CHAPTER **(9)**

Modern physics

Modern physics:

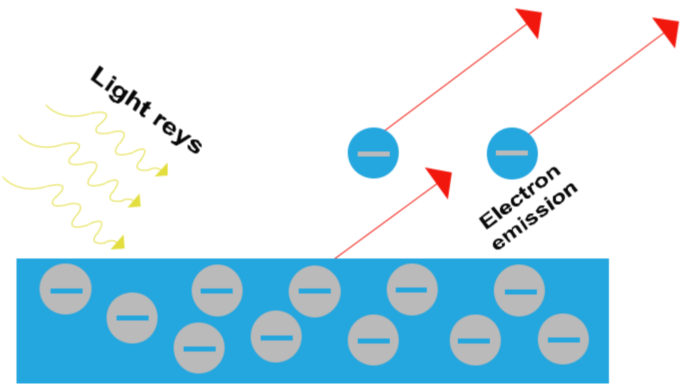
- Planck's hypotheses:
- All electromagnetic radiation is quantized and occurs in finite "bundles" of energy which we call photons. The quantum of energy for a photon is not Planck's constant h itself, but the product of h and the frequency.
- Atoms emit radiation when its vibrational energy changed and this emitted energy equals the change in the vibrational energy of the atom.
- The vibrational energy or the emitted energy from atom is given as:

E = nhf

Where E is the energy of excited atom [J], n is positive integer, h is Planck's constant [J.s], and f is the frequen-cy of radiation [Hz].

The photoelectric effect:

- Phenomenon in which electrically charged particles are released from or within a material when it absorbs electromagnetic radiation. The effect is often defined as the ejection of electrons from a metal plate when light falls on it.
- The device that is used to study it: photoelectric cell.



9.1 The vibrational energy or the emitted energy from atom is given as …

A nhf B nhλ
C nhc D nhv

9.2 If a vibrational energy of an atom changed from 5hf to 3hf, so the atom will…

A Spread energy 8hf B Absorb energy 8hf
C Spread energy 2hf D Absorb energy 2hf

9.3 If a vibrational energy of an atom changed because of a 1012 Hz frequency photon absorption, the atom energy will…
(h = 6.626x10-34J/Hz)

A Increases by 6.626×10^{-34} J B Decreases by 6.626×10^{-34} J
C Increases by 6.626×10^{-22} J D Decreases by 6.626×10^{-22} J

9.4 The quantum energy means that it takes ……… values

A Individual B Marital
C Fractional D Correct

9.5 The least value of an energy for a vibrating atom is …

A hf B 2hf
C 1/2 hf D 1/4 hf

9.6 If the vibrational energy is a quantum, which value is incorrect?

A hf B 0.5hf
C 2 hf D 3 hf

9.7 Which one of these represents a vibrating atom energy?

A 4/2 hf B 5/3 hf
C 3/2 hf D 4/3 hf

9.8 The ejection of electrons from an object when an electromagnetic light falls on it is …

A De Broglie waves B x-rays
C Photoelectric effect D Maxwell theory

Threshold frequency:

- Is defined as the minimum frequency of incident light which can cause photo electric emission i.e. this frequency is just able to eject electrons without giving them additional energy.
- The radiation that has frequency less than threshold frequency, it can't eject electrons from the metal even it has greater intensity.
- If the frequency of radiation is greater than threshold frequency or equal to it, then it can eject elections from the surface of metal and the flow of electrons increases with increasing intensity of radiation.
- Application: when the ultraviolet radiation is hitting the surface of negative zinc plate, it loses its charge be-cause the frequency of UV is greater than the thresh-old frequency of zinc.
- The work function for the metal is: energy (or work) required to withdraw an electron completely from a metal surface. The work function is important in appli-cations involving electron emission from metals.

  W = h/fo

  Where W is the work function [J], h is Planck's con-stant [J.s], and fo is the threshold frequency [Hz].

Photons and energy quantized:

- Einstein proposed photons to be quanta of elec-tromagnetic radiation having energy E=hv is the frequency of the radiation. As Einstein explained, all characteristics of the photoelectric effect are due to the interaction of individual photons with ndividual electrons.
- Photon: is a particle representing a quantum of light or other electromagnetic radiation. A photon carries energy proportional to the radiation frequency but has zero rest mass.
- Photon energy is the energy carried by a single photon. The amount of energy is directly proportional to the photon's electromagnetic frequency and thus, equivalently, is inversely proportional to the wave-length. The higher the photon's frequency, the higher its energy.

$$E = hf$$

$$E = h\frac{c}{\lambda}$$

E is the photon energy [J], Planck's constant [J.s], f is the photon's frequency [Hz], c is the speed of light [m/s], λ is the wavelength [m].

