron is integral multiple of h/2 2.

Mathematically- **mvr = nh/2π** (Bohr's quantisation condition)

3. While revolving in stationery orbits, electrons do not radiate energy. The energy is emitted (or absorbed) when electrons jump from higher to lower energy orbits (or lower to higher energy orbits). The frequency of the emitted radiation is given by

$$hv = E_i - E_f$$ (Bohr's frequency condition)

Bohr's theory of hydrogen atom.

An electron having charge -e revolves with speed v in a circular orbit of radius r round the nucleus having charge + e.

1. Radius of nth orbit $r_n = 4\pi \in_o \frac{n^2h^2}{4\pi^2 me^2}$

2. Speed of electron in nth orbit $v_n = \frac{1}{4\pi\in_o} \cdot \frac{2\pi e^2}{nh}$

3. Energy of electron in nth orbit $E_n = -\left(\frac{1}{4\pi\in_o}\right)^2 \cdot \frac{2\pi^2 me^4}{n^2h^2} = -\frac{R_H}{n^2}hc$

Here $R_H = \left(\frac{1}{4\pi\in_o}\right)^2 \cdot \frac{2\pi^2 me^4}{ch^3}$ **called Rydberg's constant for hydrogen atom.**

4. Energy of radiation emitted $E = \left(\frac{1}{4\pi\in_o}\right)^2 \cdot \frac{2\pi^2 me^4}{h^2}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$

5. Frequency of radiation emitted $\nu = \left(\frac{1}{4\pi\in_o}\right)^2 \cdot \frac{2\pi^2 me^4}{h^3}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$

6. Wavelength of radiation emitted $\frac{1}{\lambda} = \left(\frac{1}{4\pi\in_o}\right)^2 \cdot \frac{2\pi^2 me^4}{ch^3}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$

Excitation energy. The energy required to raise the electron from its ground state to some higher energy level is called excitation energy.

Excitation potential. The potential difference through which the electron in an atom has to be accelerated, so as to just raise it from its ground state to the excited state, is called excitation potential.

Ionisation energy. The energy required to knock an electron completely out of an atom is called ionisation energy.

Ionisation potential. The potential difference through which the electron in an atom has to be accelerated so as to just ionise it, is called ionisation potential.

The ionisation potential is numerically equal to the ionisation energy.

X-rays. When fast moving electrons strike a target of high atomic weight, X-rays are produced.

When electrons are accelerated through a potential difference V, the kinetic energy acquired by the electron is given by **eV = _**

When the whole of the kinetic energy of the electron is converted into the energy of X-rays produced, then X-ray of maximum frequency is produced. The maximum frequency is given by = —

where h is Planck's constant.

The minimum possible wavelength of the X-rays produced is given by = —

QUESTIONS WITH ANSWERS

Q.1 Write two important limitations of Rutherford nuclear model of the atom.

Ans. Two important limitations of Rutherford Model are:

(i) According to Rutherford model, electron orbiting around the nucleus, continuously radiates energy due to the acceleration; hence the atom will not remain stable.

(ii) As electron spirals inwards; its angular velocity and frequency change continuously, therefore it should emit a continuous spectrum. But an atom like hydrogen always emits a discrete line spectrum.

Q.2 Which is easier to remove: orbital electron from an atom or a nucleon from a nucleus?

Ans. It is easier to remove an orbital electron from an atom. The reason is the binding energy of orbital electron is a few electron-volts while that of nucleon in a nucleus is quite large (nearly 8 MeV). This means that the removal of an orbital electron requires few eV energy while the removal of a nucleon from a nucleus requires nearly 8 MeV energy

Q.3 Show that the radius of the orbit in hydrogen atom varies as n^2, where n is the principal quantum number of the atom.

Ans-

Let r be the radius of the orbit of a hydrogen atom. Forces acting on electron are centrifugal force (F_c) and electrostatic attraction (F_e)

At equilibrium, $F_c = F_e$

$$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2} \qquad \text{[for H-atom, } Z = 1]$$

According to Bohr's postulate

$$mvr = \frac{nh}{2\pi} \quad \Rightarrow \quad v = \frac{nh}{2\pi mr}$$

$$m\left(\frac{nh}{2\pi mr}\right)^2 \cdot \frac{1}{r} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2} \quad \Rightarrow \quad \frac{mn^2h^2}{4\pi^2 m^2 r^2 . r} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2}$$

$$r = \frac{n^2h^2\varepsilon_0}{\pi me^2} \quad \Rightarrow \quad \therefore \quad r \propto n^2$$

Q.4 Find out the wavelength of the electron orbiting in the ground state of hydrogen atom.

Ans-

Radius of ground state of hydrogen atom, $r = 0.53 \text{ Å} = 0.53 \times 10^{-10}$ m

According to de Broglie relation, $2\pi r = n\lambda$

For ground state, $n = 1$

$$2 \times 3.14 \times 0.53 \times 10^{-10} = 1 \times \lambda$$

$$\therefore \quad \lambda = 3.32 \times 10^{-10} \text{ m}$$

$$= \mathbf{3.32 \text{ Å}}$$

Q.5 When is H_α line in the emission spectrum of hydrogen atom obtained? Calculate the frequency of the photon emitted during this transition.

Ans-

The line with the longest wavelength of the Balmer series is called H_α.

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$$

where λ = wavelength

$R = 1.097 \times 10^7 \text{ m}^{-1}$ (Rydberg constant)

When the electron jumps from the orbit with $n = 3$ to $n = 2$,

we have

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) \quad \Rightarrow \quad \frac{1}{\lambda} = \frac{5}{36}R$$

The frequency of photon emitted is given by

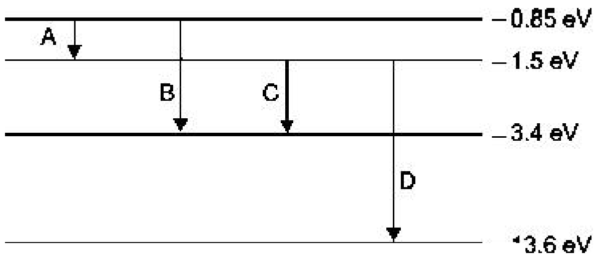
$$\nu = \frac{c}{\lambda} = c \times \frac{5}{36}R$$

$$= 3 \times 10^8 \times \frac{5}{36} \times 1.097 \times 10^7 \text{ Hz}$$

$$= \mathbf{4.57 \times 10^{14} \text{ Hz}}$$

Q.6 The energy levels of a hypothetical atom are shown alongside. Which of the shown transitions will result in the emission of a photon of wavelength 275 nm? Which of these transitions correspond to emission of radiation of (i) maximum and (ii) minimum wavelength?

Ans-



Energy of photon wavelength 275 nm

$$E = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{275 \times 10^{-9} \times 1.6 \times 10^{-19}} \text{ eV} = 4.5 \text{ eV}.$$

This corresponds to transition '*B*'.

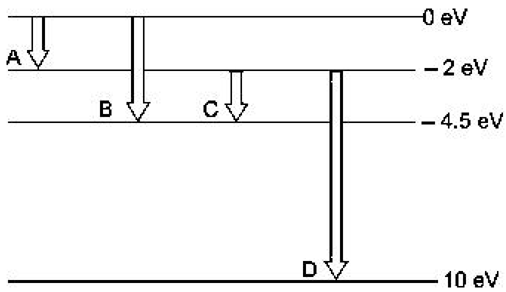
(*i*) $\Delta E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{\Delta E}$

For maximum wavelength ΔE should be minimum. This corresponds to transition *A*.

(*ii*) For minimum wavelength ΔE should be maximum. This corresponds to transition *D*.

Q.7 The energy level diagram of an element is given. Identify, by doing necessary calculations, which transition corresponds to the emission of a spectral line of wavelength 102.7 nm.

Ans-



$$\Delta E = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{102.7 \times 10^{-9}} \text{ J}$$

$$= \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{102.7 \times 10^{-9} \times 1.6 \times 10^{-19}} \text{eV}$$

$$= \frac{66 \times 3000}{1027 \times 16} = 12.04 \text{ eV}$$

Now, $\Delta E = |-13.6 - (-1.50)|$

$= \mathbf{12.1\ eV}$

Hence, transition shown by arrow *D* corresponds to emission of $\lambda = 102.7$ nm.

Q.8 Determine the distance of closest approach when an alpha particle of kinetic energy 4.5 MeV strikes a nucleus of Z = 80, stops and reverses its direction.

Ans-

Let r be the centre to centre distance between the alpha particle and the nucleus (Z = 80). When the alpha particle is at the stopping point, then

$$K = \frac{1}{4\pi\varepsilon_0}\frac{(Ze)(2e)}{r}$$

or $$r = \frac{1}{4\pi\varepsilon_0}\cdot\frac{2Ze^2}{K}$$

$$= \frac{9\times10^9\times2\times80\,e^2}{4.5\text{ MeV}} = \frac{9\times10^9\times2\times80\times(1.6\times10^{-19})^2}{4.5\times10^6\times1.6\times10^{-19}}$$

$$= \frac{9\times160\times1.6}{4.5}\times10^{-16} = 512\times10^{-16}\text{ m}$$

$$\mathbf{= 5.12\times10^{-14}\ m}$$

Q.9 The ground state energy of hydrogen atom is – 13.6 eV. If an electron makes a transition from an energy level – 1.51 eV to – 3.4 eV, calculate the wavelength of the spectral line emitted and name the series of hydrogen spectrum to which it belongs.

