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BOOK # 02

"PHYSICS IS THE SCIENCE OF ALL THE TREMENDOUSLY POWERFUL INVISIBILITIES – OF MAGNETISM, ELECTRICITY, GRAVITY, LIGHT AND SOUND. PHYSICS IS THE SCIENCE OF THE MYSTERIES OF THE UNIVERSE. HOW COULD ANYONE THINK IT DULL?"

CHAPTER # 11: HEAT & THERMODYNAMICS

Introduction

- Heat is a form of energy that is in transit. (SI unit is 'Joules' & CGS unit is 'calories')
- Temperature is a measure of degree of hotness or coldness of a body.
- Change of temperature affects the physical state of matter.
- **Effects of Temperature**
  - Change of color
  - Change of state
  - Change of resistance
- **Major Types of Thermometer**
  - Mercury glass thermometer
  - Bimetallic thermometer
- Any substance that changes uniformly with temperature can be used as thermometric substance in thermometer.
- Mercury is preferred as thermometric substance because
  - It is non-wetting
  - Its expansion is quite linear.
  - Boiling point is high

DO YOU KNOW?

Celsius degree is larger than a Fahrenheit degree by a factor of 9/5

Conversion formula of temperature scales

- $T_C = \frac{5}{9}(T_F - 32)$
- $T_F = 9/5\, T_C + 32$
- $T_K = 273 + T_C$
- $T_K = 273 + 5/9\,(T_C - 32)$
- $T_C = T_K - 273$
- $T_F = 9/5\,(T_K - 273) + 32$

DO YOU KNOW?

The Centigrade and Fahrenheit scale shows the same reading at a temperature of -40°C.

Important Temperature Conversion

DESCRIPTION	K	°C	°F
Boiling Point of water	373	100	212
Freezing point of water	273	0	32
Normal body temperature	310	37	98.6
Absolute zero	0	-273	-459.6

- Absolute zero is a temperature at which if gases remain in gaseous form, exert zero pressure and have zero volume.
- Heat flows from one body to another due to temperature difference.
- Temperature determines the direction of natural flow of heat.
- Internal energy or thermal energy is the sum of KE and PE of all molecules of a body.
- When excess of thermal energy flows from one body to another, as heat, then it is converted into internal energy.

Kinetic Molecular Theory of Gases (K.M.T.)

Main points of K.M.T. of gases are given as:

- Small volume contains large number of molecules.
- Molecules move randomly and do not exert force on one another except when they collide.
- Molecules collide with each other elastically.
- The collisions with walls give rise to gas pressure.
- Gravity does not affect the molecular motion.
- Volume of gas molecules this negligible this compared to the actual volume of the gas.

THERMAL EXPANSION

Bodies undergo change in size when they are heated. This change in size on heating is termed Thermal Expansion.

LINEAR EXPANSION: Expansion of length of solids on heating is called linear expansion.

Change in length $\Delta L = \alpha L_o \Delta T$

Where α = coefficient of ΔL, L_o = initial length ΔL = change in length

Final length: $L' = Lo\,(1 + \alpha\,\Delta T)$

Where $\propto$ is a constant of proportionally which depends upon the material of rod and is called the co-efficient of linear expansion.

$$\propto = \frac{\Delta L}{L\Delta T}$$

$\propto$ is defined as the change in length per unit length per Kelvin rise in temperature. Its unit is K^{-1}

VOLUME EXPANSION: The solids expand on heating in all the three dimensions i.e. length, breadth and thickness.

$$\Delta V \propto V\Delta T$$

$$\Delta V = \beta\, V\, \Delta T$$

Where β is co-efficient of volume expansion. It is defined as Fractional Change in Volume per unit change in temperature. Its unit is also K^{-1}. (Note that $\beta = 3 \propto$)

BIMETALLIC THERMOSTAT: Thermostats are well known devices commonly used for maintaining required temperatures. A common type of thermostat called Bimetallic Thermostat.

The Bimetallic strip works as an electric contact breaker in an electrical heating circuit.

THERMAL CONDUCTIVITY: Thermal conductivity of a substance is a measure of its ability to conduct heat energy. The amount of heat (ΔQ) flows through on object is

$$\Delta Q = \frac{K\,A\,T\,\Delta t}{\Delta L}$$

Where

- K = thermal conductivity
- A= Areas of cross- section
- Δt = change in temperature
- T = Time interval

- ΔL = Change in length

In S I unit it Is measured in J/sec. m ^{0}C. It is large for metals & small for non-metallic solids, liquids & gases.

GAS LAWS

BOYLE'S LAW:

For a given mass of a gas, at constant temperature, the volume is inversely proportional to the pressure. Graph between (P) & (V) is Hyperbolic curve while graph between (P) & (1/V) is a straight line.

$$PV = \text{constant}$$

CHARLES'S LAW:

For a given mass of a gas, at constant pressure, the volume is directly proportional to the temperature. Graph between (V) and (T) is a straight line.

$$V/T = \text{constant}$$

GENERAL GAS LAW

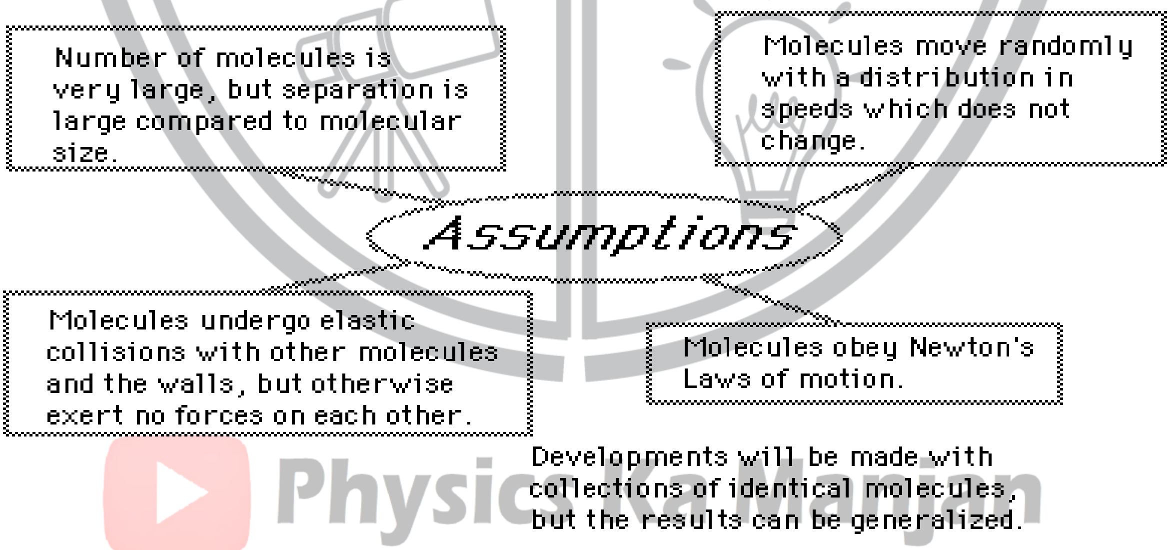
General gas law is the combination of Boyle's, Charles's & Avogadro's law i.e. the two equations

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$PV = nRT$$

Pressure and Temperature of an Ideal Gas

The Kinetic theory of the gases is the study of the microscopic behavior of molecules and the interactions which lead to microscopic relationships like the ideal gas law.



$P = \frac{1}{3} P \overline{V}^2$ = 1/3*(RHO)*(MEAN SQUARE VELOCITY)

$P = \frac{1}{3} N_V M \overline{V}^2$ (SINCE $P = M N_V$)

BOLTZMANN CONSTANT (K):

Boltzmann Constant = Universal Gas Constant / Avogadro Number

$K = R/N_A = 1.38 \times 10^{-23}$ J / (MOLECULES – K).

Equation of State: P V = N K T

RELATION B/W AVERAGE TRANSLATIONAL K.E. (ATKE) & ABSOLUTE TEMPERATURE: -

$\frac{1}{2}m\overline{V}^2 = \frac{3}{2}KT$

ATKE $\propto$ T

AVERAGE TRANSLATIONAL KINETIC ENERGY PER MOLECULE:

$ATKE_{(MOLECULE)} = \frac{3}{2}KT$

AVERAGE TRANSLATIONAL KINETIC ENERGY PER MOLE:

$ATKE_{(MOLE)} = \frac{3}{2}RT$

Specific Heats

- Amount of heat required to raise the temperature of a substance through 1 K is called heat capacity. It is measured in J/Kg.

$$Q = C_{HC}\,\Delta T$$

- Specific heat capacity is the amount of heat required to raise the temperature of unit mass (1 Kg in SI or MKS System / 1 gram in CGS System) through unit temperature. It is measured in J/Kg-K.

$$Q = m\,C_{SP}\,\Delta T$$

- Molar Specific Heat Capacity is the amount of heat required to raise the temperature of one mole of a substance through unit temperature. It is measured in J/Mole-K.

$$Q = m\,C_{MHC}\,\Delta T$$

- There are two kind of molar specific heat of a gas.
  - Molar specific heat at constant volume.
  - Molar specific heat at constant pressure

- Avogadro's law states

  "Equal volumes of gases at same temperature and pressure contain equal number of molecules."

- Law of Heat of Exchange:

  "If no heat is lost to surroundings or gained from it, then Heat Loss = Heat Gained."

LATENT HEAT: Quantity of heat required to change the state of a substance (having unit mass) at constant temperature (Q = mH) where H is Latent Heat measured in J/Kg.