9.9 The smallest frequency for the incident rays that can be released the electrons from surface of element is …

A Frequency of ray B Photon's frequency
C Light's frequency D Threshold frequency

9.10 When an UV rays incident on Zinc plate, the electrons releases. In other hand it doesn't re-lease if white light incident on the same plate, because of …

A The frequency of UV > threshold frequency of Zinc
B Frequency of white light < frequency of UV
C Frequency of white light > Threshold frequen-cy of Zinc
D Frequency of UV > Threshold frequency of Zinc

9.11 The threshold frequency for a metal is 4.4 x 1014 Hz, Determine the needed energy to re-lease the electrons from its surface.

A $h + 4.4 \times 10^{14}$ B $4.4 \times 10^{14} - h$
C $4.4 \times 10^{14}\ h$ D $4.4 \times 10^{14} / h$

Solution:
E = hf = 4.4x1014 h , The answer is C

9.12 The photon is discovered by ………..

A Honed B Einstein
C Heisenberg D Pauli

9.13 Einstein interpreted the photo electric effect as the light consists of energy bands called …..

A Electrons B Protons
C Neutrons D Photons

9.14 A massless particle and carries energy is ……..

A Electron B Photon
C Proton D Nucleus

9.15 The product of Plank's constant and photon's frequency is …..

A The wavelength of photon B Energy of photon
C Speed of photon D Mass of photon

9.16 The energy of photon is proportional:

A Directly with the wavelength
B Inversely with the wavelength
C Directly with the mass
D Inversely with mass

Einstein's equation for photoelectric effect:

$$K.E = E - W = h\ f\ (-f_o)$$

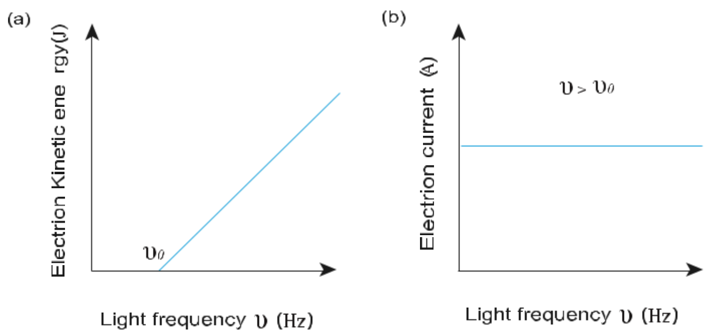
KE is the kinetic energy of the ejected electron [J], E is the energy of photon [J], W is the work function [J], h is Planck's constant [J.s], f is the photon's frequency [Hz], fo is the threshold frequency [Hz].

- The electron volt: (eV) is the energy of electron ac-celerates in 1V potential difference.

  1 eV = 1.6x10-19 J

Example:
The energy of incident photon on a surface of metal is 5.5 eV, and the work function for the metal is 4.5 eV, what is the energy of the ejected electron? K.E = E –W = 5.5 – 4.5 = 1 eV.

- The graph for KE of electron versus the frequency:



9.17 Determine the photon's energy in Joule if its frequency is 1 x 105 Hz. (h = 6.62 x 10-34 J/Hz)

A 1.5×10^{49}
B 6.62×10^{19}
C 6.62×10^{-19}
D 1.5×10^{-49}

9.18 The wave A has frequency 10^23 Hz, and wave B has wavelength 10^-12, compare between their energies

A A>B
B B>A
C B≥A
D A≥B

9.19 If the frequency of wave increase, then:

A Its energy decreases
B Its wavelength increases
C Its mass increases
D Its energy increases

9.20 Which of the following statements is true about the electromagnetic waves?

A When its frequency increases, the energy increases
B When its wavelength increases, the energy increases
C When its frequency increases, the wave-length increases
D When its wavelength increases, frequency decreases

9.21 Which of the following radiations has lowest energy?

A 6×10^{20} Hz
B 1.5×10^{9} Hz
C 7.5×10^{6} Hz
D 5×10^{13} Hz

9.22 The energy of electron accelerates in 1V poten-tial difference is …

A Electron volt
B Joule
C Watt
D Atomic mass unit

9.23 A photon's energy is 13.9 eV falls on a metal surface and the work function for the metal is 7 eV, what is the kinetic energy of the ejected electron, in the same unit?