Ans-

Energy difference = Energy of emitted photon

$$= E_1 - E_2$$

$$= -1.51-(-3.4) = 1.89\text{ eV} = 1.89\times1.6\times10^{-19}\text{ J}$$

$$\lambda = \frac{hc}{E_1 - E_2}$$

$$= \frac{6.6\times10^{-34}\times3\times10^8}{1.89\times1.6\times10^{-19}} = \frac{19.8}{3.024}\times10^{-7}$$

$$= 6.548\times10^{-7}\text{ m} = \mathbf{6548\ \text{Å}}$$

This wavelength belongs to Balmer series of hydrogen spectrum.

Q10. **Calculate the orbital period of the electron in the first excited state of hydrogen atom.**

Ans:- For ground state, $n = 1$ For first excited state, $n = 2$

Now, $T_n \propto n^3$

$$\frac{T_2}{T_1} = \frac{2^3}{1^3}$$

$T_2 = 8T_1$ i.e T_2 = 8 times of orbital period of the electron in the ground state.

Q11. A hydrogen atom in the ground state is excited by an electron beam of 12.5 eV energy. Find out the maximum number of lines emitted by the atom from its excited state.

Ans. Energy in ground state, $E1 = -13.6$ eV

Energy supplied = 12.5 eV

Energy in excited state, −13.6 + 12.5 = − 1.1 eV

But, $E_n = \frac{--13.6}{n^2} = --1.1$ then we will get n = 3

Hence no,of spectral lines = 3

MIND MAP : LEARNING MADE SIMPLE CHAPTER - 12

Atoms

Contribution

In 1898 J.J Thomson proposed the first model of atom also known as plum-pudding model

α – particle scattering experiment

- α- particle bombarded on thin gold foil
- Most of α– particle passed undeviated or with a small angle
- 1 out of 8000 α particles were deflected by scattering angle

Impact parameter

$$b = \frac{Ze^2 \cot\theta/2}{4\pi\varepsilon_0\left(\frac{1}{2}mv^2\right)}$$

Rutherford's Model

Postulates

- Atoms have a central, massive, positively charged core called nucleus around which electron revolves
- Size of nucleus ≈ 1 fermi $= 10^{-15}$m

Draw backs

- Doesn't explain the stability of atom
- Doesn't explain the atomic spectrum

Energy Level

Energy of electron in each stationary orbits is

Given by $E_n = -13.6\frac{Z^2}{n^2}$ eV

Where n = 1,2,3….

Z = atomic number of atom

- These stationary energy orbits are also called energy levels.
- When electron jumps from higher energy level to lower energy level it releases energy.

$$\Delta E = E_f - E_i = 13.6\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]Z^2 eV$$

Hydrogen Spectrum

Hydrogen gas heated in a sealed tube emits radiation which passes through prism

- Component of different wavelength appears
- Wavelength in each series given by

$$\bar{v} = \frac{1}{\lambda} = R\left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right]$$

$n_f > n_i$

- Lyman series [U.V. region]
  $n_i = 1, n_f = 2,3,4….$
  $\lambda_{min} = 912$ A°, $\lambda_{max} = 1216$ A°
- Balmer series [visible region]
  $n_i = 2$ $n_f = 3, 4, 5…..$
  $\lambda_{min} = 3648$ A°, $\lambda_{max} = 6563$ A°
- Paschan series [I–R region]
  $n_i = 3$ $n_f = 4, 5, 6…..$
  $\lambda_{min} = 8208$ A°, $\lambda_{max} = 18761$ A°
- Brackett series [I R region]
  $n_i = 4$ $n_f = 5, 6, 7…$
  $\lambda_{min} = 14592$ A° $\lambda_{max} = 40533$ A°
- P –fund [I R region]
  $n_i = 5$ $n_f = 6, 7, 8……$
  $\lambda_{min} = 23850$ A° $\lambda_{max} = 74618$ A°

Bohr Model

Postulates

- Electron revolves around the nucleus in stationary orbits
- Angular momentum of electron
  $$mvr_n = n \times \frac{h}{2\pi}$$
  n = Integers. It is also known as principle Quantum Number
- It explains spectrum of hydrogen or hydrogen like $[He^+, Li^{++}]$ atom

Limitations

- Fails to explain spectrum of complex atoms/ions of multi electron system
- Dosn't explain Zeeman's and Stark's effect

Radius of nth Bohr's orbit

$$R_n = \frac{\varepsilon_0 h^2}{\pi me^2}\left(\frac{n^2}{Z}\right) = 0.53\frac{n^2}{Z} A°$$

Velocity of electron in nth Bohr's orbit

$$v_n = \frac{e^2}{2\varepsilon_0 h}\left(\frac{Z}{n}\right) = 2.2 \times 10^6 \frac{Z}{n} m/s$$

Potential Energy

$$U_n = -\frac{KZe^2}{r_n} = \frac{-me^4}{4\varepsilon_0^2 h^2}\left(\frac{Z^2}{n^2}\right) = \frac{-27.2 Z^2}{n^2} eV$$

Kinetic Energy

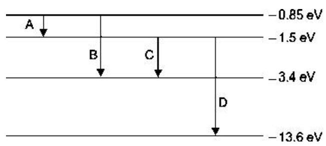
$$E_k = \frac{KZe^2}{2r_n} = \frac{me^4}{8\varepsilon_0^2 h^2}\frac{Z^2}{n^2} = \frac{13.6^2}{n^2}Z^2 eV$$

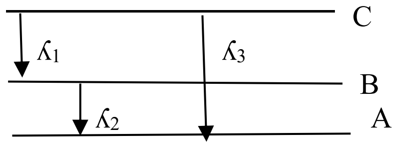
Total Energy

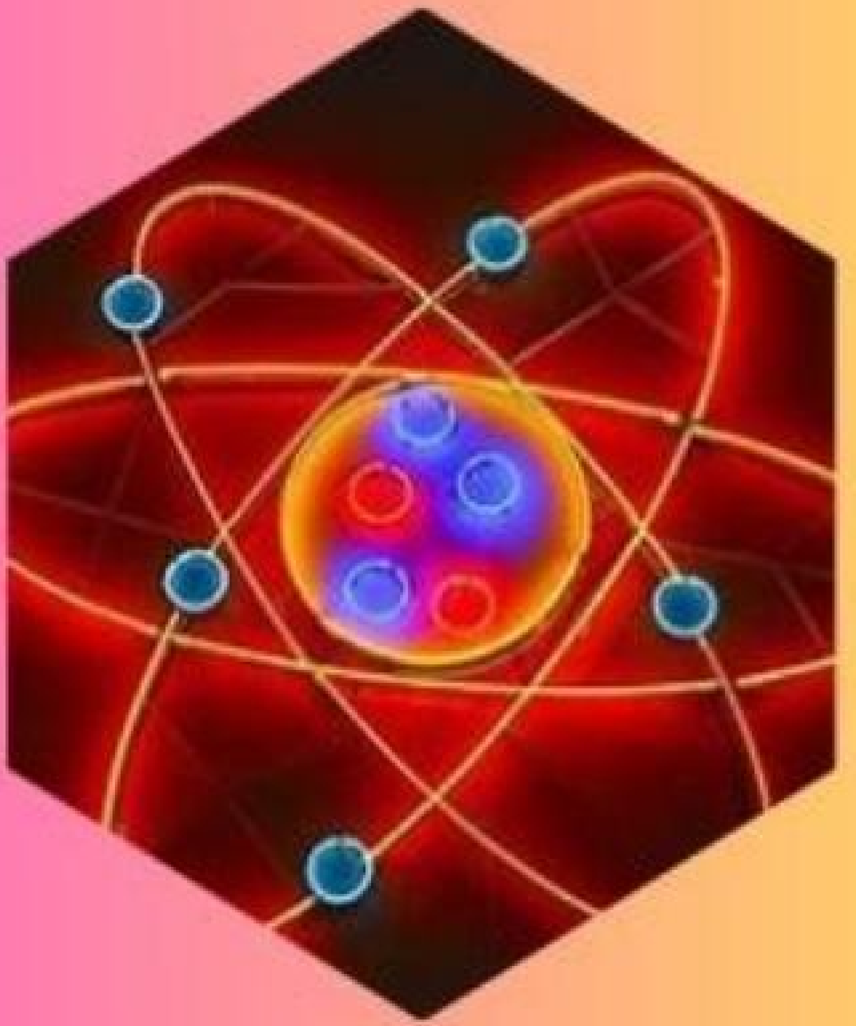
$$E = U_n + E_K = -\frac{KZe^2}{2r_n} = \frac{-13.6 Z^2}{n^2} eV = \frac{U_n}{2} = -E_K$$

REVISION PAPER UNIT- XII–ATOMS

Note: Q. No. 1-4 is of 01 mark each, Q. 5-6 is of 02 marks each, Q.No.7 is of 03 marks, Q. No. 8 is a case study based and is of 04 marks, Q. No. 11 is of 5 marks.