LATENT HEAT OF FUSION: It is the quantity of heat required to transform one kg of ice completely into water at 0^0C.

$$H_f = \frac{\Delta Q}{m}$$

LATENT HEAT OF VAPORIZATION: It is the quantity of heat required to transform one kg of water completely into steam at 100^0C.

$$H_v = \frac{\Delta Q}{m}$$

Calorie: Unit of heat energy. it is defined as, the amount of heat required to raise the temperature of one gram of water from 14.5 ^{0}C to 15.5 ^{0}C

$$1 \text{ Calorie} = 4.2 \text{ joule}$$

Effect of Pressure On Melting Point: Increase of pressure lowers the freezing point of water.

Effect of Pressure On Boiling Point: Decrease in pressure lowers the boiling point of liquid.

Introduction to Thermodynamics

Thermodynamics is the study of relationship between heat and other forms of energy.

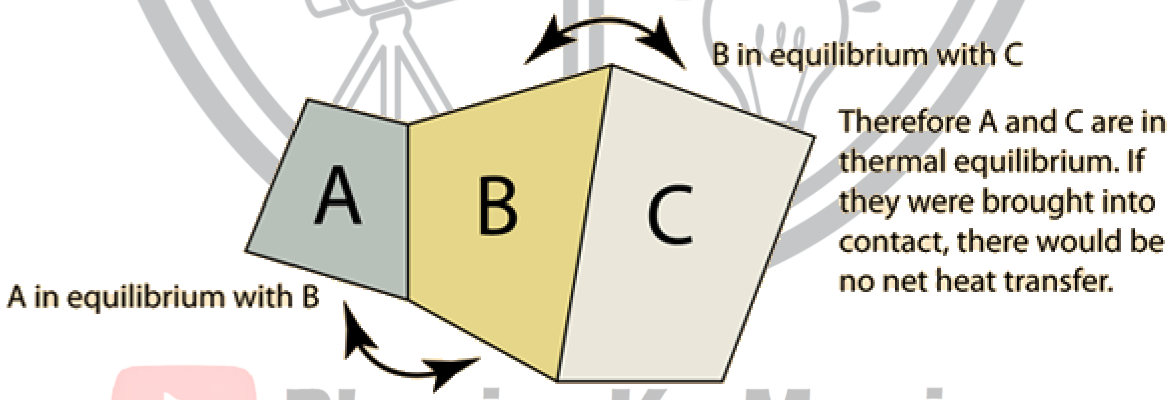
- Thermodynamics states derives the states of a system.
- Any collection of matter having distinct boundaries is called a system.
- Sum of translational KE, rotational KE, vibrational KE and PE is called internal energy.
- Internal energy of an ideal gas system is generally the translational KE of its molecules.
- Increase in temperature of the object is an indication of increase in the internal energy.
- Internal energy is similar to the gravitation PE.
- Work done on a system in which gas is enclosed as written as $W = P\Delta V$.

LAWS OF THERMODYNAMICS

Thermal Equilibrium:
It is observed that a higher temperature object which is in contact with a lower temperature object will transfer heat to the lower temperature object. The objects will approach the same temperature, and in the absence of loss to other objects, they will then maintain a constant temperature. They are then said to be in thermal equilibrium. Thermal equilibrium is the subject of the Zeroth Law of Thermodynamics.

ZEROTH LAW OF THERMODYNAMICS

The "Zeroth Law" states that if two systems are at the same time in thermal equilibrium with a third system, they are in thermal equilibrium with each other.



If A and C are in thermal equilibrium with B, then A is in thermal equilibrium with B. Practically this means that all three are at same temperature, and it forms the basis for comparison of temperatures. It is so named because it logically precedes the First and Second laws of Thermodynamics.

FIRST LAW OF THERMODYNAMICS (Law of conservation of energy)

When heat is transformed into other forms of energy total heat energy remains constant.

$$\Delta Q = \Delta U + W$$

SIGN CONVENTION:

Amount of Heat:

- If heat is supplied to the system (absorbed), ΔQ is taken Positive.
- If heat is given by the system (released), ΔQ is taken Negative.

Work done:

- If work is done by the system, then +ve Work done is considered (Expansion or Change in volume is +ve)
- If work is done on the system, then -ve Work done is considered (Compression or Change in volume is -ve)

Change in Internal energy:

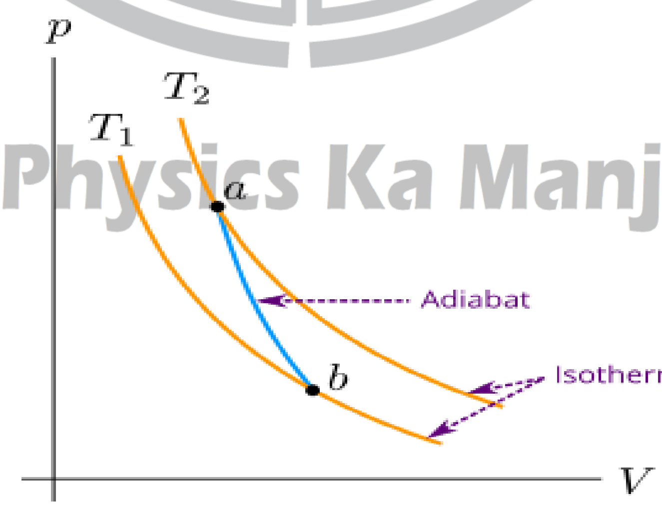
- If internal energy of the system increases, ΔU is taken Positive.
- If Internal energy of the system decreases, ΔU is taken Negative.

Inferences from 1st Law of Thermodynamics

- Change in internal energy = Heat energy flowing in - Energy flowing out as mechanical work
$$\Delta U = \Delta Q - \Delta W$$
- Internal energy is a state function i.e. depends on initial and final states.
- For a cyclic system, we have
$$\Delta U = 0$$
$$U_i = U_f$$
$$\Delta Q = \Delta W$$

Applications of 1st Law of Thermodynamics

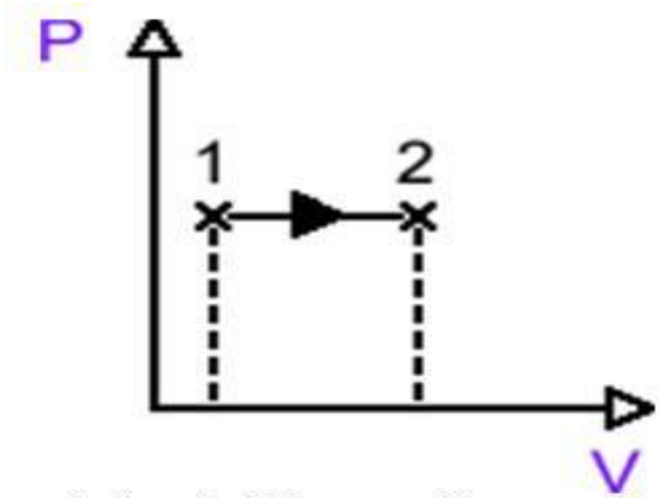
- **Isothermal Process**: is that in which temperature remain constant
$$\Delta Q = \Delta W \qquad \Delta U = 0$$
- **Isochoric Process**: is that in which volume remains constant.
$$\Delta Q = \Delta U \qquad \Delta W = 0$$
- **Isobaric Process**: is that in which pressure remains constant.
$$\Delta Q = \Delta U + P\Delta V$$
- **Adiabatic Process:** is that in which no heat enters or leaves the system. (Q=0)



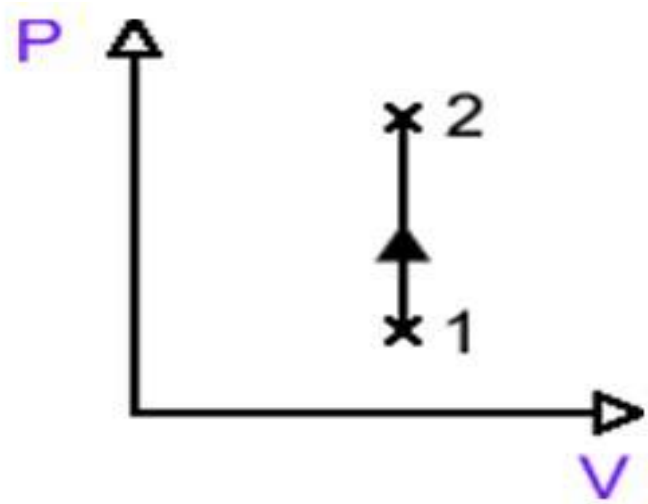
Note: Cooling is produced when adiabatic expansion takes place and heating is produced during that adiabatic compression.

Adiabatic process is also termed as iso-entropic process. i.e. a process in which the entropy of the system remains constant.