A 97.3
B 20.9
C 6.9
D 3.45

9.24 A photon's frequency is 108×10^{14} Hz falls on surface with 8×10^{14} Hz threshold frequency, what is the energy of the ejected electron, ($h = 6.63 \times 10^{-34}$ J.s)?

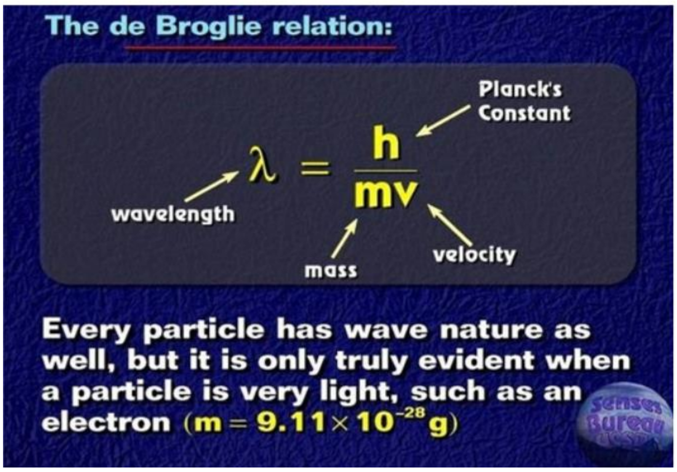
A 6.63×10^{-34} J
B 6.63×10^{-18} J
C 116×10^{14} J
D 100×10^{14} J

Compton Effect and uncertainty principle:

- Compton Effect:
  The Compton Effect (also called Compton scattering) is the result of a high-energy photon colliding with a target, which releases loosely bound electrons from the outer shell of the atom or molecule. The effect is important because it demonstrates that light cannot be explained purely as a wave phenomenon.
- Heisenberg uncertainty principle states that for particles exhibiting both particle and wave nature, it will not be possible to accurately determine both the position and velocity at the same time.

De Broglie waves:

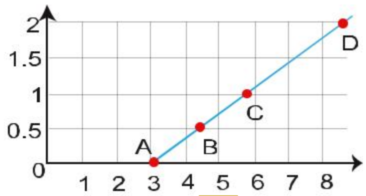
- De Broglie wavelength : is $\lambda = h/mv$, where λ is wavelength, h is Planck's constant, m is the mass of a particle, moving at a velocity v. de Broglie suggested that particles can exhibit properties of



The Nuclear model:

- Rutherford experiment: Most important, he postulated the nuclear structure of the atom: experiments done in Rutherford's laboratory showed that when alpha particles are fired into gas atoms, a few are violently deflected, which implies a dense, positively charged central region containing most of the atomic mass.
- Rutherford observations:
- Rutherford's experiment showed the existence of a nuclear atom - a small, positively-charged nucle-us surrounded by empty space and then a layer of electrons to form the outside of the atom. Most of the alpha particles did pass straight through the foil. The atom being mostly empty space.
- Rutherford model:
  The whole mass of the atom is concentrated in the center of atom called nucleus. The positively charged particles are present in the nucleus of atom. The charge on the nucleus of an atom is equal to (+z.e) where Z= charge number, e = charge of proton.
- Rutherford's atomic model became known as the nuclear model. In the nuclear atom, the protons and neutrons, which comprise nearly all of the mass of the atom, are located in the nucleus at the center of the atom. The electrons are distributed around the nucle-us and occupy most of the volume of the atom.

9.25 This chart shows the relation between the maximum kinetic energy and the frequency for a metal, the threshold frequency is determined by the point …



A A
B B
C C
D D

9.26 The result of a high-energy photon colliding with a target, which releases loosely bound electrons is ..

A De Broglie waves
B Compton Effect
C Photoelectric
D Heisenberg's principle

9.27 "It will not be possible to accurately determine both the position and velocity of a particle at the same time" this is the principle of …

A Heisenberg
B De Broglie
C Einstein
D Compton

9.28 The wavelength of a moving object is …

A Radiation wavelength
B Standing wavelength
C Stationary wavelength
D De Broglie wavelength

9.29 The λ in De Broglie relation represents the …

A wavelength
B frequency
C Amplitude
D Wave power

9.30 The scientist who discovers the atom is …

A Boor
B Rutherford
C Thompson
D Rontgen

9.31 What is the significance of a few Alpha particles bouncing back when Rutherford beams towards a thin sheet of gold ?