S N	Question	M M
1	When an electron in an atom goes from a lower to a higher orbit, its (a) kinetic energy (KE) increases, potential energy (PE) decreases (b) KE increases, PE increases (c) KE decreases, PE increases (d) KE decreases, PE decreases	1
2	**Assertion (A):** Bohr postulated that the electrons in stationary orbits around the nucleus do not radiate. **Reason (R):** According to classical Physics, all moving electrons radiate. a- Both assertion and reason are correct and the reason is the correct explanation of assertion. b- Both assertion and reason are correct and reason is not a correct explanation of assertion. c- Assertion is correct but the reason is incorrect. d- Assertion is incorrect but the reason is correct.	1
3	A set of atoms in an excited state decay. (a) in general, to any of the states with lower energy. (b) into a lower state only when excited by an external electric field. (c) all together simultaneously into a lower state. (d) to emit photons only when they collide.	1
4	The simple Bohr model cannot be directly applied to calculate the energy levels of an atom with many electrons. This is because (a) of the electrons not being subject to a central force (b) of the electrons colliding with each other (c) of screening effects (d) the force between the nucleus and an electron will no longer be given by Coulomb's law	1
5	Write two important limitations of Rutherford nuclear model of the atom.	2
6	Find out the wavelength of the electron orbiting in the ground state of hydrogen atom.	2
7	The energy level diagram of an element is given below. Identify, by doing necessary calculations, which transition corresponds to the emission of a spectral line of wavelength 102.7 nm. 	3
	Case study-based questions (questions no 8- 10) Line Spectra of the Hydrogen Atom The spectral series of hydrogen atom were accounted for by Bohr using the relation $\bar{\nu} = R(\frac{1}{n_1^2} - \frac{1}{n_2^2})$ where R = Rydberg constant = 1.097 x 10^7 m^{-1} Lyman series is obtained when an electron jumps to first orbit from any subsequent orbit. Similarly, Balmer series is obtained when an electron jumps to 2nd orbit from any subsequent orbit, Paschen series is obtained when an electron jumps to 3rd orbit from any subsequent orbit. Whereas Lyman series lies in U.V. region, Balmer series is in visible region and Paschen series lies in infrared region. Series limit is obtained when $n_2 = \infty$ 8. Find the wavelength of first spectral line of Lyman series. 1	4

	9. What is the value angle of scattering if impact parameter(i) b =0 (ii) b= infinite 10. What is the ratio of maximum to minimum wavelength in Lyman series? OR 10. What is the ratio of maximum to minimum wavelength in Balmer series?	2 2
11	Derive the expression for the total energy of the electron in hydrogenatom. What is the significance of total negative energy possessed by the electron?	5
12	The kinetic energy of the electron orbiting in the first excited state of hydrogen atom is 3.4 eV. Determine the de Broglie wavelength associated with it.	2
13	When the electron orbiting in hydrogen atom in its ground state moves to the third excited state, show how the de Broglie wavelength associated with it would be affected.	2
14.	A photon emitted during the de-excitation of electron from a state *n* to the first excited state in a hydrogen atom, irradiates a metallic cathode of work function 2 eV, in a photo cell, with a stopping potential of 0.55 V. Obtain the value of the quantum number of the state *n*.	3
15	Find the relation between the three wavelengths λ_1, λ_2 and λ_3 from the energy level diagram shown below.  	
16	The short wavelength limit for the Lyman series of the hydrogen spectrum is 913.4 Å. Calculate the short wavelength limit for Balmer series of the hydrogen spectrum.	2
17	Define ionisation energy. What is its value for a hydrogen atom ?	1



CHAPTER 13

NUCLEI

KEY FEATURES

1. The nucleus of an element, whose chemical symbol is X, is represented as , where Z and A are respectively the atomic number and mass number of the element.

2. Mass number is the integer closest to the nuclear mass.

3. The number of protons in the nucleus of an atom is equal to its atomic number (Z).

4. The number of neutrons in the nucleus of an atom is equal to the difference between its mass number and atomic number (A — Z).

5. Neutrons and protons are collectively called **nucleons**.

6. Neutron is unstable particle outside the nucleus.

7. The atoms of an element (same atomic number) having different mass number are called **isotopes.**

8. The atoms of different elements (different atomic number) having the same mass number are called **isobars**.

9. The atoms, whose nuclei have same number of neutrons are called **isotones.**

10. The atoms, whose nuclei have same difference in the number of neutrons and protons are called **isodiaspheres.**

11. The volume of a nucleus is always directly proportional to its mass number. It leads to the expression for nuclear radius as **R =** $^{1}/_{3}$

Where R_o = 1.2 x 10^{-15} m is known as nuclear unit radius.

12. The order of the size of the nucleus is **10^{-15} m.**

13. The order of the size of the atom is **10^{-10} m**.

14. The density of nuclear matter is same for all nuclei i.e. independent of the mass number of the nucleus. It is found to be of the order of 10^{17} kg/m^3

15. The extremely large magnitude of electrostatic force of repulsion between protons is the basic cause of nuclear instability.

16. Inside the nucleus, Coulomb's electrostatic repulsion between two protons is about **10^{36}** times the gravitational attraction between them.

17. The forces holding the nucleons together inside the nucleus are called nuclear forces.

(i) Nuclear forces are exchange type of forces. These forces arise between the nucleons due to the exchange of **-mesons**.

(ii) These forces are short range, basically very strong attractive, charge independent, charge symmetric, spin dependent and non- central forces.

18. The relative strengths of the gravitational, Coulomb's and nuclear forces are $\boldsymbol{F_g}$: $\boldsymbol{F_e}$: $\boldsymbol{F_n}$**: :1:10^{36}: 10^{38}**

19. Atomic mass unit (a.m.u.) is defined as 1/12 th of the mass of one atom.

Mathematically: **1 amu = 1:660565 x 10^{-27} kg ≈ 931.5 MeV**

20. Mass of a proton, **m_p = 1.007275 a.m.u. = 1.67265 x 10^{-27} kg**

21. Mass of a neutron, $\mathbf{m_n = 1.008665}$ **a.m.u.** $\mathbf{= 1.67495 \times 10^{-27}}$ **kg**

22. The difference between the sum of the masses of nucleons constituting a nucleus and the rest mass of the nucleus is called mass defect.

Mathematically- $\mathbf{\Delta m = [Z\, m_p + (A-Z)\, m_n] - m_N(\,_Z X^A)}$

23. The energy equivalent to mass defect of the nucleus is called its binding energy.

Mathematically- **B.E.=**$(\Delta m)c^2$

24. Nucleons are bound together by the strong nuclear force. The binding energy of the nucleus may be termed as the work done against the binding force to pull the nucleons apart.

25. The average energy required to extract one nucleon from the nucleus is called its binding energy per nucleon.

Mathematically- **B.E. per nucleon =** $\frac{\cdot\ \cdot}{\ }$

26. Packing fraction is defined as the mass defect per nucleon of the nucleus.

Mathematically- **Packing fraction =** $\frac{\Delta m}{\ }$

27. The stability of a nucleus depends upon a number of factors. A nucleus is found to be more stable, if

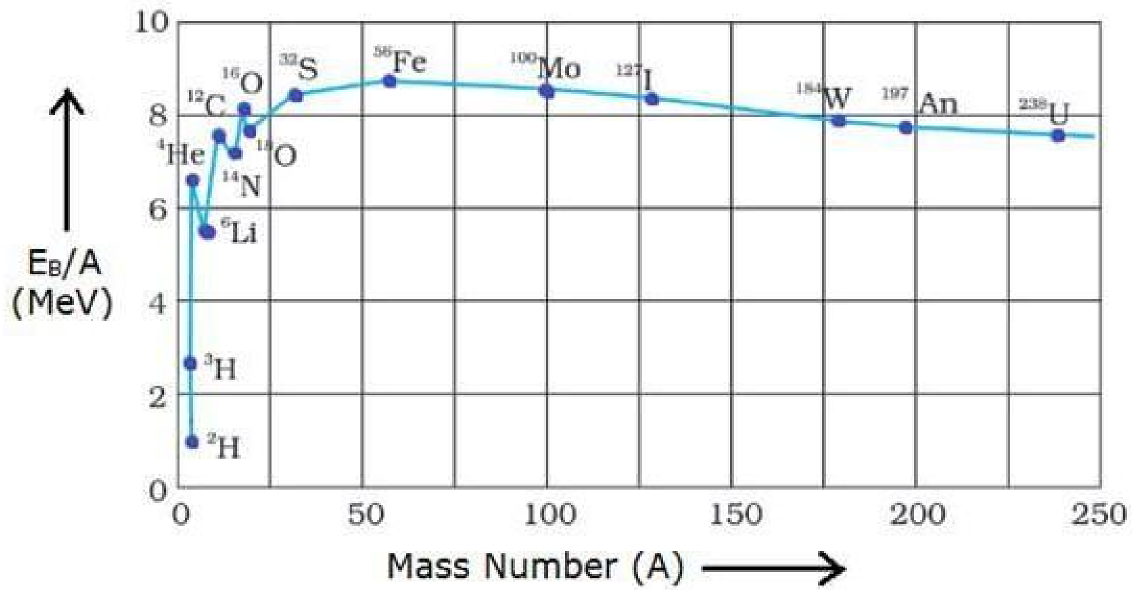
(i) its binding energy per nucleon (rather than the total binding energy of the nucleus) is high.

(ii) its neutron to proton ratio is high.

(iii) it is even-even nucleus (even no. of protons and even no. of neutrons). The even-odd and odd-even nuclei are less stable, while odd-odd nuclei are least stable.

28. Refer to following Fig.

Following conclusions can be drawn from the graph between B.E./A and A:



(i) The binding energy per nucleon has a low value for both very light and very heavy nuclei.

(ii) In the region A < 20, the B.E./A of the nuclei is quite low except for the nuclei He, cl and O. In an attempt to have greater value of B.E./A, the nuclei in the region A < 20 unite to form a heavier nucleus and therefore, the nuclei in this region are prone to nuclear fusion.

(iii) In the region A > 210, the B.E./A of the nuclei is again quite low. The nuclei in this region have a tendency to split so as to improve the value of their B.E./A. Hence, in region A > 210, the nuclei are prone to nuclear fission.

(iv) In the region 40 < A < 120, the nuclei are most stable. It is indicated by the flat shape of the graph. The value of the B.E./A in this region is maximum (= 8:8 MeV per nucleon).

29. This low value of binding energy per nucleon in case of heavy nuclei is unable to have control over the Coulomb's repulsion between the large number of protons. Such nuclei are unstable and are found to undergo α-decay.