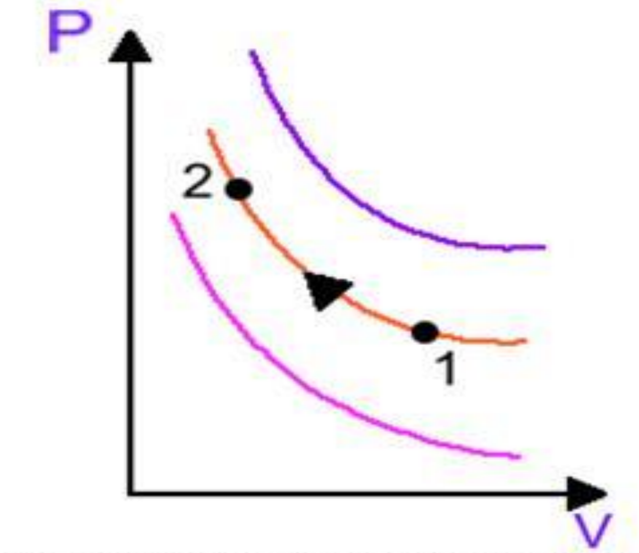
Graphical Representation



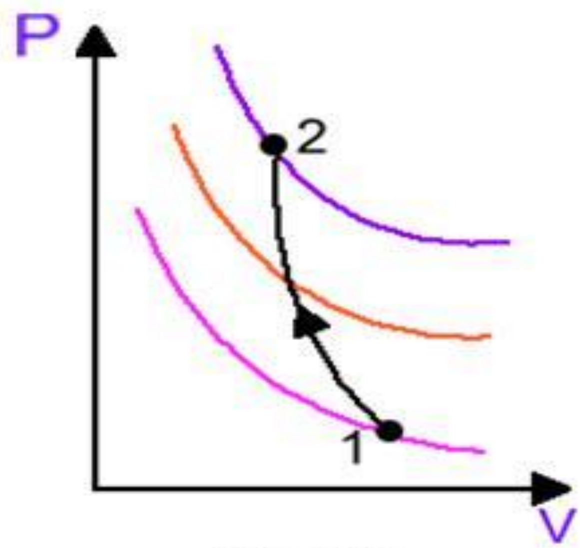
Isobaric (Constant Pressure)



Isochoric (constant volume)



Isothermal (constant temperature)



Adiabatic

Thermodynamic Processes

Process	Definition of Process	Equation of Process	1st law applied to it ($Q = \Delta U + W$)
Isothermal	Constant temperature	PV = Constant	$\Delta U = 0$, ($Q = W$)
Isobaric	Constant pressure	V/T = Constant	$W = P\Delta V$ ($Q = \Delta U + P\Delta V$)
Isochoric	Constant volume	P/T = Constant	$\Delta V = 0$ ($Q = \Delta U$)
Adiabatic	No Heat Supplied to the system	PV = Constant	$Q = 0$ ($+\Delta U = -W$) & ($-\Delta U = +W$)

Note: C_P is greater in value than C_V

- $Q_V = n C_V \Delta T$ (Heat supplied at constant volume)
- $Q_P = n C_P \Delta T$ (Heat supplied at constant pressure)
- $C_P - C_V = R$
- $C_P / C_V = \gamma$
- For monatomic gases: $C_P = \frac{5R}{2}$ and $C_V = \frac{3R}{2}$
- For diatomic gases: $C_P = \frac{7R}{2}$ and $C_V = \frac{5R}{2}$

SECOND LAW OF THERMODYNAMICS

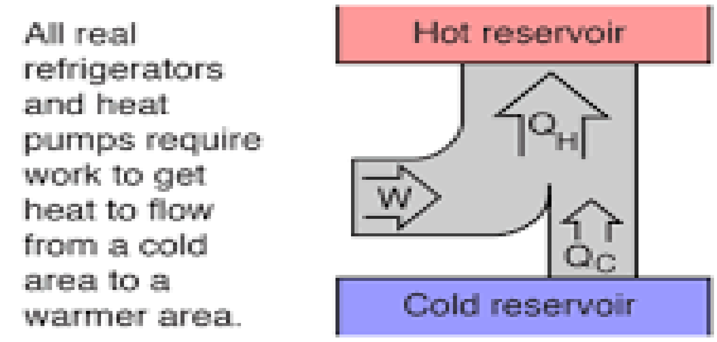
- **Kelvin Statement (Heat Engine Statement)**

  "It is impossible to construct a heat engine which converts all heat energy absorbed from source without having a sink."
- **Clausius's Statement (Refrigerator Statement)**

  "It is impossible to transfer heat from cold to hot region without expenditure of external energy."

Refrigerator

A refrigerator is a heat engine in which work is done in a refrigerant substance in order to collect energy from a cold region and exhaust it in a higher temperature region, thereby further cooling the cold region.



Heat Engine

Heat engine is a thermo-device, which converts heat energy into mechanical energy.

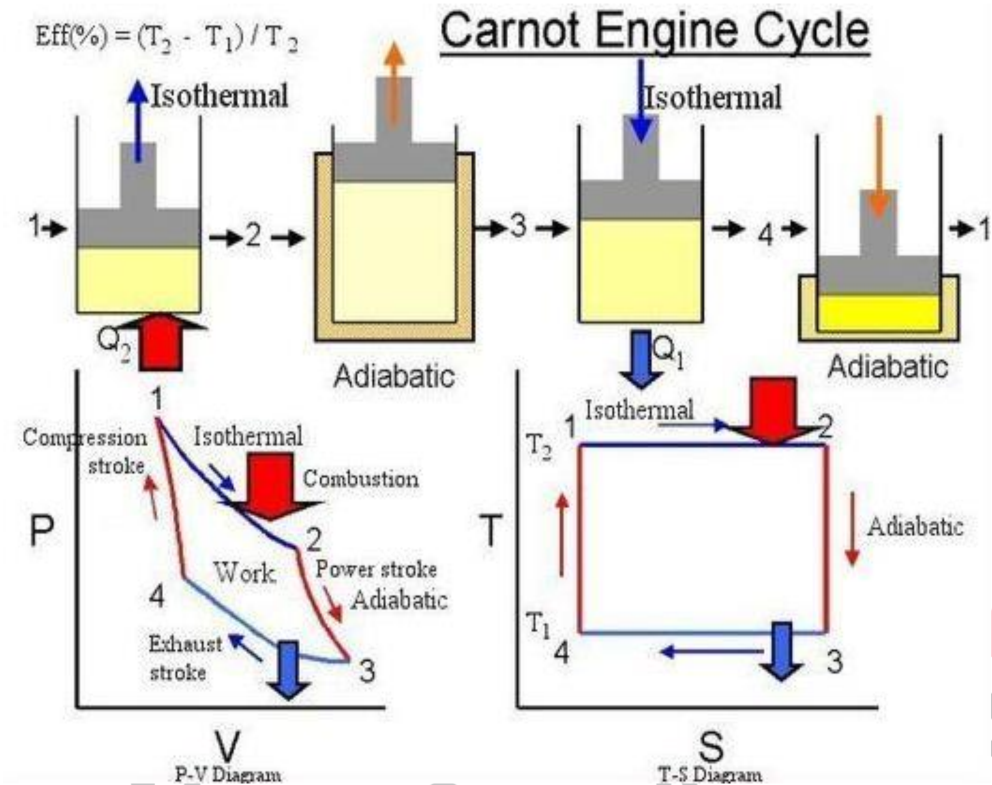
- There exists no perfect engine.
- Heat engine always operates in a cycle.
- Cycle means set of changes, which bring a system to its initial state.

Carnot Heat Engine

- Saudi Carnot proposed it in 1840. (Ideal Engine)
- Carnot Heat Engine has maximum efficiency, but not 100%.

$$\eta_c = (1 - T_2/T_1) \times 100$$

- Carnot cycle consists of following processes
  1) Isothermal Expansion
  2) Adiabatic Expansion
  3) Isothermal compression
  4) Adiabatic compression



DO YOU KNOW?

The area under the PV diagram gives us the work done by the engine.

Following things should be kept in mind about efficiency about Carnot engine:

- It depends upon ΔT.
- It is independent of working substance.
- It is 100% only when $T_2 = 0K$ OR $Q_2 = 0J$ (Both the cases are not possible)

ENTROPY

Entropy is a measure of molecular disorder and in any process the entropy increases or remains constant, that is the disorder increases or remains constant. The degree of delocalization is a measure of disorder. Entropy or disorder always increases or remains constant.

- Degree of disorderliness is called statistical entropy.
- Unavailability of heat energy is called thermo entropy.
- **Law of increase of entropy**

  "Entropy of a thermodynamic system is either remains constant (during reversible process) or it increases (during irreversible process)."
- We can represent change in entropy by following relation;

$$\Delta S = \Delta Q/T$$

  Where ΔS is positive if heat enters and vice versa
- Its unit is J/K.
- Entropy may remain constant for a reversible process.
- Entropy increases for all irreversible processes.

  Entropy: A state variable whose change is defined for a reversible process at T where Q is the heat absorbed.
  Entropy: A measure of the amount of energy which is unavailable to do work.
  Entropy: A measure of the disorder of a system.
  Entropy: A measure of the multiplicity of a system. (Point to ponder)

Environmental Crisis as Entropy Crisis

- Entropy is a time arrow.
- Increase of entropy leads to heat death of universe because of thermal pollution because of inevitable consequence of second law of thermodynamics.
- Environmental crisis is an entropy or disorder crisis resulting from our future efforts to ignore the 2nd law of thermodynamics.

PRACTICE SHEET # 01

1. Which of the following properties of matter is used in the construction of thermometer?
   A) Expansion of matter on heating. B) Change of color with temperature.
   C) Increase of resistance with rise of temperature. D) All of above.
2. Mercury is used in mercury-in-glass thermometer as a thermometric substance because:
   A) It does not wet the capillary tube walls. B) It is opaque.
   C) Its expansion is uniform over a wide range of temperature. D) All of above.
3. Two fixed point used for the temperature scales are:
   A) The temperature of freezing and boiling mercury.
   B) The temperature of freezing and boiling water.
   C) The temperature of alcohol at 0^o C & 100^oC.
   D) None of these.
4. In liquid-in-glass thermometer, the thermometric property used is:
   A) Thermal expansion. B) Color change on heating.
   C) Resistance changes on heating. D) None of these.
5. Which of the following is correct w.r.t to size of division.
   A) $1^oF = 1^oC$ B) $1^oF > 1^oC$
   C) $1^oF < 1^oC$ D) None of these.
6. Which of the following is correct w.r.t to size of division.
   A) 1C > 1K B) 1C = 1K
   C) 1C < 1K D) None of these.
7. The centigrade and Fahrenheit scale have the same reading at:
   A) 40^0 B) 140^o
   C) -140^o D) -40^o
8. One degree of centigrade scale is equal to w.r.t size of division
   A) 1^o of Fahrenheit B) 1.8^o of Fahrenheit
   C) 32^o of Fahrenheit D) 3^o of Fahrenheit
9. The temperature of absolute zero correspond (equals) to:
   A) $-273\ C^o$ B) $273\ C^o$
   C) $0\ C^o$ D) $20\ C^o$
10. What temperature of Fahrenheit correspond to absolute zero.
    A) 212^oF B) 32^oF
    C) $-32\ ^oF$ D) $-460\ ^oF$
11. On calorie is equal to:
    A) 41.8J B) 4.18J
    C) 18.4J D) 4.5J
12. SI unit of heat energy is:
    A) Calorie B) B.T.U
    C) Joule D) Kilo-Calorie
13. Absolute zero is considered to be the temperature at which:
    A) All gasses become liquid B) All liquid become gases
    C) Water freezes D) Molecular motion in gas would cease
14. Melting point of ice and boiling point of water in Fahrenheit scale are taken as:
    A) 0^o and 100^0 B) 32^0 and 273^0
    C) 100^0 and 373^0 D) 32^0 and 212^0
15. The average K.E. of all molecules in a substance is a measure of its:
    A) Heat energy B) Temperature
    C) Boiling point D) Specific heat