A The atom has a positive charge
B Most of the atom is empty
C There is a dense mass in the center of atom
D There are some negative electrons

9.32 Which one of these is not of the properties of atom?

A No empty space in it
B It's mass is concentrated in the nuclear
C Atom is electrically neutral
D Different elements consists of different atoms

Bohr's theory:

The electromagnetic theory is not applied inside the atoms.

- Stable atom: the state that energy of atom at the minimum amount allowed.
- Exited atom: when the atom absorbs specific amount of energy which allowed atom to transfer at higher level of energy.
- When the exited atom transfer at higher level of ener-gy then it emits photon.
- Transfer of electrons between two levels:
- $\Delta E = E_f - E_i$

Where ΔE is the change in atom's energy [eV], Ef is the energy of final level [eV], Ei is the energy of initial level [eV].
Example:
Determine the absorbed energy when the electron of Hydrogen atom transfers from the first level (-13.6 eV) to the second energy level (-3.4 eV). Solution:

$\Delta E = E_f - E_i = -3.4 - (-13.6) = +10.2$ eV.

Notes:

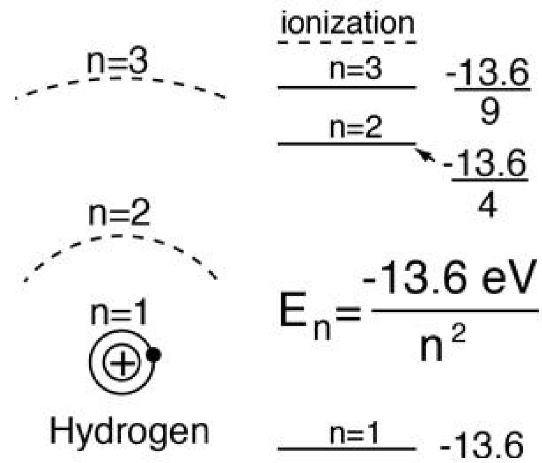
- When the electron transfer from the exited level to the first energy level, the atom emits high frequency photon (short wavelength).
- When the electron transfers from the exited level to the third level, the atom emits photon with low frequency (long wavelength).

Bohr's model predictions:

- Determine the radius of electron's level in hydrogen atom:
$r_n = 5.3 \times 10^{-11} n^2$

Where rn is the radius of electron's level [m], n is the quantum number (Number of level).

- Determine the energy of the Hydrogen atom:



Where En is the atom's energy [eV], n is the quantum number. (Number of electron's level).

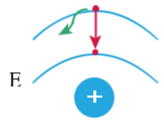
9.33 His theory states that "The electromagnetic lows don't apply inside the atom"

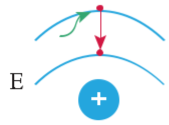
A Thompson
B Rutherford
C Geiger
D Bohr

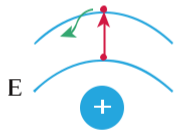
9.34 The state that energy of atom is at the minimum amount allowed, is called ….

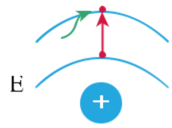
A Exited
B Stable
C Change
D Emission

9.35 The state that describes the transfer of e from high energy level to low energy level is:

A 

B 

C 

D 

9.36 In the chart, when comparing the change in photon's energy in the hydrogen atom, then …

A $\Delta E_3 > \Delta E1$ B $\Delta E_2 < \Delta E_1$

C $\Delta E_3 < \Delta E_1$ D $\Delta E_3 = \Delta E_2 = \Delta E_1$

9.37 The change which is responsible of photon emission at the highest frequency is…

A From E_3 to E_1 B From E_4 to E_3

C From E_3 to E_2 D From E_2 to E_5

9.38 Which energy transfer gives the highest wave-length photon?

A From E_4 to E_3 B From E_3 to E_1

C From E_3 to E_2 D From E_5 to E_2

9.39 How much is the radius of the second Bohr's orbit in a hydrogen atom?

A 5.3×10^{-11} m B 10.6×10^{-11} m

C 15.9×10^{-11} m D 21.2×10^{-11} m

9.40 The energy of the second energy level of hy-drogen atom equals…

A 54.4 eV B -54.4 eV

C 3.4 eV D -3.4 eV

Solution:

En = -13.6/n2 = -13.6/4 =-3.4 eV , Answer is D

Emission spectrum:

- An emission spectrum is the range or array of wave-lengths (spectra) obtained when the light emitted by a substance is passed through a prism and examined directly with a spectroscope.
- Example about emission spectrum: the spectrum emitted from hot excited gases under the influence of high voltage.
- Each gas is glowing with specific emission spectrum.
- The emission spectrum emitted from atom when the electrons transfer to low energy levels.