30. The neutron to proton ratio increases during β-decay.

31. The B-decay leads to increase in Coulomb's repulsive force, but it increases binding energy per nucleon.

32. The neutron to proton ratio decreases during β-decay

33. has highest value of binding energy per nucleon.

QUESTIONS WITH ANSWERS

Q.1 Write two characteristic features of nuclear force which distinguish it from Coulomb's force.

Ans. Characteristic Features of Nuclear Force

(i) Nuclear forces are short range attractive forces (range 2 to 3 fm) while Coulomb's forces have range up to infinity and may be attractive or repulsive.

(ii) Nuclear forces are charge independent forces; while Coulomb's force acts only between charged particles

Q.2 Why do stable nuclei never have more protons than neutrons?

Ans. Protons are positively charged and repel one another electrically. This repulsion becomes so great in nuclei with more than 10 protons or so, that an excess of neutrons which produce only attractive forces, is required for stability.

Q.3 Two nuclei have mass numbers in the ratio 8:125. What is the ratio of their nuclear radii?

Ans:-

$$A_1 : A_2 = 8 : 125 \quad \Rightarrow \frac{A_1}{A_2} = \frac{8}{125}$$

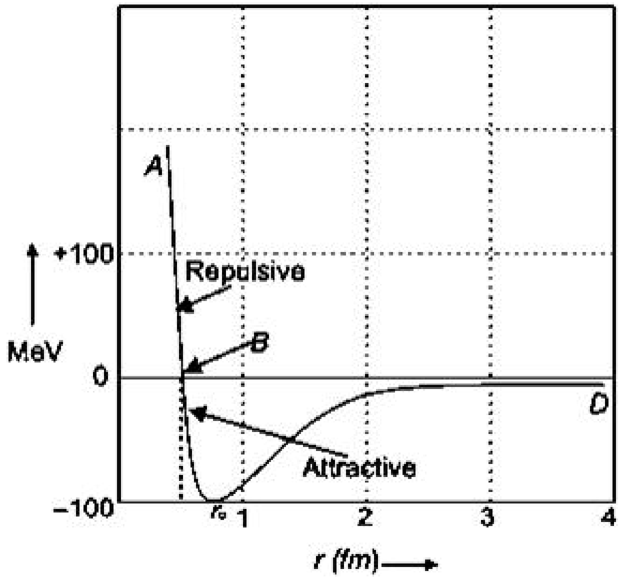
$$\text{Since } R = R_0 A^{1/3} \quad \therefore \frac{R_1}{R_2} = \frac{A_1^{1/3}}{A_2^{1/3}} = \frac{8^{1/3}}{125^{1/3}} = \frac{2}{5}$$

Q.4 Two nuclei have mass numbers in the ratio 1: 2. What is the ratio of their nuclear densities?

Ans:- Nuclear density is independent of mass number. Hence ratio of nuclear densities for given nuclei is 1:1

Q5 . Draw a graph showing the variation of potential energy between a pair of nucleons as a function of their separation. Indicate the regions in which the nuclear force is (i) attractive, (ii) repulsive. Write two important conclusions which you can draw regarding the nature of the nuclear forces.

Ans-



Conclusions:

(i) The potential energy is minimum at a distance r_0 of about 0.8 fm.

(ii) Nuclear force is attractive for distance larger than r_O.

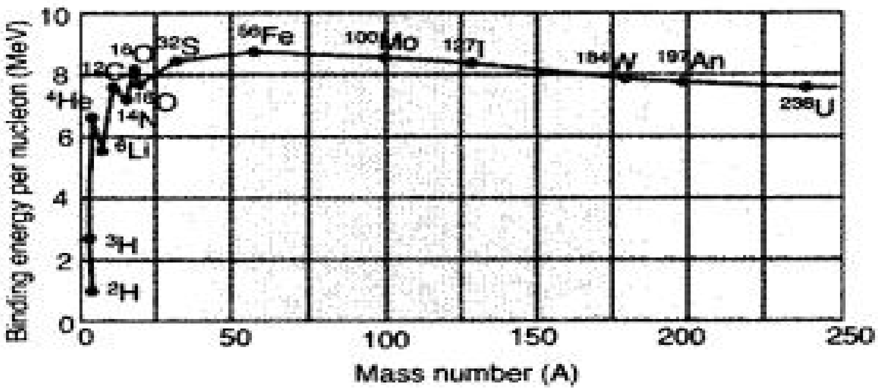
(iii) Nuclear force is repulsive if two are separated by distance less than r_O.

(iv) Nuclear force decreases very rapidly at r0/equilibrium position.

Q6. Using the curve for the binding energy per nucleon as a function of mass number A, state clearly how the release of energy in the processes of nuclear fission and nuclear fusion can be explained.

Ans:-

Nuclear fission : Binding energy per nucleon is smaller for heavier nuclei than the middle ones i.e. heavier nuclei are less stable. When a heavier nucleus splits into the lighter nuclei, the B.E./nucleon changes (increases) from about 7.6 MeV to 8.4 MeV. Greater binding energy of the product nuclei results in the liberation of energy. This is what happens in nuclear fission which is the basis of the atom bomb.



Explanation of nuclear fusion: When two very light nuclei ($A \leq 10$) join to form a heavy nucleus, the binding is energy per nucleon of fused heavier nucleus more than the binding energy per nucleon of lighter nuclei, so again energy would be released in nuclear fusion.

Q.7 The neutron separation energy is defined as the energy required to remove a neutron from the nucleus. Obtain the neutron separation energies of the nuclei $^{41}_{20}$ $^{27}_{13}$

from the following data

$m(^{40}_{20}\text{Ca}) = 39.962591$ u $m(^{26}_{13}\text{Al}) = 25.986895$ u

$m(^{41}_{20}\text{Ca}) = 40.962278$ u $m(^{27}_{13}\text{Al}) = 26.981541$ u

Ans-

When a neutron is separated from $^{41}_{20}\text{Ca}$, we are left with $^{40}_{20}\text{Ca}$ and the reaction becomes

$$^{41}_{20}\text{Ca} \longrightarrow {}^{40}_{20}\text{Ca} + {}_0n^1$$

Mass defect,

$$\Delta m = m\,(^{40}_{20}\text{Ca}) + m(_0n^1) - m\,(^{41}_{20}\text{Ca})$$

$$= 39.962591 + 1.008665 - 40.962278$$

$$= 0.008978 \text{ u}$$

Energy for separation of neutron $= \Delta m \times 931$

$$= 0.008978 \times 931$$

$$= 8.358 \text{ MeV}$$

When a neutron is separated from $^{27}_{13}\text{Al}$, we are left with $^{26}_{13}\text{Al}$. Thus, the reaction becomes

$$^{27}_{13}\text{Al} \longrightarrow {}^{26}_{13}\text{Al} + {}^1_0n$$

Mass defect,

$$\Delta m = m\,(^{26}_{13}\text{Al}) + m(_0n^1) - m(^{27}_{13}\text{Al})$$

$$= 25.986895 + 1.00865 - 26.981541$$

$$= 0.014019$$

$\therefore$ Energy for separation of neutron

$$= \Delta m \times 931 = 0.014019 \times 931$$

$$= 13.06 \text{ MeV}$$

Q8. A nucleus with mass number *A* = 240 and *BE/A* = 7.6 MeV breaks into two fragments each of *A* = 120 with *BE/A* = 8.5 MeV. Calculate the released energy.

Ans :-

Binding energy of nucleus with mass number 240,

$$(E_{BN})_1 = 240 \times 7.6 \text{ MeV} \quad \ldots(i)$$

Binding energy of two fragments

$$(E_{BN})_2 = 2 \times 120 \times 8.5 \text{ MeV} \quad \ldots(ii)$$

Energy released $= (E_{BN})_2 - (E_{BN})_1$

$$= (2 \times 120 \times 8.5) - (240 \times 7.6)$$

$$= 240(8.5 - 7.6) = 240 \times 0.9$$

$$= 216 \text{ MeV}$$

MIND MAP : LEARNING MADE SIMPLE — CHAPTER - 13

Nuclei

Composition
- Nuclei consists of protons and neutrons.
- Total No. of protons & neutrons in the nucleus is called nucleons
- $_{Z}X^{A}$, $A = Z + N$ = Mass Number
  - A = Atomic Number
  - N = No. of neutrons

Types of Nuclei
- **Isotopes**
  - Same atomic No.(Z)
  - Different mass No.(A)
  - e.g. $_6C^{12}$, $_6C^{14}$
- **Isobars**
  - Same mass No.(A)
  - Different atomic No.(Z)
  - e.g. $_6C^{14}$, $_7N^{14}$
- **Isotone**
  - Atoms whose nuclei having same number of neutron (N)
  - e.g. $_{11}Na^{23}$, $_{12}Mg^{24}$

Contribution
- In 1896, Henri Becquerel discovers Radioactivity
- **Mass-Energy Relation**: Einstein shows that mass is an another form of energy and gives a relation $E = mc^2$
- **Mass Defect**
  - $\Delta M = [Z m_p + (A - Z)m_n] - M$
  - m_p = mass of proton, m_n = mass of neutron
  - M = mass of nucleus
- **Binding Energy**
  - B.E. $= \Delta Mc^2 = [Z m_p + (A - Z)m_n - M] \times c^2$
  - B.E. per nucleon = B.E/A
- **Nuclear Fission**
  - Splitting of a heavy nucleus into two or more lighter nuclei.
  - $_{92}U^{235} + {_0n^1} \rightarrow {_{56}Ba^{141}} + {_{36}Kr^{92}} + 3{_0n^1}$ +200 mev
- **Nuclear Fusion**
  - Combining two lighter nuclei to form a heavy nucleus
  - ${}_1^1H + {}_1^1H \rightarrow {}_1^2H + e^+ + \nu$ + 0.42 MeV (energy)