16.The sum of all energies of a molecule in a substance is called:
A) Heat energy B) Kinetic energy
C) Threshold energy D) Potential energy

17. While keeping the temperature constant, the graph between volume (V) and (1/P) is:
A) A parabola B) Koe bhe curve hoskta h.....hume kea pata
C) A straight-line D) A hyperbola

18. At constant pressure, the graph between volume (V) and temperature (T) is:
A) A curve B) A parabola
C) A hyperbola D) A straight line

19.Real gases strictly obey gas laws at:
A) Low pressure low temperature B) High pressure low temperature
C) Low pressure high temperature D) High pressure and high temperature

20. Volume of a gas is directly proportional to its temperature (absolute) while keeping the pressure constant, this is called:
A) Boyle's law B) Charles's law
C) Ideal gas law D) Bilal's law

21. "Volume of a gas is inversely proportional to its pressure while keeping temperature constant". This is called:
A) Boyle's law B) Charles's law
C) Ideal gas law D) Bilal 's law

22. For a gas obeying Boyle's law, if pressure doubled (made twice) the volume becomes:
A) Three fourth B) Double
C) One half D) Remains the same

23. The K.E. of the molecules of an ideal gas at absolute zero will be:
A) Zero B) Infinite
C) Very high D) None of these

24. At absolute zero temperature, the molecules have:
A) Rotational K.E. B) Translational K.E.
C) Maximum energy D) Zero KE energy

25. The molecules of a gas exert pressure on the walls of the container due to:
A) Their velocity B) Their continuous collisions
C) Their free motion D) Their energy

26. The relationship between Boltzmann Constant K, gas constant R and Avogadro's number N_A is:
A) $K=N_A/R$ B) $K=RN_A$
C) $K=R/N_A$ D) $K=R-N_A$

27. The absolute temperature of an ideal gas is:
A) Directly proportional to the average translational K.E. of molecules
B) Inversely proportional to average translational K.E. of molecules
C) Directly proportional to the universal gas constant
D) None of these

28.Average translational K.E. of ideal gas molecules depends upon:
A) Volume of a gas B) Pressure of a gas
C) Temperature of gas D) All of the above

29.Heat is a form of energy associated with:
A) Molecular mass B) Molecular motion
C) Molecular weight D) None of these

30. When the pressure is increased the boiling point of liquid:
A) Increases B) Decreases
C) Remains unchanged D) None of these

31.Pressure is measured in:

A) Pascal
B) Atmospheric Pressure (atm)
C) N/m^2
D) All of the above

32.At constant temperature if volume of given mass of the gas is doubled then density of the gas become:

A) One half
B) One Fourth
C) Double
D) Remains constant

33. The change in length per unit length per kelvin rise in temperature is called :

A) Coefficient of superficial expansion.
B) Coefficient of volumetric expansion
C) Coefficient of linear expansion.
D) None of these

34.Linear Thermal Expansion is related to:

A) Liquid only
B) Gases only
C) Both A & B
D) Solids only

35. A sample of an ideal gas is heated, doubling its absolute temperature. Which of the following statements best describes the result of heating the gas?

A) The root-mean-square speed of the gas molecules doubles.
B) The average kinetic energy of the gas molecules increases by a factor of $\sqrt{2}$.
C) The average kinetic energy of the gas molecules increases by a factor of 4.
D) The root-mean-square speed increases by a factor of $\sqrt{2}$.

36. The fractional change in volume per kelvin rise in temperature is called:

A) Coefficient of linear expansion
B) Coefficient of thermal conductivity
C) Bilal's Coefficient of Manjan
D) Coefficient of volumetric expansion

37. The amount of heat needed to raise the temperature of one mole of a substance through 1K is called:

A) Heat capacity
B) Specific heat capacity
C) Caloric heat
D) Molar heat capacity

38. The amount of heat energy required to raise the temperature of unit mass of a substance through 1K is called:

A) Heat capacity
B) Specific heat capacity
C) Molar heat capacity
D) Latent heat of vaporization

39. The relation between heat capacity and specific heat is:

A) heat capacity = specific heat/mass
B) heat capacity = specific heat x mass
C) heat capacity = specific heat - mass
D) none of these

40. The amount of heat needed to raise the temperature of 1gm of water through 1^oC is called:

A) 1 Joule
B) 1 Calorie
C) 1 Kilo calorie
D) None of these

41. In Fahrenheit scale the thermometer is divided into

A) 50 Parts
B) 100 parts
C) 180 parts
D) 200 parts

42. Heat needed to vaporize 1 Kg of water at its boiling point without change in temperature:

A) Heat capacity
B) Latent heat of vaporization
C) Specific heat
D) Latent heat of fusion

43. Heat needed to melt 1 Kg of ice at its melting point without change of temperature is called:

A) Heat capacity
B) Latent heat of vaporization
C) Specific heat
D) Latent heat of fusion

44. The quantity of heat needed to change the state of a substance at constant temperature:

A) Specific heat
B) Molar specific heat

C) Heat capacity D) Latent Heat

45. For a mono atomic gas, if C_P and C_V represent specific heats at constant pressure and constant volume respectively, then:

A) $C_P < C_V$ B) $C_P > C_V$

C) $C_P = C_V$ D) None of these

46.SI unit of specific heat:

A) J-Kg/K B) J /Kg-K

C) Cal. / Kg-K D) KCal. / Kg-C

47. The difference between C_P & C_V is equal to:

A) One calorie heat B) Boltzmann constant

C) Universal gas constant D) Zero

48. The ratio (Gamma = C_P/ C_V) for a diatomic gas (like air) is:

A) 1.40 B) 1.30

C) 1.50 D) 1.67

49. The ratio (Gamma = C_P/ C_V) for mono atomic (like Helium) is:

A) 1.30 B) 1.40

C) 1.52 D) 1.67

50. Some heat is added to a mixture of ice and it is melted. During the melting process, the temperature of the mixture:

A) Increases B) Decreases

C) Remains the same D) Decrease first and then increase

51. A system in which there is no transfer of mass and energy across the boundary is called:

A) A closed system B) An isolated system

C) An open system D) None of these

52. The first law of thermodynamics is merely the revision statement of:

A) Law of conservation of momentum B) Law of conservation of mass

C) Law of conservation of energy D) Charle's law

53. The process in which the temperature of the system remains constant is called:

A) Adiabatic process B) Isothermal process

C) Isochoric process D) Isobaric process

54. In which the following processes, no heat enters or leaves the system:

A) Isobaric process B) Isothermal process

C) Isochoric process D) Adiabatic process

55. The process in which pressure of the thermodynamic system remains constant is called:

A) Isobaric process B) Adiabatic process

C) Isochoric process D) Isothermal process

56. In an adiabatic process:

A) Work done is always positive B) Work is done at the cost of internal energy

C) No work is done D) Neither of these

57. In an isothermal process the internal energy of the system:

A) Increases B) Decreases

C) Remains the same D) None of these

58. If the temperature of the heat source increases, the efficiency of the Carnot engine:

A) Increases B) Decreases

C) Remains the same D) None of these

59. If the temperature of the heat sink decreases, the efficiency of the Carnot engine:

A) Increases B) Decreases

C) Remains the same D) None of these

60. Which property of the system remains constant during an adiabatic change:

A) Pressure
B) Temperature
C) Internal energy
D) Entropy

61. The efficiency of a Carnot engine depends on:
A) The temperature of source only
B) The temperature of sink only
C) Both temperature of source and sink
D) The working substance

62. Entropy is the measure of:
A) Order of the system
B) Disorderliness of the system
C) Internal energy of the system
D) K.E. of the system

63. When the temperature of source and sink of a heat engine becomes equal, the efficiency will be:
A) Maximum
B) Minimum
C) Zero
D) Negative

64. A perfect gas (ideal) is that which:
A) Obeys Charles's law only
B) Obeys Boyle's law only
C) Does not obey gas laws
D) Strictly obeys all the gas laws

65. The pressure of gas is defined as:
A) force per unit length
B) force per unit area
C) force per unit volume
D) force per unit density

66. The energy possessed by molecules in a substance consist of:
A) Vibrational energy
B) Rotational energy
C) Translational energy
D) All of the above

67. In a Kelvin Scale the thermometer is divided in:
A) 50 parts
B) 150 parts
C) 100 parts
D) 200 parts

68. The temperature at which the gases exert zero pressure and have zero volume is called:
A) Absolute pressure
B) Absolute volume
C) Absolute zero
D) None of these

69. The lower fixed point of Fahrenheit scale is taken to be:
A) 32^0F
B) 273^0F
C) 373^0F
D) 310^0F

70. Which of the following is the temperature at which pure ice melts at STP.
A) 32^oF
B) 273^oF
C) 373^oF
D) 310^oF

ANSWER KEY # 01

1→D	10→D	19→C	28→C	37→D	46→B	55→A	64→D
2→D	11→B	20→B	29→B	38→B	47→C	56→B	65→B
3→B	12→C	21→A	30→A	39→B	48→A	57→C	66→D
4→A	13→D	22→C	31→D	40→B	49→D	58→A	67→C
5→C	14→D	23→A	32→A	41→C	50→C	59→A	68→C
6→B	15→B	24→D	33→C	42→B	51→B	60→D	69→A
7→D	16→A	25→B	34→D	43→D	52→C	61→C	70→A
8→B	17→C	26→C	35→D	44→D	53→B	62→B	
9→A	18→D	27→A	36→D	45→B	54→D	63→C	

PRACTICE SHEET # 02

1. **The Process of Expansion during heating:**
   a. Occurs at the same rate for all materials
   b. Occurs at different rates for different materials
   c. Increases the weight of a material
   d. Increases the density of a material

2. **Two spheres of same size are made of the same material but one is hollow and the other is solid. They are heated to the same temperature. Then:**
   a. Both the spheres will expand equally
   b. The hollow sphere will expand more than the solid one
   c. The solid sphere will expand more than the hollow one
   d. No conclusion can be drawn about their relative expansions unless the nature of the material is known.