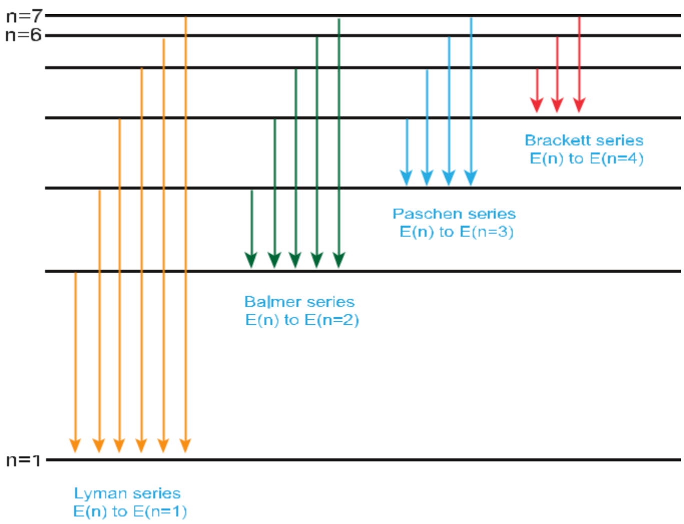
Absorption spectrum:

- An absorption spectrum is defined as the spectrum obtained when electromagnetic radiations are passed through a substance; a part of the radiation is ab-sorbed by the material, and the rest is transmitted. When an atom gives an absorption spectrum, it is because it has gained a higher energy level.
- Fraunhofer lines are a band of special absorption lines. They are named after Joseph von Fraunhofer, a German Physicist. These sets of lines were origi-nally observed in the optical spectrum of the sun.

Spectroscopy:

- Spectroscopy is used as a tool for studying the struc-tures of atoms and molecules. The large number of wavelengths emitted by these systems makes it pos-sible to investigate their structures in detail, including the electron configurations of ground and various excited states.

Electron transition for thr Hydrogen atom



- Lyman series: takes place when the electron transfers from an excited energy level to the first energy level. The radiation produced is UV radiation.
- Balmer series: takes place when the electron transfer from the excited level to the second energy level. The radiation produced is the visible light.
- Paschen series: takes place when the electron transfers from the excited energy level to the third energy level. The radiation produced is infrared radiation.

9.41 The Neon gas in the tube emits atomic spectrum when ……….. Increases.

A Pressure of gas
B Potential difference
C Amount of gas
D The volume of the tube

9.42 The property that is used to identify the type of gas is:

A Atomic spectrum
B Quantum energy
C Magnetic spectrum
D Energy of photon

9.43 The emitted spectrum of Hydrogen atom will take place because of ……

A The electron has uniform energy in the orbit
B Transfer of electron to low energy level orbits
C Transfer of electron to high energy level orbits
D The electron has uniform speed in the orbit.

9.44 Which of the following statements is true?

A The low temperature gases emit the same wavelengths which can be emitted as they excited.
B The low temperature gases ionized the wavelengths when they excited
C The low temperature gases excited the wavelengths that emitted by them
D The low temperature gases absorb the wavelengths which emitted by them as they excited

9.45 The only instrument that is available to study the composition of stars in the space is …..

A Space ships
B Spectroscopy
C Telescope
D Ejected protons

9.46 The UV rays emit from Hydrogen atom when the electrons transfer from high energy level to …….

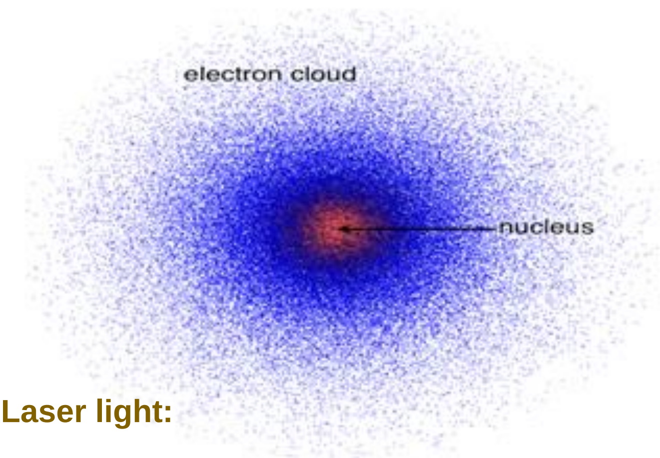
A First energy level
B Second energy level
C Third energy level
D Fourth energy level