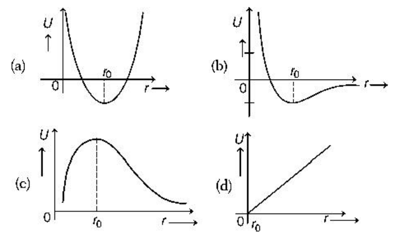
Size of Nucleus
- **Nuclear Radius**
  - $R = R_0A^{1/3}$
  - $R_0 = 1.2 \times 10^{-15}$ m
  - A = Mass No.
- **Nuclear Volume**
  - $V = \frac{4}{3}\pi R^3$
  - $= \frac{4}{3}\pi R_0^3 A$
  - $V \propto A$ (mass no.)
- **Nuclear Density**
  - $\rho = \frac{\text{mass of nucleus}}{\text{volume of nucleus}}$
  - $= \frac{A \times 1.67 \times 10^{-27}}{\frac{4}{3}\pi \times (1.2 \times 10^{-15})^3 \times A}$
  - $\approx 2.9 \times 10^{17}$ kgm^{-3} (independent of A)

Radioactivity
Disintegration of heavy elements into comparatively lighter elements by emission of α, β and γ radiations
- **Law of radioactivity**
  - $\frac{-dN}{dt} = \lambda N$
  - $N = N_0 e^{-\lambda t}$
- **Half life**
  - $t_{\frac{1}{2}} = \frac{0.693}{\lambda}$
  - $N = N^0 \left(\frac{1}{2}\right)^{t/t_{\frac{1}{2}}}$
- **Mean life**
  - $\tau = \frac{1}{\lambda}$
  - $= t_{\frac{1}{2}} / 0.693$

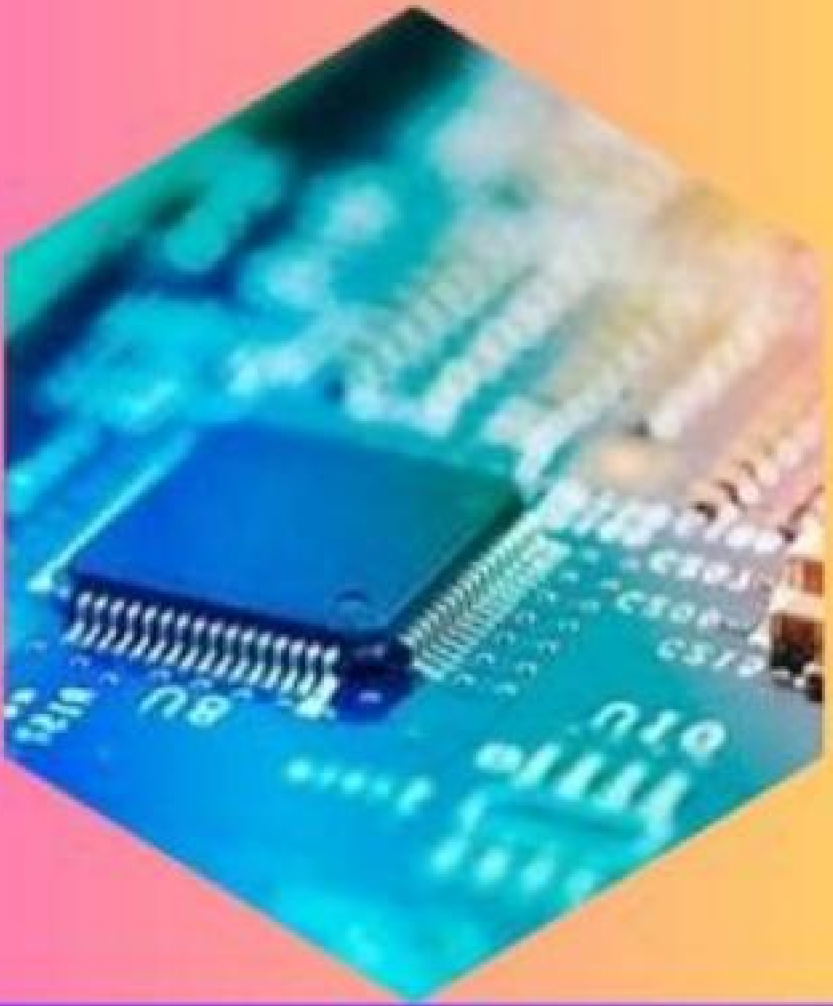
Properties of α, β & γ
- **α – Particle**
  - is a heavy doubly ionized helium ion
  - least penetrating power
  - highest ionizing power
  - decay of 1 α particle cause decrease in atomic no. by 2 and mass no. by 4.
- **β – Particle**
  - is an electron moderate penetrating power (100 times α)
  - less ionizing power than α –particle
  - one β – particle decay cause increase in atomic no. by 1 and mass no. remains uncharged.
- **γ Rays**
  - A wave having high frequency having no mass,
  - least ionizing power but highest penetrating power
  - No charge in atomic No. and Mass No. on γ decay.

REVISION PAPER UNIT- XIII–NUCLEI

Note: Q. No. 1-4 is of 01 mark each, Q. 5-6 is of 02 marks each, Q.No.7 is of 03 marks, Q. No. 8 is a case study based and is of 04 marks, Q. No. 11 is of 5 marks.

SN	Question	Marks
1	Density of a nucleus is (a) more for lighter elements and less for heavier elements (b) more for heavier elements and less for lighter elements (c) very less compared to ordinary matter (d) a constant	1
2	**Assertion (A):** Two atoms of different elements having same mass number but different atomic numbers are called isobars. **Reason (R):** Atomic number is the number of protons present and atomic number is the total number of protons and neutrons present in a nucleus e- Both assertion and reason are correct and the reason is the correct explanation of assertion. f- Both assertion and reason are correct and reason is not a correct explanation of assertion. g- Assertion is correct but the reason is incorrect h- Assertion is incorrect but the reason is correct.	1
3	Which amongst the following is a correct graph of potential energy U of a pair of nucleons as a function of their separation r ?  	1
4	, are the nuclear forces between proton-proton, neutron-neutron and neutron-proton, respectively. Then, relation between them is (a) $F_{pp} = F_{nn} \neq F_{np}$ (b) $F_{pp} \neq F_{nn} F_{np}$ (c) $F_{pp} = F_{nn} = F_{np}$ (d) $F_{pp} \neq F_{nn} \neq F_{np}$	1
5	State three properties of nuclear forces.	2
6	Show that the density of nucleus over a wide range of nuclei is constant and independent of mass number.	2
7	Explain the processes of nuclear fission and nuclear fusion by using the plot of binding energy per nucleon (BE/A) versus the mass number A.	3
	Case study-based questions (questions no 8- 10) NUCLEAR DENSITY The density of nuclear matter is the ratio of the mass of a nucleus to its volume. As the volume of a nucleus is directly proportional to its mass number A, so the density of nuclear matter is independent of the size of the nucleus. Thus, the nuclear matter behaves like a liquid of constant density. Different nuclei are like drops of this liquid, of different sizes but of same density. Let A be the mass number and R be the radius of a nucleus. If m is the average mass of a nucleon, then Mass of nucleus = mA Volume of nucleus $= \frac{4\pi}{3}R^3 = \frac{4\pi}{3}(R\ A^{1/3})^3 = \frac{4\pi}{3}R^3 A$	4

	Nuclear density, $= \frac{\quad}{\quad} = \frac{\quad}{\frac{4}{3}\quad{}^{3}A} = \frac{3}{4}$ Clearly, nuclear density is independent of mass number A or the size of the nucleus. The nuclear mass density is of the order 10^{17} kg m^{-3}. This density is very large as compared to the density of ordinary matter, say water for which = 1.0×10^{3} kg^{-3} 8. What is the nucleus density of hydrogen atom? Name the factor on which nucleus density depends. 9. If the radius of $^{27}_{13}$ has a nuclear radius of about 3.6 fm, then find the radius of $^{125}_{52}$. OR 10. If the nuclear mass of $^{56}_{26}$ is 55.85 amu, then find its nuclear density. 2	
11	Draw the graph showing the variation of binding energy per nucleon with the mass number for a large number of nuclei 2< A < 240. What are the main inferences from the graph? How do you explain the constancy of binding energy in the range 30 < A < 170 using the property that the nuclear force is short-ranged? Explain with the help of this plot the release of energy in the processes of nuclear fission and fusion.	3
12	Write the difference between Fission & Fusion? In which process more, energy released? explain	3

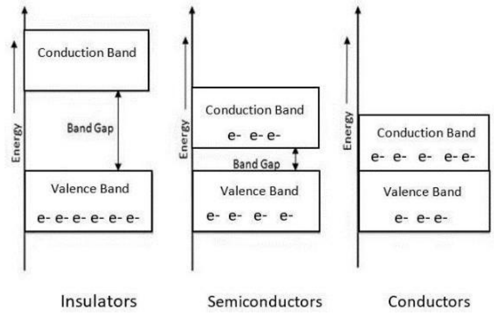


CHAPTER 14

SEMICONDUCTOR ELECTRONICS: MATERIAL DEVICES

KEY FEATURES

Energy bands in solids. Due to interaction between closed packed atoms in solids, the splitting of energy levels take place and it gives rise to formation of energy bands. The energy band formed by a series of levels containing valence electrons is called valence band and the lowest unfilled energy band formed just above the valence band is called conduction band.



The energy gap is called forbidden energy gap.