3. **A metal sheet with a circular hole is heated. The hole will:**
   a. Contract
   b. Expand
   c. Remain unaffected
   d. Contract or expand depending on the value of the linear expansion coefficient.

4. **The pressure exerted on the walls of the container by a gas is due to the fact that the gas molecules:**
   a. Lose their kinetic energy
   b. Stick to the wall
   c. Are accelerated towards the walls
   d. Change their momenta due to collision with the walls

5. **The correct & exact value of 0°C on the Kelvin scale is:**
   a. 273.15 K b. 272.85 K c. 273 K d. 273.2 K

6. **The ideal gas law is expressed as:**
   a. PV=nRT b. $PV = \frac{1}{nRT}$ c. PV = nT d. P = RT

7. **All real heat engines are less efficient than Carnot engine due to:**
   a. friction b. energy dissipation c. heat loss d. all of above

8. **PV= RT represents:**
   a. Gas equation for one mole b. Gas equation for n mole
   c. Boyle's law d. Charles's law

9. **In an adiabatic process:**
   a. No heat enters or leaves the system b. Entropy of the system remains constant
   c. $-\Delta U = W$, represents adiabatic expansion d. All of these

10. **What is the average translational kinetic energy of molecules in a gas at temperature 27°C?**
    a. 6.21×10^{-21}J b. 3×10^{-21}J
    c. 5×10^{-21}J d. None of these

11. Efficiency of Carnot engine will become 100% if:
a. Temperature of the source and the sink are both equal
b. Temperature of the source is 0 K (absolute zero)
c. Temperature of the sink is 0K (absolute zero)
d. None of these

12. The efficiency of a Carnot engine operating between two temperatures T_1 and T_2 ($T_1 > T_2$) is given by:
a. $\eta = \frac{T_1}{T_2}$ b. $\eta = \frac{T_2}{T_1}$ c. $\eta = 1 - \frac{T_2}{T_1}$ d. $\eta = 1 - \frac{T_1}{T_2}$

13. When heat will face death:
a. Temperature of source and sink of heat engine will become equal
b. All the heat energy will become unavailable
c. Entropy of the universe will be maximum
d. All of the above

14. Two temperature scales A and B are related by:

$$\frac{A-42}{110} = \frac{B-72}{220}$$

At which temperature two scales will have the same reading?
a. 42° b. 72°
c. 12° d. 40°

15. The pressure exerted on the walls of the container by the gas molecules is defined as:
a. force per unit volume b. force per unit area
c. mass per unit volume d. energy per unit area

16. The product of the pressure and volume of an ideal gas is:
a. A constant
b. Approximately equal to the universal gas constant
c. Directly proportional to its temperature
d. Inversely proportional to its temperature

17. At 0K which of the following properties of a gas will be zero:
a. Kinetic energy b. Potential energy c. Vibrational energy d. Density

18. The temperature of source and sink of a Carnot engine are 327°C and 27°C, respectively. The efficiency of the engine (without multiplying by 100) is:
a. 1 – (27/327) b. 27/327 c. 0.5 d. 0.7

19. A Carnot engine takes 300 cal. of heat at 500 K and rejects 150 cal. of heat to the sink, the temperature of the sink is:
a. 1000 K b. 750 K c. 250 K d. 125 K

20. The temperature of a substance increases by 27℃. On the Kelvin scale this increase is equal to:
a. 300 K b. 48.6 K
c. 27 K d. 7 K

21. For a diatomic gas $C_P = 7R/2$ & $C_V = 5R/2$, therefore gamma 'γ' for this gas is:
a. 5/7 b. 4/35 c. 7/5 d. 35/4

22. The pressure exerted by the ideal gas is:
a. Inversely proportional to average translational K.E. of gas
b. Directly proportional to average translational K.E. of gas molecules
c. Inversely proportional to number of molecules per unit volume of gas
d. None of the above

23. Adiabatic change occurs when the gas expands or is compressed:
a. very slowly b. slowly c. rapidly d. both slowly & rapidly

24. First law of thermodynamics when applied to an adiabatic process becomes:
a. $W = \Delta U$ b. $W = (-\Delta U)$ c. $Q = \Delta U$ d. $Q = W$

25. The first law of thermodynamics states that:
a. Momentum is conserved b. Energy is conserved
c. Charge is conserved d. Weight is conserved

26. For a gas obeying Boyle's law, if the pressure is tripled, the volume becomes:
a. one third b. double c. three-fold d. remains constant

27. For an isothermal process, the first law of thermodynamics reduces to:
a. $Q = \Delta U + W$ b. $Q = \Delta U - W$ c. $Q = W$ d. $Q = \Delta U$

28. A centigrade and a Fahrenheit thermometer are dipped in boiling water. The water temperature is lowered until the Fahrenheit thermometer registers 140°. What is the fall in temperature as registered by the centigrade thermometer?
a. 30° b. 40°
c. 60° d. 80°

29. Which of the following is the smallest temperature?
a. 1°R b. 1°C
c. 1°F d. 1 K

30. The temperature at which the reading of a Fahrenheit thermometer will be double that of centigrade thermometer is: (Hint: $\frac{T°C - 0}{100 - 0} = \frac{T°F - 32}{212 - 32}$ & Put T°F = 2T°C)
a. 160° b. 180°
c. 32° d. 100°

31. The value of Boltzmann constant is:
a. $13.8\times10^{-23}\ JK^{-1}$ b. $13.8\times10^{23}\ JK^{-1}$ c. $1.38\times10^{-23}\ JK^{-1}$ d. None of these

32. Which of the following flows from a hot body to a cold body?
a. None b. Temperature c. Specific heat d. Heat energy

33. Working of a bicycle pump is in accordance to:
a. Pascal's law b. Ohm's Law
c. First law of thermodynamics d. Second law of thermodynamics

34. Which quality must be the same for two bodies if they are to be in thermal equilibrium?
a. None b. Potential energy c. Temperature d. Mass

35. At what temperature, the Fahrenheit and Celsius scales will give numerically equal (but opposite in sign) values?

a. - 40°F and 40°C
b. 11.43°F and -11.43°C
c. -11.43°F and 11.43°C
d. 40°F and -40°C

36. The efficiency of a Carnot engine working between a high (T_1) and a low temperature (T_2) reservoir is given by:

a. $\eta = \frac{T_2 - T_1}{T_1}$
b. $\eta = \frac{T_1 - T_2}{T_1}$
c. $\eta = \frac{T_2 - T_1}{T_2}$
d. $\eta = \frac{T_1}{T_1 - T_2}$

37. Thermoelectric thermometer (Thermocouple) is based on:

a. Bilal's Effect
b. See beck Effect
c. Compton Effect
d. Joule Effect

38. The efficiency of a real world diesel engine roughly ranges from:

a. 25% to 35%
b. 35% to 40%
c. 45% to 65%
d. 65% to 85%

39. If the temperature of the sink is increased, the efficiency of a Carnot engine:

a. increases
b. decreases
c. remains constant
d. first increases then decreases

40. Maximum density of water is at the temperature: (Hint: Anomalous expansion of Water)

a. 4°C
b. All of these
c. 277K
d. 39.2°F

41. Entropy of universe is increasing day by day due to:

a. Depletion of ozone
b. Energy being used into work
c. Power generation processes
d. All of the above

42. The temperature on Celsius scale is 25℃. What is the corresponding temperature on the Fahrenheit scale?

a. 40°F
b. 77°F
c. 50°F
d. 45°F

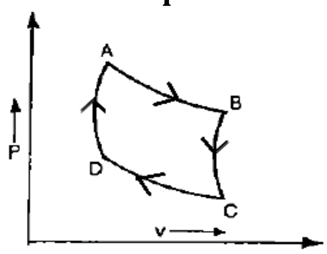
43. If the boiling point of water is 95℉, what will be reading at Celsius scale?

a. 7°C
b. 65°C
c. 63°C
d. 35°C

44. On a new scale of temperature (which is linear) and is called as the W scale, the freezing and boiling points of water are 39°W and 239°W respectively. What will be the temperature on the new scale, corresponding to a temperature of 39℃ on the Celsius scale?

a. 200°W
b. 139°W
c. 78°W
d. 117°W

45. The pressure-volume graph of an ideal gas cycle consisting of isothermal and adiabatic process is shown in the figure. The adiabatic process is described by:



a. AB and BC
b. AB and CD
c. BC and CD
d. AD and BC

46. If an ideal gas is isothermally expanded, its internal energy will:
a. Increase
b. Decrease
c. Remain the same
d. Decrease or increase depending on the nature of the gas

47. During an adiabatic expansion the increase in volume is associated with:
a. Decrease in pressure & decrease in temperature
b. Increase in pressure & decrease in temperature
c. Increase in pressure & increase in temperature
d. Decrease in pressure & increase in temperature

48. The bimetallic thermostats are used to:
a. Increase the temperature b. Maintain the temperature
c. Measure the mass d. All

49. If a bimetallic strip is heated it will:
a. Bend towards the metal with lower thermal expansion coefficient
b. Bend towards the metal with higher thermal expansion coefficient
c. Twist itself into helix
d. Not bend at all

50. In an isothermal change an ideal gas obeys:
a. Boyle's law b. Charles's law c. Both (a) and (b) d. None of these

51. The formula connecting the pressure and volume of a gas undergoing an Isothermal change is:
a. P^2V = constant b. PV = constant c. PV^{n-1} = constant d. PV^2 = constant

52. Increase in length per unit length per degree rise in temperature of Aluminum rod of 10m length is $24 \times 10^{-6}/°C$. What would be the increase in volume per unit volume per degree rise in temperature of cube of aluminum of volume 1000 m^3 when both are heated through the same range of temperature: (Hint: $\beta = 3\alpha$)
a. $24 \times 10^{-6}/°C$. b. $2.4 \times 10^{-3}/°C$.
c. $72 \times 10^{-6}/°C$. d. $7.2 \times 10^{-3}/°C$.