9.47 Transfer of electron from the fourth energy level to the second energy level emits ……… Series.

A Paschen
B Lyman
C Balmer
D Absorption

The quantum model of an atom:

- The quantum mechanical model is based on quantum theory, which says matter also has properties associated with waves. ... The quantum mechanical model of the atom uses complex shapes of orbitals (sometimes called electron clouds), volumes of space in which there is likely to be an electron.



Laser light:

- Lasers emit light that is highly directional. Laser light is emitted as a relatively narrow beam in a specific direction. Ordinary light, such as coming from the sun, a light bulb, or a candle, is emitted in many directions away from the source.

- Properties of laser light are: monochromacity (the same color), coherence (all of the light waves are in phase both spatially and temporally), collimation (all rays are parallel to each other and do not diverge significantly even over long distances).
- Applications: Laser light is used in optical fiber communications to send information over large distances with low loss. Laser light is used in underwater communication networks. Lasers are used in space communication, radars and satellites.

9.48 The colored spectrum lines in visible Hydrogen spectrum is known by .... series.

A Compton B Ballmer
C Lyman D Paschen

9.49 When the electron transfer from level 4 to level 3, the spectrum that is produced is ….

A Infrared B Light
C Ultra violet D Radio

9.50 A 3D simulation for the high probability area where the electrons can be found is ……..

A Electron's cloud B Nucleus
C Flux of electrons D Level

9.51 Study the property of matter using its wave property is …….

A Particle model B Wave model
C Quantum mechanics D Atomic mechanics

9.52 Emitting light with highly directional is

A X rays B Laser
C Analyzing light D Collecting light

9.53 Laser generates when the emitted photons have…….

A The same phase and frequency
B The same phase but different frequency
C Different in phase and frequency
D Different in phase but the same frequency

9.54 Laser is light that …….

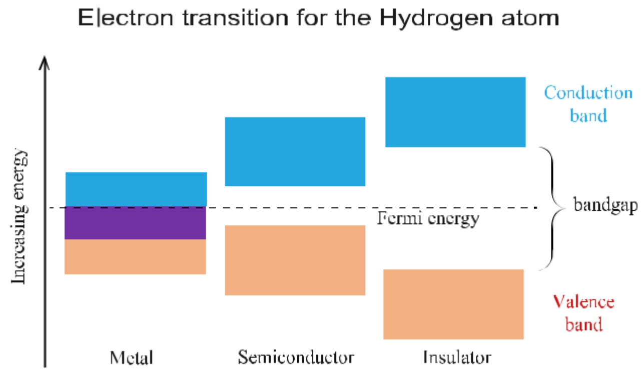
A Monochromatic, Coherent, directed, and has high energy
B Monochromatic, incoherent, undirected, and has high energy
C Monochromatic, coherent, directed, and has low energy
D Monochromatic, coherent, undirected, and has high energy

9.55 Used for Tunnels and pipes straightness test :

A Gamma rays B UV
C Laser D X rays

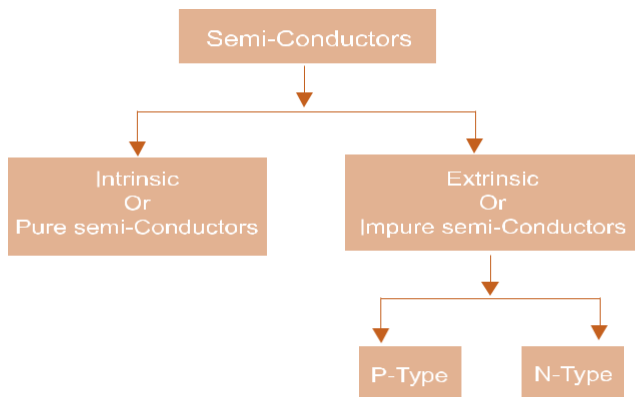
Band theory of solids:

- Band theory, in solid-state physics, theoretical model describing the states of electrons, in solid materials, that can have values of energy only within certain specific ranges. The band of energies permitted in a solid is related to the discrete allowed energies (the energy levels) of single, isolated atoms.
- The valence band: The valence band is the band of electron orbitals that electrons can jump out of, moving into the conduction band when excited. The valence band is simply the outermost electron orbit-al of an atom of any specific material that electrons actually occupy.
- The conduction band: The conduction band is the band of electron orbitals that electrons can jump up into from the valence band when excited. When the electrons are in these orbitals, they have enough energy to move freely in the material. This movement of electrons creates an electric current.
- Energy gaps: is an energy range in a solid where no electron states exist.
- The conductivity of materials increases when the energy gap decreases.
- The energy band in semiconductor equals 1 eV approximately.