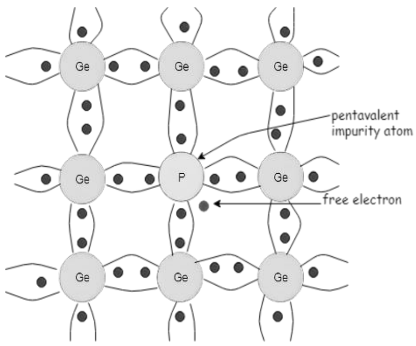
Conductors. The conduction and valence bands partly overlap each other in case of conductors. In other words, there is no forbidden energy gap in conductors.

Semiconductors. The conduction and valence bands are separated by the small width (= 1 eV) of forbidden energy gap. The valence band is completely filled, while the conduction band is empty. The electrons cross from valence band to conduction band even when a small amount of energy is supplied.

Insulators. The width of forbidden energy gap between the valence and conduction bands is quite large (= 10 eV). Ordinarily, electrons cannot jump from valence to conduction band even on applying, a strong electric field.

Intrinsic semiconductors. A semiconductor free from all types of impurities is called intrinsic semiconductor. At 0 K, a semiconductor is an insulator i.e. it possesses zero conductivity. When temperature is increased, a few covalent bonds break up and release the electrons. These electrons move to conduction band leaving behind equal number of holes in valence band. The conductivity of an intrinsic semiconductor is due to both electrons and holes.

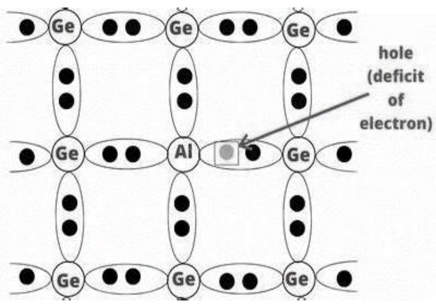
Doping. The process of adding impurity atoms (pentavalent or trivalent) to a pure semiconductor, so as to increase its conductivity in a controlled manner is called doping. The impurity atoms added are very small (= 1 in 10° semiconductor atoms). The pentavalent impurity atoms are called donor atoms, while the trivalent impurity atoms are called acceptor atoms.



Extrinsic semiconductor. A semiconductor doped with a suitable impurity, so as to possess conductivity much higher than the semiconductor in pure form is called an extrinsic semiconductor.

n-type semiconductor. When a pentavalent impurity, such as arsenic or antimony or phosphorus is added to a pure semiconductor, the number of free electrons become more than the holes in the semiconductor and such an extrinsic semiconductor is called n-type semiconductor. In other words, in a n-type semiconductor, electrons are majority carriers and holes are minority carriers.

p-type semiconductor. When a trivalent impurity, such as indium or gallium or boron is added to a pure semiconductor, the semiconductor becomes deficient in electrons i.e. number of holes become more than the number of electrons. Such a semiconductor is called p-type semiconductor. It has holes as majority carriers and electrons as minority carriers.



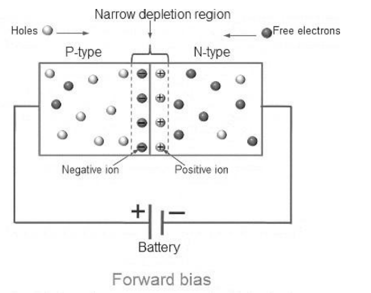
Electrical conductivity of a semiconductor. The conductivity of a semiconductor is determined by the mobility (μ) of both electrons and holes and their concentration.

Mathematically- $\sigma = e\ (n_e\mu_e + n_h\mu_h)$

Here, n_e *and* n_h represent number density, while μ_e *and* μ_h represent mobility of electrons and holes respectively.

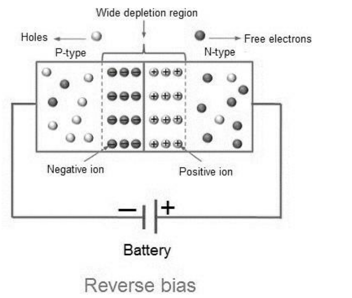
p-n junction. The device obtained by growing a p-type semiconductor over a n-type semiconductor or vice-versa is called a p-n junction. It conducts in one direction only. It is also called a junction diode.

Depletion layer. It is a thin layer formed between the p and n-sections and devoid of holes and electrons. Its width is about 10^{-8} m. A potential difference of about 0.7 V is produced across the junction, which gives rise to a very high electric field (= 10^6 V m^{-1}).



Forward biasing. The p-n junction is said to be forward biased, when the positive terminal of the external battery in the circuit is connected to p-section and the negative terminal to n-section of the junction diode.

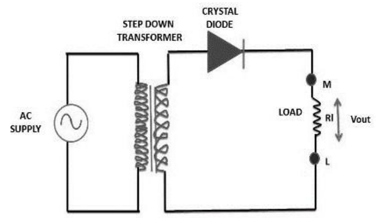
The flow of majority carriers across the junction from both the sections of the junction diode is responsible for the forward current.



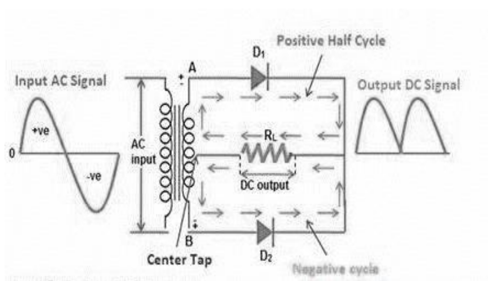
Reverse biasing. The p-m junction is said to be reverse biased, when the positive terminal of the external battery in the circuit is connected to n-section and the negative terminal to p-section of the junction diode.

The flow of minority carriers across the junction from both the sections of the junction diode is responsible for the reverse current.

Junction diode as rectifier. Because of its unidirectional conduction property, the p-n junction is used to convert an a,c. voltage into d. c, voltage, It is, then, said to be acting as a rectifier.



1. **Half wave rectifier**. A rectifier, which rectifies only one half of each a.c. input supply cycle, is called a half wave rectifier. A half wave rectifier gives discontinuous and pulsating d.c. output. As alternative half cycles of the a.c. input supply go waste, its efficiency is very low.
2. **Full wave rectifier**. A rectifier which rectifies both halves of each a.c. input cycle is called a full wave rectifier. The output of a full wave rectifier is continuous but pulsating in nature. However, it can be made smooth by using a filter circuit.



QUESTIONS WITH ANSWERS

Q. 1 What is valence band?

Ans. The energy band formed by a series of energy levels containing the valence electrons is known as valence band.

Q. 2 What is conduction band?

Ans. The lowest unfilled energy band lying just above the valence band is called conduction band.

Q. 3 What is forbidden energy gap?

Ans. The energy gap between the valence band and the conduction band is called the forbidden energy gap.

Q. 4. What is the value of forbidden gap energy of germanium?

Ans. 0:7 eV. Since this is an intrinsic semiconductor.

Q. 5 Why germanium is preferred over silicon for making semiconductor devices?

Ans. For germanium (Ge) and silicon (Si), the values of forbidden energy gap are 0.7 eV and 1.1 eV respectively. Owing to the smaller value of forbidden energy gap, germanium is preferred over silicon.

Q. 6. What is Fermi energy level?

Ans. The highest energy level, which an electron can occupy in the valence band at 0 K is called Fermi energy level.

Q. 7. What is an intrinsic semiconductor?

Ans. A semiconductor free from all types of impurities is called an intrinsic semiconductor.

Q 8. What is the ratio of number of holes and the number of conduction electrons in an n-type intrinsic semiconductor?

Ans. It is less than 1.

Q. 9. What is doping?

Ans. The process of adding trivalent or pentavalent atoms to a pure semiconductor in a very small ratio is called doping.

Q. 10. Why semiconductors are doped?

Ans. The conductivity of intrinsic semiconductors is so small that it is practically of no use. The semiconductors are dopped so as to increase their conductivity.

Q. 11. What type of impurity is added to obtain n-type semiconductor?

Ans. Pentavalent atoms, such as arsenic and phosphorous.

Q. 12 Which type of semiconductor is formed, when

(a) germanium is doped with indium?

(b) germanium is duped with arsenic?

Ans. (a) p-type (b) n-type

Q. 13. What is a p-type semiconductor?

Ans. When a semiconductor is doped with a trivalent impurity, the holes are created in the covalent bonds. As a result, the semiconductor possesses a large number of holes (majority carriers) and a small number of electrons (minority carriers). Such a semiconductor is called p-type semiconductor.

Q. 14. What is a hole?

Ans. A vacancy created in the covalent bond of a semiconductor is called hole.

Q. 15. Which type of doping creates a hole?

Ans. The doping of semiconductor with impurity atoms having 3 electrons in valence shell creates holes.

Q. 16. Distinguish between intrinsic and extrinsic semi-conductors?

Ans. A semiconductor free from all types of impurities is called an intrinsic semiconductor. At room temperature, a few covalent bonds break up and the electrons come out. In the bonds, from which electrons come out, vacancies are created. These vacancies in covalent bonds are called holes. In an **intrinsic semiconductor**, holes and electrons are equal in number and they are free to move about in the semiconductor. On the other hand, a semiconductor doped with a suitable impurity (donor or acceptor), so that it possesses conductivity much higher than that of pure semiconductor, is called an **extrinsic semiconductor**. The extrinsic semiconductor may be of n-type or p-type.

Q. 17 An n-type semiconductor has a large number of electrons but still it is electrically neutral.Explain.

Ans. An n-type semiconductor is obtained by doping pure Si or Ge-crystal with a pentavalent impurity. As the impurity atoms enter into the configuration of the Si-crystal, its four electrons take part in covalent bonding, while the fifth electron is left free. Since each atom of the semiconductor as a whole is electrically neutral; the n-type Ge-crystal, though having large number of free electrons, is electrically neutral.