53. During adiabatic compression of a gas its temperature:
a. remains constant b. becomes zero c. falls d. rises

54. A bicycle pump works in accordance with:
a. Newton's first law of motion b. First law of thermodynamics
c. Pascal's law d. Bilal's law

55. Environmental crises are:
a. entropy crises b. disorder crises c. randomness crises d. all of these

56. If 20J of work is done in compressing a gas adiabatically, the change in internal energy is equal to:
a. 20J b. -20J c. 10J d. 200J

57. A gas receives an amount of heat equal to 110 joules and performs 40 joules of work. The changes in the internal energy of the gas is:
a. 70J b. 150J c. 110J d. 40J

58. In the gas equation PV=RT, V is the volume of:
a. 1 mole of gas b. 1 g of gas c. gas d. 1 liter of gas

59. If the number of gas molecules in a cubical vessel is increased from N to 3N, then its pressure and total energy will become:
a. four times b. three times c. two times d. half

60. Which of the following methods will enable the volume of an ideal gas to be made four times greater?
a. Quarter the pressure at constant temperature
b. Quarter the temperature at constant pressure
c. Half the temperature, double the pressure
d. Double the temperature, double the pressure

61. One calorie is equal to:
a. 4.18 erg b. 4.18 J c. 41.8 J d. 4.35 J

62. At constant pressure, the graph between V (volume) and T (absolute temp.) is:
a. Hyperbola b. Parabola c. Straight line d. Ellipse

63. Pressure of an ideal gas can be written in terms of its density 'ρ':
a. $P = \rho v^2$ b. $P = \frac{2}{3}\rho v^2$ c. $P = \frac{1}{3}\rho v^2$ d. $P = \frac{1}{2}\rho v^2$

64. If the pressure is decreased, the boiling point of the liquid:
a. Increases b. Remains unchanged
c. Decreases d. Decreases first and then increases

65. The coefficient of thermal expansion depends upon:
a. Length b. Temperature
c. Nature of material d. Both a & b

66. Two bars of copper having same length but unequal diameter are heated to the same temperature. The change in the length will be:
a. More in thinner bar
b. More in thicker bar
c. Same for both the bars
d. Determine by the ratio of length and diameter of the bar

67. A beaker is completely filled with water at 4°C. It will overflow:
a. When heated but not when cooled
b. When cooled but not when heated
c. Both when heated or cooled
d. Neither when heated nor when cooled

68. No entropy change is associated with:
a. Isothermal process b. Adiabatic process

c. Isochoric process d. Isobaric process

69. Food is cooked quicker in a pressure cooker because:

a. Cooker is made of metal
b. It is a good conductor of heat
c. No heat is lost
d. High steam pressure raises the boiling point of liquid

70. A system does 600 J of work and at the same time has its internal energy increased by 320J. How much heat has been supplied?

a. 280J b. 920J c. 600J d. 20 J

71. At constant volume temperature is increased. Then:

a. Collision on walls will be less
b. No. of collisions per unit time will increase
c. Collisions will be in straight lines
d. Collisions will not change

ANSWER KEY # 02

1.	B	31.	C	61.	B
2.	A	32.	D	62.	C
3.	B	33.	C	63.	C
4.	D	34.	C	64.	C
5.	A	35.	B	65.	C
6.	A	36.	B	66.	C
7.	D	37.	B	67.	C
8.	A	38.	B	68.	B
9.	D	39.	B	69.	D
10.	A	40	B	70	B
11.	C	41.	D	71.	B
12.	C	42.	B	72.	
13.	D	43.	D	73.	
14.	C	44.	D	74.	
15.	B	45.	D	75.	
16.	C	46.	C	76.	
17.	A	47.	A	77.	
18.	C	48.	B	78.	
19.	C	49.	A	79.	
20.	C	50.	A	80.	
21.	C	51.	B	81.	
22.	B	52.	C	82.	
23.	C	53.	D	83.	
24.	B	54.	B	84.	
25.	B	55.	D	85.	
26.	A	56.	A	86.	
27.	C	57.	A	87.	
28.	B	58.	A	88.	
29.	C	59.	B	89.	
30.	A	60.	A	90.	

CHAPTER # 12: ELECTROSTATICS

Electrostatics is the branch of physics which deals with the study of electric charges at rest under the action of electric forces. An electric force is the force which holds the positive and negative charges that could make up atoms and molecules.

CHARGE

- The property by virtue of which two particles exert forces of attraction or repulsion on one another is called charge.
- The unit of charge is Coulomb. The charge of 6.25×10^{18} electrons equal to 1 coulomb.
- The minimum charge of a body can never be less than the charge of electron
- Charge on any object is always quantized. Q = Ne where N = no of electrons & e= 1.6×10^{-19} C

COULOMB'S LAW (Inverse Square Law)

The law states there is a force (of attraction or repulsion) between two-point charges, which is directly proportional to the product of the magnitude of the charges and inversely proportional to the square of the distance between them.

$$F = \frac{Kq_1q_2}{r^2}$$

Where K is the constant of proportionality and its value depends on the medium between the charges and system of units. The measured value of K for free space or air is 9×10^9 $Nm^2.C^{-2}$

$$K = \frac{1}{4\pi\epsilon_0}$$

$$F = \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r^2}$$

Note:

- Coulomb found and validated this famous equation by using Torsion Balance, an instrument that is used to measure small forces.
- According to coulomb's law, there is a force between every two-point charges, this force is, attractive when the two point charges have opposite signs. And this force is repulsive when the two point charges are of same sign.
- The mathematical form of coulomb's law is,

$$F = \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r^2}$$

Where, ϵ_0 = permittivity of free space or vacuum or air.

If there is some other medium (other than free space) i.e. wood, glass, mica etc. then formula becomes.

$$F = \frac{1}{4\pi\epsilon_0\epsilon_r}\frac{q_1q_2}{r^2}$$

Where, ϵ_r = Relative permittivity w.r.t. free space

RELATIVE PERMITIVITY OR DIELECCTRIC CONSTANT

The ratio ϵ / ϵ_0 is denoted by ϵ_r is called relative permittivity of the medium with respect to vacuum.

ELECTRIC FIELD

- The space or region around charged body in which another charge experience an electric force is called electric field.
- An electric field consists of electric lines of forces, which are directed outward from positive charge and inward into negative charge.

ELECTRIC INTENSITY OF A FIELD

The strength of an electric field is known as electric intensity. It is defined as,

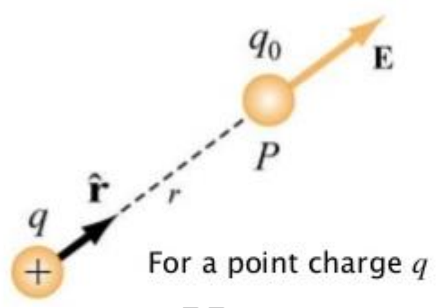
"The electric force experienced by unit positive charge when placed at a point inside an electric field, is called electric field intensity."

Explanation

Electric intensity is a vector quantity and it is denoted by $\vec{E}$. If a charge q_0 experienced a force F when placed at a point inside an electric field, then mathematically we can write,

$$\vec{E} = \frac{\vec{F}}{q_0}$$

Electric Intensity due to a Point Charge



$$\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\hat{r}$$

It is formula to calculate electric intensity at distance 'r' from the position of point charge 'q'.

Units

The SI unit of electric intensity is newton per coulomb (NC^{-1})

Note:

- The direction of the intensity is the same as that of the force F.
- The force F acts along the line joining the positions of two-point charges.

ELECTRIC FIELD LINES

"The imaginary lines which could be drawn around any electric charge, to get direction of electric intensity at various points inside electric field, are called lines of electric field."

These lines show the direction of force on positive test charge at various positions, so these are also called lines of force.

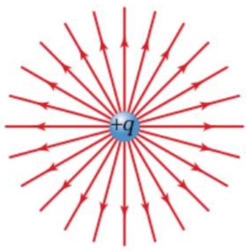
Characteristics of Lines of Force

- Electric field lines originate from positive charges and end on negative charges.
- The tangent to a field line at any point gives the direction of the electric field at that point.

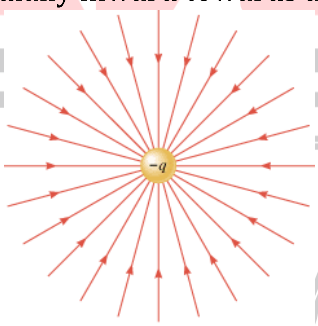
- The lines of force are drawn so that the number of lines per unit cross sectional area is proportional to the magnitude of E, i.e. (lines are closer when the field is strong, the lines are farther apart where the field is weak).
- The lines of electric field do not intersect each other. This is because, $\vec{E}$ has only one direction at any given point. If the lines cross, here $\vec{E}$ could have more than one direction.