Semiconductors:

- Pure semiconductors: (Intrinsic)
  An intrinsic (pure) semiconductor, also called an undoped semiconductor or i-type semiconductor, is a pure semiconductor without any significant dopant species present. The number of charge carriers is therefore determined by the properties of the material itself instead of the amount of impurities.
- Treated semiconductors: (Extrinsic)
  Extrinsic semiconductors are semiconductors that are doped with specific impurities. While adding impurities, a small amount of suitable impurity is added to pure material, increasing its conductivity by many times. Extrinsic semiconductors are also called impurity semiconductors or doped semiconductors.



- The particles that conduct electricity and heat in semi-conductors are:
  1. Electrons: conduct electricity and heat in n-type semiconductor. (-)
  2. 2Holes: conduct electricity and heat in p-type semi-conductors. (+)

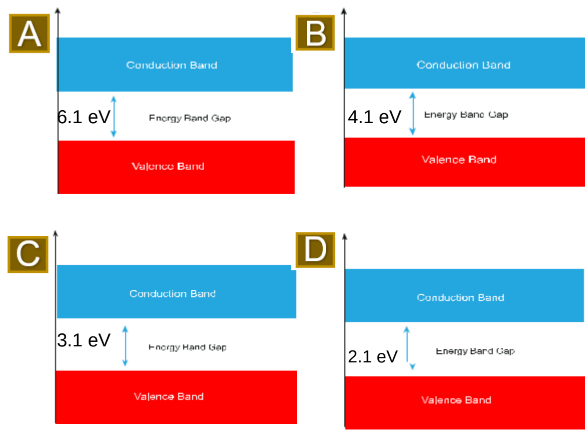
9.56 The importance of band theory of solids is understanding….

A Electrical voltage
B Electrical conduction
C Electric field
D Electrical power.

9.57 The band gap energy for Germanium 0.7 eV and for Silicon 1.1 eV, which of the following is true?

A Si is more conductivity
B Ge is more conductivity
C Si is conductor and Ge is insulator
D Si is insulator and Ge is conductor

9.58 Which of the following diagrams represents the material with more conductivity?



9.59 Material A has band gap energy 2 eV, and Mate-rial B has no band gap energy..

A A insulator and B conductor
B A is conductor and B is semiconductor
C A is conductor and B is conductor
D A is semiconductor and B is semiconductor

9.60 Material A has band gap energy 2 eV, and Mate-rial B has no band gap energy..

Crystal	A	B	C
Band gap energy	0	1 eV	5 eV

A Conductor, Semiconductor, insulator
B Insulator, Semiconductor, Conductor
C Semiconductor, insulator, Conductor
D Insulator, Conductor, semiconductor

9.61 In semiconductors, the positive type charges carriers are

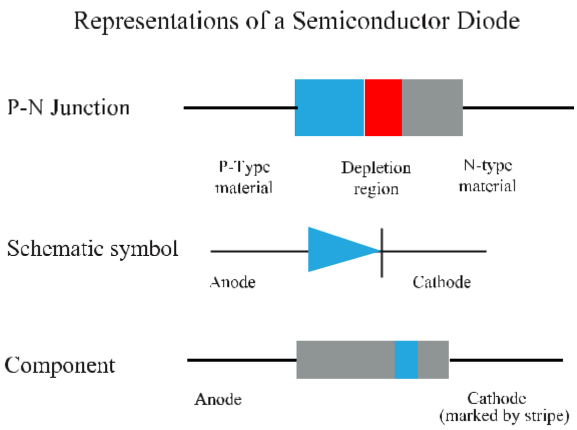
A Electrons
B Negative ions
C Positive ions
D Holes