Q.18. What is the difference between hole-current and electron current?

Ans. In a p-type semiconductor, there are vacancies called holes. When such a material conducts, an electron from a nearby covalent bond jumps into the vacant place in order to fill it and thereby the hole shifts to the covalent bond from which the electron has jumped. The movement of holes constitutes the hole-current. In an n-type semiconductor, the free electrons constitute the electron-current.

Q. 19 Why is a semiconductor damaged by a strong current?

Ans. A strong current, when passed through a semiconductor, heats up the semiconductor and the covalent bonds break up. It results in a large number of free electrons. The material, then, behaves just as a conductor. As now the semiconductor no longer possesses the property of low conduction, it is said to be damaged.

Q.20 Explain the terms depletion layer and potential barrier for a junction diode.

Or

What do you mean by depletion region and potential barrier in a junction diode?

Ans. **Depletion region**. A layer, created around the junction between p and n-sections of a junction diode devoid of holes and electrons, is called depletion region.

Potential barrier. The potential difference developed across the junction due to migration of majority carriers is called potential barrier.

Q. 22. How does the width of the depletion region of a p-n junction vary, if the reverse bias applied toit increases? Or

Why does the thickness of the depletion layer in a p-n diode vary with increase in reverse bias?

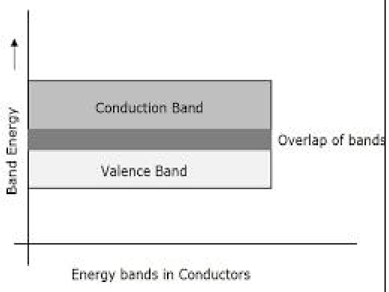
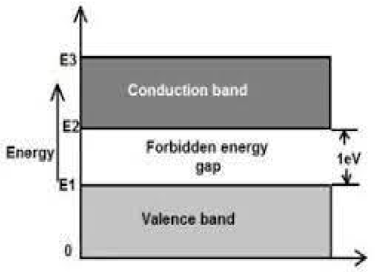
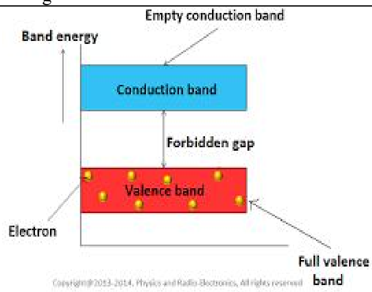
Ans. When a p-n junction is formed, a small potential difference (fictitious battery) is set up across the depletion layer. When the junction diode is reverse biased, the polarity of the applied d.c. source aids the fictitious battery. Due to this, potential drop across the junction increases and diffusion of holes and electrons across the junction decreases. It makes the width of the depletion layer larger.

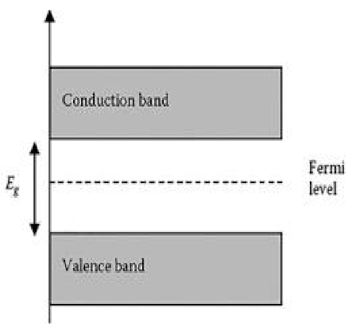
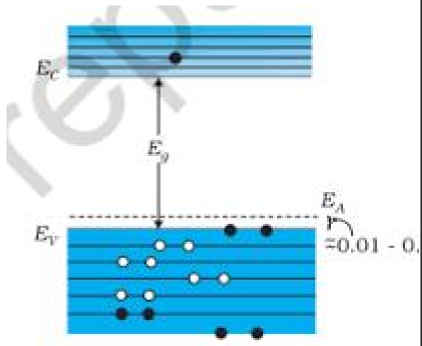
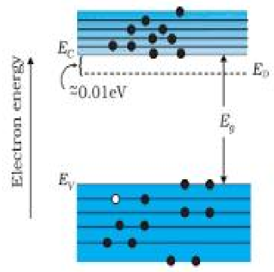
Q. 23 The resistance of a p-n junction is low, when forward biased and is high, when reverse biased.Explain.

Ans. When a p-n junction is forward biased, the junction width decreases and as a result its resistance also decreases. On the other hand, when a p-n junction is reverse biased, the junction width increases. It brings about an increase in its resistance.

Q. 24 How is forward biasing different from reverse biasing in a p-n junction diode?

Ans. To forward bias a p-n junction, positive pole of the battery is connected to its p-section and negative pole of the battery is connected to its n-section. During forward bias, the width of the depletion layer small and as a result, the resistance of a p-n junction Is low. The above facts in case of reverse bias of a p-n junction, are exactly opposite.

CONDUCTOR	SEMI-CONDUCTOR	INSULATOR
1. A conductor is a material that allows the flow of charge when applied with a voltage.	1. A semiconductor is a material whose conductivity lies between conductor & insulator	1. An insulator is a material that does not allow the flow of current.
2. The conductors have very **high conductivity**	2. They have **intermediate conductivity**	2. They have very **low conductivity**
3. The resistance of a conductor increases with an increase in temperature.	3. The resistance of a semiconductor decrease with increases in temperature. Thus it acts as an insulator at absolute zero.	3. Insulator has very high resistance but it still decreases with temperature.
4. Resistivity is low	4. Resistivity is normal	4.Resistivity is very high
5. Forbidden energy gap $E_g = 0ev$	5.Forbidden energy gap $E_g < 3ev$	5.Forbidden energy gap $E_g > 3ev$
6. 	6.  (Energy band diagram of semiconductor)	 6.

INTRINSIC SEMICONDUCTOR	P-TYPE SEMICONDUCTOR	N-TYPE SEMICONDUCTOR
1. Pure form of semi conductor	1. Pure semiconductor is doped with trivalent impuities to get p-type	1. Intrinsic semiconductor is doped with pentavalent impurity to get n-type semiconductor
2. Electrons and holes are equal ($n_e = n_h$)	2.The holes are majority carriers and electrons are minority carriers (*nh >> ne*). Here $n^2_i = n_e n_h$	2.The electrons are majority carriers and holesare minority carriers (*ne >> nh*) Here $n^2_i = n_e n_h$
3. 	3.  (b) T > OK	3. 
4.Fermi energy level lies in the middle of the valency band and conduction band	4.Fermi energy level lies just above the valence band	4.Fermi energy level lies just below the conduction band.
5. Pure form of semi conductor	5.Acceptor impuity	5.Donar impurity

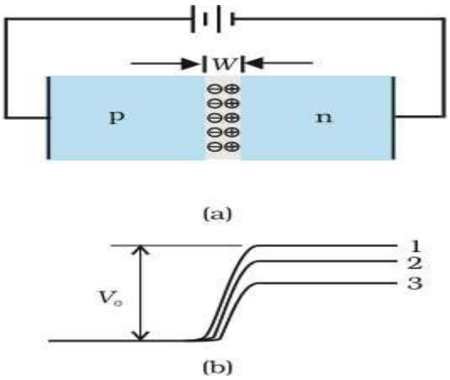


FIGURE 14.13 (a) p-n junction diode under forward bias, (b) Barrier potential (1) without battery, (2) Low battery voltage, and (3) High voltage battery.

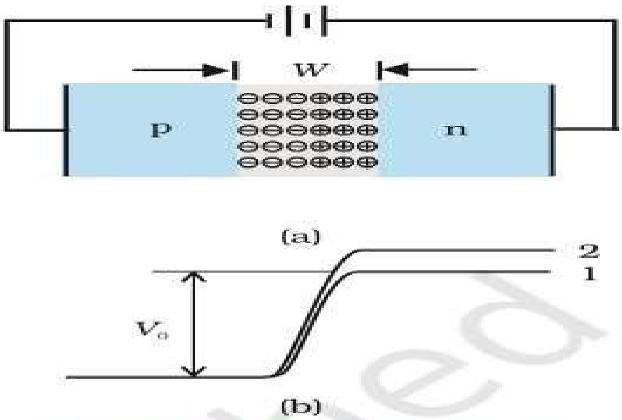


FIGURE 14.15 (a) Diode under reverse bias, (b) Barrier potential under reverse bias.

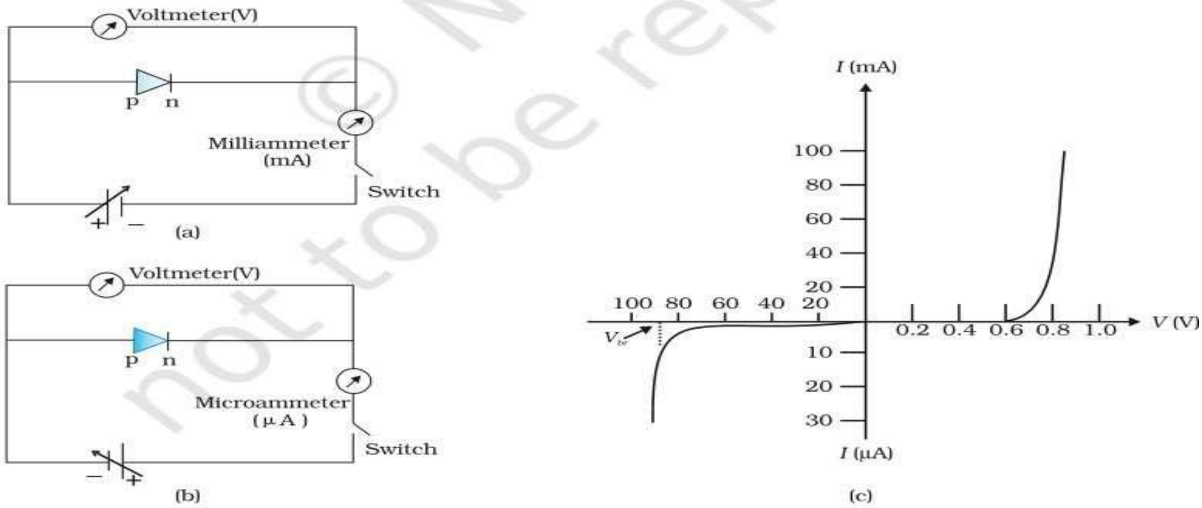


FIGURE 14.16 Experimental circuit arrangement for studying *V-I* characteristics of a p-n junction diode (a) in forward bias, (b) in reverse bias. (c) Typical *V-I* characteristics of a silicon diode.