Examples of electric Lines of Force

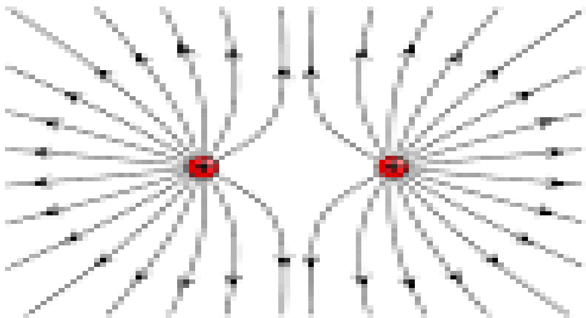
a) The electric field lines are directed radially outward from the positive point charge +q.



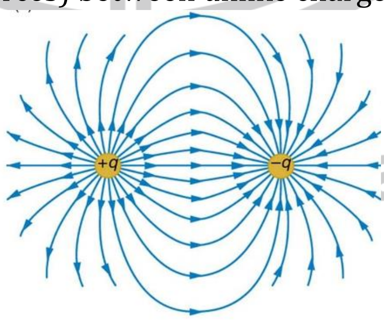
b) The electric field lines are directed radially inward towards a negative point charge −q.



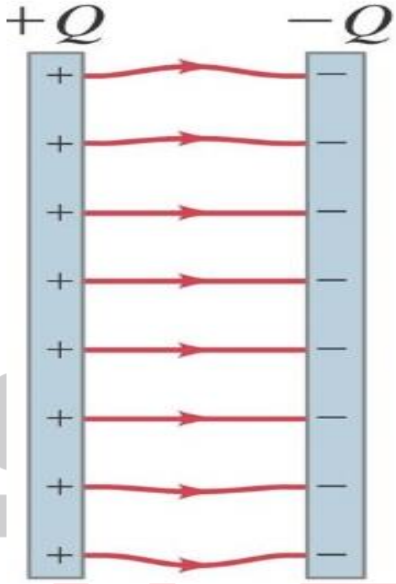
c) The electric field lines for two identical positive charges.



d) The electric field lines (attractive forces) between unlike charges.



e) Figure shows the line of a force, of a field between two oppositely charged plates parallel to each other, with small distance apart. The lines are uniformly spaced normal to the plates inside between them; therefore, intensity 'E' is the same at each point within the plates. The lines are curved at the edges of the plates where the field is not uniform. If, however the plates of infinite size, the field will be uniform between them.



Note:

If a charge is placed at that point, where it would experience equal and opposite forces, such that no net force would act upon it, then intensity E of the field would be zero. Such points are called neutral points.

ELECTRIC FLUX

"The number of electric field lines passing through an area (when it is placed anywhere in the field in any direction) is called electric flux."

Electric flux, being a scalar product, is a scalar quantity. Its SI unit is Nm^2C^{-1}

The flux through a surface placed in an electric field depends upon:

- **The intensity of the Electric Field $\vec{E}$**
  The greater the intensity, closer the lines of force and more is the electric flux through the surface.
- **The area of the Surface ($\vec{A}$)**
  The larger the area of the surface, more lines of force pass through it and the electric flux through it is greater.
- **The orientation of the surface relative to the field**
  The orientation is determined by the angle between the field directions an outward drawn normal to the surface (area vector).
  Mathematically, the electric flux ($\emptyset_0$) through the surface can be expressed in the form of a scalar product as:

$$\emptyset_0 = \vec{E} \cdot \vec{A}$$
OR
$$\emptyset_0 = EA \cos\theta$$

Where, θ is the angle between $\vec{E}$ and $\vec{A}$

(Here area vector '$\vec{A}$' is a vector whose magnitude is equal to area of a surface and whose direction is along outward drawn normal or perpendicular to that surface).

SPECIAL CASES:

Case 1:

When a plane surface of area A is placed parallel to the electric field, the angle between $\vec{E}$ and $\vec{A}$ is 90 degrees then:

The electric flux through the surface is then given by,

$$\phi_0 = \vec{E}\,.\,\vec{A}$$
$$\phi_0 = EA \cos\theta$$
$$\phi_0 = 0$$

i.e. The electric flux through the surface placed parallel to the field is zero or minimum.

Case 2:

When a plane surface of area $\vec{A}$ is placed perpendicular to the electric field, the angle between $\vec{E}$ and $\vec{A}$ is zero degree.

The electric flux through the surface is given by:

$$\phi_0 = \vec{E}\,.\,\vec{A}$$
$$\phi_0 = EA \cos 0°$$
$$\phi_0 = EA$$

i.e. The flux through the surface placed perpendicular to the electric flux is maximum.

Case 3:

When the vector area $\vec{A}$ is neither perpendicular nor parallel to the electric lines of force, but is inclined at angle θ with the lines. In this case we have to find the projection of the area which is perpendicular to the field lines. The area of projection is A cos θ.

The flux ϕ in this case is:

$$\phi_0 = EA \cos\theta$$

<u>Electric Flux through a Surface Enclosing a Charge</u>

$$\phi_0 = \frac{q}{\epsilon_0}$$

It is the value of electric flux passing through the surface of a sphere, due to point charge placed at its center.

"The total flux through a closed surface does not depend upon the shape or geometry of the closed surface. It depends upon the medium and charge enclosed."

<u>GAUSS'S LAW</u>

The law states that, total electric flux passing through any closed surface is equal to $\frac{1}{\epsilon_0}$ times the total charge enclosed by the closed surface.

If we denote total charge enclosed by the closed surface as, ($q_0 + q_1 + q_2 + ... + q_n = Q$).

The mathematical expression of Gauss's law can be expressed as:

$$\phi_0 = \frac{1}{\epsilon_0}(Q)$$

Application of Gauss's Law

Gauss's law is used for the evaluation of electric intensity due to different charge configurations.

a) Intensity of Field Inside a Hollow Charged Sphere

$$\vec{E} = 0$$

The electric flux inside a hollow charged sphere is zero. Thus, the interior of a hollow charged metal sphere, is a ''free field" region.

Note:

Any apparatus placed within the metal enclosure is "shielded" from external electric field.

b) Electric Intensity due to Infinite Sheet of Charge

$$E = \frac{\sigma}{2\epsilon_0}$$

(Charge per unit area or surface charge density) = σ

If '$\hat{r}$' is a unit vector normal to the sheet and directed away it, then electric intensity at 'I' is vector form.

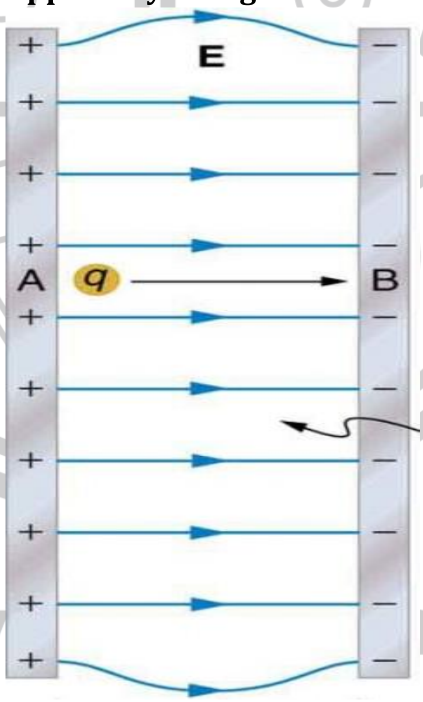
$$\vec{E} = \frac{\sigma}{2\epsilon_0}\hat{r}$$

Note:

If the sheet is negatively charged, the electric intensity will be directed towards it. Which is given by,

$$\vec{E} = \frac{-\sigma}{2\epsilon_0}\hat{r}$$

c) Electric Intensity between Two Oppositely Charged Parallel Plates



Hence the magnitude of resultant intensity (due to positive and negative plate) at point **'P'** is written as follow

$$E = E_1 + E_2$$

$$E = \frac{\sigma}{2\epsilon_0} + \frac{\sigma}{2\epsilon_0}$$

$$E = \frac{\sigma}{\epsilon_0}$$

It is intensity of electric field at any point between two oppositely charged sheets of infinite size. The direction of the electric intensity will be along the normal to the plates, directed from positively charged plate towards the negatively charged plate.
If unit vector $\hat{r}$ represents the direction of the intensity, then

$$\vec{E} = \frac{\sigma}{\epsilon_0}\hat{r}$$

ELECTRIC POTENTIAL DIFFERENCE

The value of electric potential difference between any two points inside an electric field is defined as,

"The work done on a unit positive charge, in moving it against the electric field from one point to the other"

$$\frac{W_{A\to B}}{q_0} = V_B - V_A = \Delta V$$

It is the potential difference (P.D.) between the points 'A' and 'B' in the electric field.

Note:

The potential difference between two points can also be defined as,

"The difference of the potential energy per unit charge"

VOLT

"The potential difference between two points is one volt, if the work done is one joule in moving a charge of one coulomb from one point to the other"

i.e. $$1\text{ Volt} = \frac{1\text{ Joule}}{1\text{ Coulumb}}$$

ELECTRIC FIELD AS POTENTIAL GRADIENT

(Relation between potential difference and Electric Intensity)

$$E = -\frac{\Delta V}{\Delta r}$$

The quantity $\frac{\Delta V}{\Delta r}$ gives the maximum value of the rate of change of potential with distance (because the charge has been moved along a field line along which the distance 'r' between the two plates is minimum). It is to own at potential gradient.

Thus, the electric intensity is equal to the negative of the gradient of potential.

The negative sign indicates that the direction of E is along the decreasing potential.