9.62 A semiconductor composed of P – type connected to n-Type, this composition is

A Capacitor
B Transistor
C Diode
D Microchip

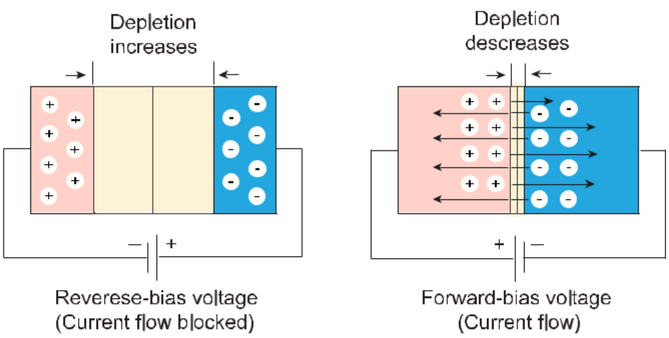
Diode:

- A diode is a semiconductor device that essentially acts as a one-way switch for current. It allows current to flow easily in one direction, but severely restricts current from flowing in the opposite direction. Diodes are rated according to their type, voltage, and current capacity.



Diode in the electric circuit and its voltage:

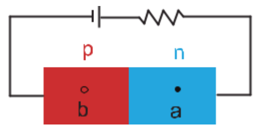
- Forward conducting diode: conduct current
- Reverse conducting diode: current blocked



- Determine the voltage drop in diode: Vb = IR + Vd

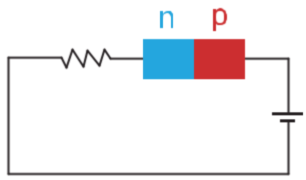
Where Vb si the battery voltage (source) (V), I is the current (A), R is the resistance (Ω), and Vd is the voltage of diode (V).

9.63 In the following diode, what is the direction of a and b?



A Right, left
B Left, right
C Both to the right
D Both to the left

9.64 In the shown figure, the connection of diode is



A Forward
B Reverse
C Positive
D Negative

9.65 Determine the voltage of battery that required to generate current 0.003 A in diode connected with 500 Ω, if the drop in voltage for diode is 0.5 V?

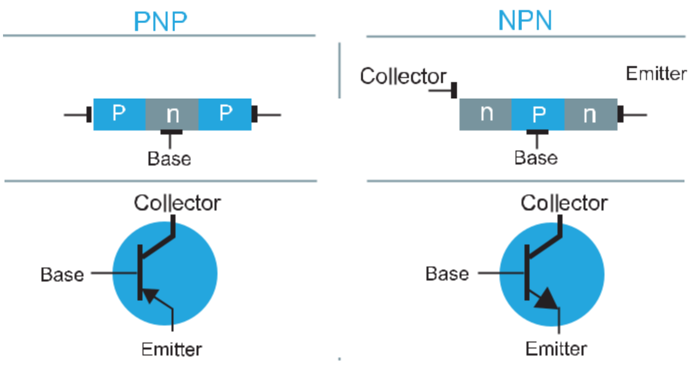
A 1 V
B 1.5 V
C 2 V
D 3 V

Solution:

Vb = IR + Vd = 0.003 x 500 + 0.5 = 1.5 + 0.5 = 2 V, Answer is C

Transistors and integrated circuits:

- **Transistor**: is a three terminal semiconductor device used to regulate current, or to amplify an input signal into a greater output signal. Transistors are also used to switch electronic signals. The circulation of electrical current through all types of transistors is adjusted by electron addition.
- Parts: the emitter (E), the collector (C), and the base (B).
- Types of transistors:

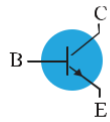


- **Microchips**: a tiny wafer of semiconducting material used to make an integrated circuit. It contains thousands of transistors, diodes and resistors, in addition to conductors.

9.66 A piece made of semiconductor material, consists of 2 layers of same type semiconductor material in the two edges of the piece and different semiconductor in the middle, this is ....

A Transistor
B Diode
C Emitter
D Microchip

9.67 The following diagram represents a transistor of type ....



A npp
B ppn
C pnp
D npn

9.66 Integrated circuits consist of thousands of transistors and diodes, in addition to resistors and conductor materials are ......

A Binary gauges
B Triple gauges
C Microchips
D Transistor circuits

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	C	C	D	A	B	A	C	D	D	C	B	D	B	B	B	C	A	D	D
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
C	A	C	B	A	B	A	D	A	B	C	A	D	B	A	A	A	A	D	D
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
B	A	B	D	B	A	C	B	A	A	C	B	A	A	C	B	B	D	A	A
61	62	63	64	65	66	67	68												
D	C	A	A	C	A	D	C												