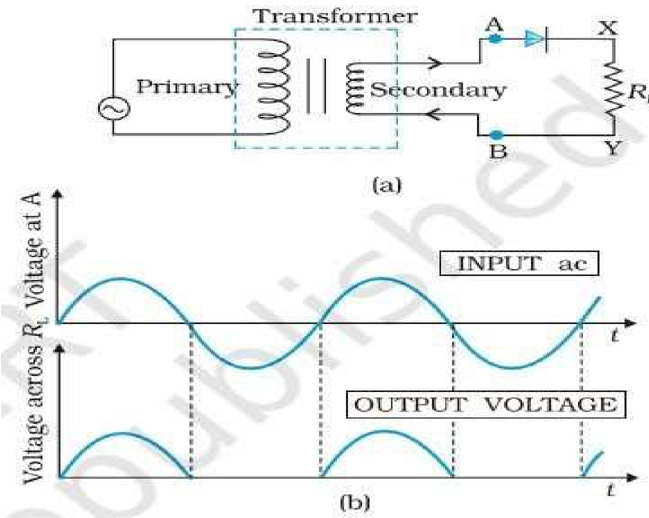


FIGURE 14.18 (a) Half-wave rectifier circuit, (b) Input ac voltage and output voltage waveforms from the rectifier circuit.

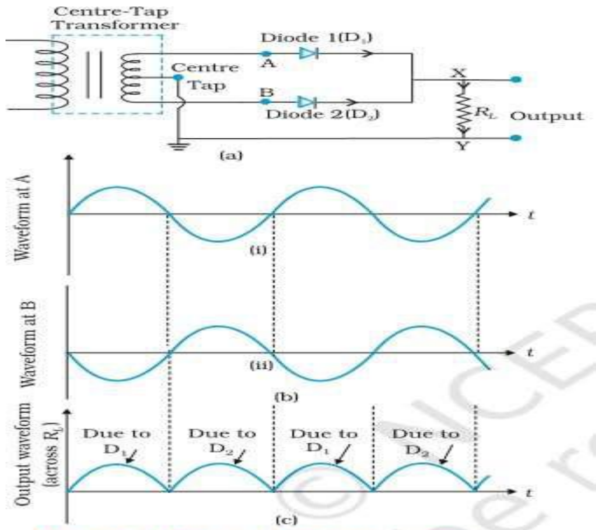
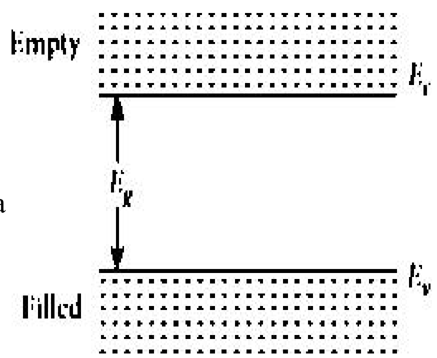
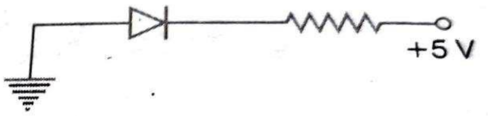
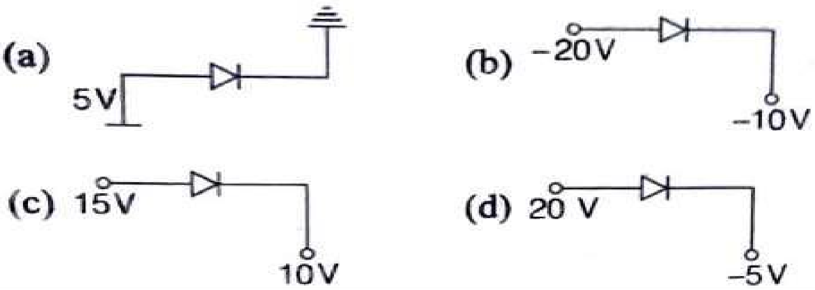
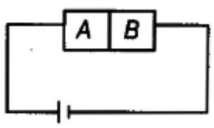
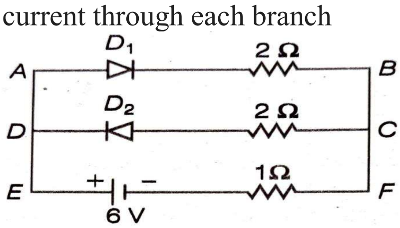
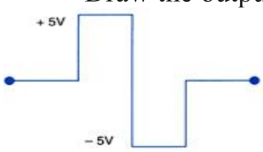
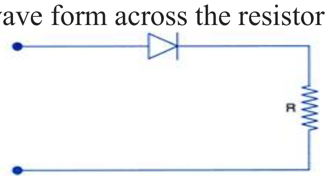


FIGURE 14.19 (a) A Full-wave rectifier circuit; (b) Input wave forms given to the diode D_1 at A and to the diode D_2 at B; (c) Output waveform across the load R_L connected in the full-wave rectifier circuit.

REVISION PAPER UNIT- XIV-SEMICONDUCTOR

Note: Q. No. 1-4 is of 01 mark each, Q. 5-6 is of 02 marks each, Q.No.7 is of 03 marks, Q. No. 8 is a case study based and is of 04 marks, Q. No. 11 is of 5 marks.

S N	Questi on	Ma rks
1	The substance which is doped in an intrinsic semiconductor to make p-type semiconductor is (a) phosphorus (b) antimony (c) aluminium (d) arsenic	1
2	**Assertion (A):** The energy gap between the valence band and conduction band is greater insilicon than in germanium. **Reason (R):** Thermal energy produces fewer minority carriers in silicon than in germanium. i- Both assertion and reason are correct and the reason is the correct explanation of assertion.j- Both assertion and reason are correct and reason is not a correct explanation of assertion. k- Assertion is correct but the reason is incorrect l- Assertion is incorrect but the reason is correct.	1
3	The conductivity of a semiconductor increases with increase in temperature because (a) number density of free current carriers increases. (b) relaxation time increases. (c) both number density of carriers and relaxation time increase. (d) number density of current carriers increases; relaxation time decreases but effect of decrease inrelaxation time is much less than increase in number density.	1
4	Electrical conduction in a semiconductor occurs due to (a) electrons only (b) holes only (c) electrons and holes both (d) neither electrons nor holes	1
5	Write two characteristic features to distinguish between n-type and p-type semiconductors.	2
6	Draw the energy band diagram when intrinsic semiconductor (Ge) is doped with impurity atoms of Antimony (Sb). Name the extrinsic semiconductor so obtained and majority charge carriers in it.	2
7	(i) Distinguish between n-type and p-type semiconductor on the basis of energy band diagram. (ii) Compare their conductivities at absolute zero temperature and at room temperature.	3
	Case study-based questions (questions no 8- 10) ENERGY BAND GAP From Bohr's atomic model, we know that the electrons have welldefined energy levels in an isolated atom. But due to interatomic interactions in a crystal, the electrons of the outer shells are forced to have energies different from those in isolated atoms. Each energy level splits into a number of energy levels forming a continuous band. 'The gap between top of valence band and bottom of the conduction band in which no allowed energy levels for electrons can exist is called energy gap.  8. What is the energy gap in an insulator? 1 9. What is Fermi energy level? Explain diagrammatically the position of fermi energy level incase of intrinsic, P-type and n-type smi conductors. 2 10. Based on the band theory of conductors, insulators and semiconductors, which has thesmallest forbidden energy gap? 2 OR 10. Name the solids having highest energy level partially filled with electrons. 2	4

11	Draw the circuit arrangement for studying the V–I characteristics of a p-n junction diode (i) in forward bias and (ii) in reverse bias. Draw the typical V–I characteristics of a silicon diode. Describe briefly the following terms: (i) “minority carrier injection” in forward bias (ii) “breakdown voltage” in reverse bias.	3
12	**The number of silicon atoms per m^3 is 5 × 10^{28}. This is doped simultaneously with 5 × 10^{22} atoms per m^3 of Arsenic and 5 × 10^{20} per m^3 atoms of Indium. Calculate the number of electrons and holes. Given that *ni* = 1.5 × 10^{16} per m^3. Is the material *n*-type or *p*-type?**	2
13	**The energy gaps in the energy band diagrams of a conductor, semiconductor and insulator are *E*1, *E*2 and *E*3. Arrange them in increasing order.**	2
14	i) In the following diagrams, is the junction diode forward biased or reverse biased?   ii)	3
15	Draw the circuit diagram of a full wave rectifier and state how it works? If frequency of AC input is 50HZ then what will be the frequency of output DC ?	
16	Draw the labelled diagram of a full wave rectifier circuit. State its working principle. Show the Input-output waveforms. What will be the output if a capacitor is connected in the output circuit instead of load resistance?	
17	There are two semiconductor materials A and B which are made by doping germanium crystal with indium and arsenic respectively. As shown in the figure, the junction of two is biased with a battery. Will the junction be forward bias and reverse bias? 	2
18	Find the current through each branch 	3
19	Draw the output wave form across the resistor  	2