Note:

Electric field as potential gradient is given by,

$$E = -\frac{\Delta V}{\Delta r}$$

The unit of electric intensity from this equation is, (volt/meter) which is equal to NC^{-1}.

i.e. $$\frac{\text{Volt}}{\text{metre}} = \frac{\text{Joule/Coulomb}}{\text{metre}}$$

$$\frac{\text{Volt}}{\text{metre}} = \frac{\frac{(\text{newton})(\text{metre})}{\text{coloum}}}{\text{metre}}$$

$$\frac{\text{Volt}}{\text{metre}} = \frac{\text{newton}}{\text{coulumb}} = NC^{-1}$$

ELECTRIC POTENTIAL AT A POINT DUE TO A POINT CHARGE & ABSOLUTE POTENTIAL

$$V_A - V_B = \left(\frac{q}{4\pi\epsilon_0}\right)\left(\frac{1}{r_A} - \frac{1}{r_B}\right)$$

It is formula to calculate electric potential difference between two points 'A' and 'B' in the electric field due to a point charge.

Special Case

When point 'B' lies at infinite distance from point charge 'q'.

i.e. $r_B = \infty$

So, $\frac{1}{r_B} = \frac{1}{\infty} = 0$

In this case, when 'B' lies at infinite distance from 'q' then its potential difference is zero at infinite distance.

Or $V_B = 0$

Putting these values in last expression of electric potential,

We get,

$$V_A - 0 = \left(\frac{q}{4\pi\epsilon_0}\right)\left(\frac{1}{r_A - 0}\right)$$

OR

$$V_A - 0 = \left(\frac{q}{4\pi\epsilon_0}\right)\left(\frac{1}{r_A}\right)$$

It is the absolute value of electric potential at point 'A'.

As 'A' is any point inside the electric field of 'q', therefore general formula for absolute value of electric potential at any point in the field is,

$$V = \frac{q}{4\pi\epsilon_0 r}$$

ABSOLUTE ELECTRIC POTENTIAL

Absolute electric potential at a point in an electric field is defined as,

"Work done in moving a unit positive charge against the electric field from infinity to that point"

P.E. AND K.E. IN AN ELECTRIC FIELD

When a charged particle is displaced against an electric field, the work done upon it is stored as potential energy in it. If a particle carrying a charge '+q' is displaced from a point 'A' and 'B' with a potential difference ΔV, then the work done in displacing the particle against the field is:

$$W_{A\rightarrow B} = q\,(V_B - V_A) = q\Delta V$$

The work is change in the potential energy of the particle, i.e.

Change in its P.E. $= q\Delta V$

OR

$$\Delta(P.E.) = q\Delta V \text{........... (i)}$$

If now, the particle is allowed to move in the direction of the field from B to A, its potential energy changes into kinetic energy.

According to law of conservation of energy, in the absence of any external force,

Decrease in P.E. = Increase in K.E.

OR

$$\Delta(P.E.) = \Delta(K.E..)$$

OR

$$q\Delta V = \Delta K.E..$$

It is the relation between potential and kinetic energies of a charged particle in an electric field.

ELECTRON VOLT

It is a smaller unit of energy used in atomic physics. It can be defined as:

"The energy gained or lost by an electron when it is moved between two points with a potential difference of one volt."

It is denoted by eV

$$1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$$

CAPACITOR

It is a device which can store electric charge, usually it is made up of two parallel conducting plates separated by an insulator (i.e. air or other medium).

Equation of Capacitor

$$Q \propto V$$

OR

$$Q = (\text{Constant})\, V$$

OR

$$Q = CV$$

It is called equation of capacitor. Where 'C' is capacitance of a capacitor. It value depends upon the geometry of the plates and medium between two plates of the capacitor.

Capacitance

The ability of capacitor to store electric charge is called capacitance of capacitor. It is defined as,

"The amount of charge on one plate necessary to rise the potential of that plate by one volt with respect to the other".

Its unit is "coulomb per volt", it is also called farad (F).

"The capacitance of a capacitor is one farad if a charge of one coulomb, given to one of the plates of a capacitor, produces a potential difference of one volt between them".

$$C\ (1\ \text{farad}) = \frac{Q\ (1\ \text{coulumb})}{V\ (1\ \text{volt})}$$

Note:

Farad is a very large unit and for practical purposes we use its submultiples, which are,

Micro Farad (μF) = 10^{-6} F

Pico Farad (pF) = 10^{-12} F

CAPACITANCE OF A PARALLEL PLATE CAPACITOR

$$C_{vac.} = \frac{\epsilon_0 A}{d} \text{........ (1)}$$

It is an expression for the capacitance of a parallel plate capacitor with air or vacuum as dielectric.

Effect of Dielectric Medium

If an insulating material, called dielectric of relative permittivity ϵ_r is introduced between the plates, then the electric intensity of the field between the plates is:

$$E' = \frac{\sigma}{\epsilon_0 \epsilon_r} = \frac{Q}{\epsilon_0 \epsilon_r A}$$

Therefore, the potential difference between the plates is given by,

$$\Delta V' = E'd = \left(\frac{Q}{\epsilon_0 \epsilon_r A}\right)(d)$$

Hence the capacitance of a parallel plate with dielectric medium of relative permittivity ϵ_r is:

$$C_{,med.} = \frac{Q}{\Delta V'}$$

$$C_{,med} = \frac{\epsilon_0 \epsilon_r A}{d} \text{........ (2)}$$

This expression shows the dependence of a capacitor upon the area of plates, the separation between the plates and the medium between them.

Dielectric Constant

Dividing eq. (2) and (1) we get expression for dielectric constant as,

$$\boldsymbol{\epsilon_r = \frac{C_{med}}{C_{vac}}}$$

Thus, we can define dielectric coefficient and dielectric constant as:

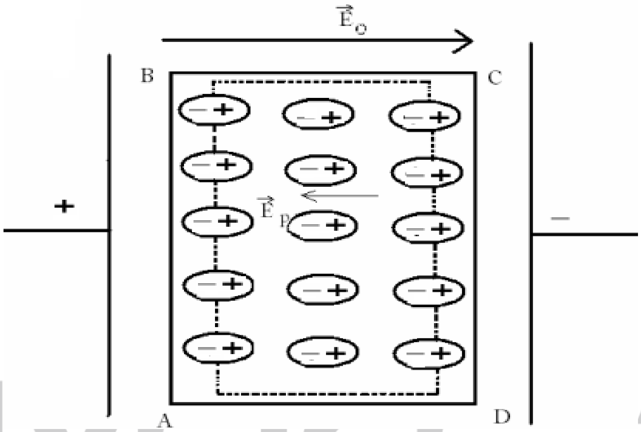
"The ratio of the capacitance of the parallel plate capacitor with an insulating substance as medium between the plates to its capacitance with vacuum (or air) as medium between them."

Electric Polarization of Dielectrics

Definition:

The changes in a dielectric slab cannot move freely. When a dielectric slab is placed between the plates of a charged capacitor, the electric field acting on the molecules of the slabs. As a result, the positive charge of each molecule is shifted a little bit in the direction of the electric field and negative charge opposite to the field.

Thus, each molecule becomes an electric dipole (i.e. two equal and opposite charges separated by a short distance are said to make a dipole).



The dielectric slab is said to be polarized and such redistribution of charges under an electric field is called electric polarization, as shown in figure.

The capacitance of a parallel plate capacitor increases with the use of dielectric medium instead of free space.

ENERGY STORED IN A CAPACITOR

$$\text{Energy} = \frac{1}{2}CV^2$$

ENERGY STORED IN TERMS OF ELECTRIC FIELD

When we consider that energy is being stored between the two plates rather than the potential energy of the charges on the plates than we put,

$$C = \frac{A\epsilon_0\epsilon_r}{d}$$

(Capacitance of a parallel plate capacitor with a dielectric medium)

And $$V = Ed$$

In the last expression of energy to get,

$$\text{Energy} = \frac{1}{2}\left(\frac{A\epsilon_0\epsilon_r}{d}\right)(Ed)^2$$

$$\text{Energy} = \frac{1}{2}\epsilon_0\epsilon_r E^2\,(Ad)$$

It is an expression for energy stored in the electric field between the plates.

ENERGY DENSITY

Energy density defined as,

"Energy per unit value".

i.e. $$\text{Electric density} = \frac{\text{Energy}}{\text{Volume}}$$

Here, volume between the plates = Ad

Therefore,

$$\text{Energy Density} = \frac{\frac{1}{2}\epsilon_0\epsilon_r E^2\,(Ad)}{Ad}$$

OR

$$\text{Energy Density} = \frac{1}{2}\epsilon_0\epsilon_r E^2$$

This equation is valid for any electric field strength

TIME CONSTANT

As the unit of product 'RC' is that of time, so this product is known as 'time constant' (the time required to grow 63% of maximum charge is called time constant).

COMBINATIONS OF CAPACITOR

- **Parallel Combination:**

The potential difference is the same across each capacitor is that of source.

$$V = V_1 = V_2 = V_3$$

Charge (q) equals the sum of the charges across each capacitor.

$$q = q_1 + q_2 + q_3 + \ldots\ldots$$

Hence, capacitance is

$$C = C_1 + C_2 + C_3 + \ldots\ldots$$

- **Series Combination:**

Charge (q) is the same across each capacitor is that of source.

$$q = q_1 = q_2 = q_3$$

The potential difference equals the sum of the charges across each capacitor.

$$V = V_1 + V_2 + V_3 + \ldots\ldots$$

Hence, capacitance is

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots$$

COMPOUND CAPACITORS:

$$C_d = \frac{A\,\epsilon_o}{(d - t) + \frac{t}{\epsilon r}}$$

Where; $(d - t)$ is the thickness of the air space.

DIFFERENT TYPES OF CAPACITORS

- **Multiplate Capacitor:**

A Multiplate capacitor consisting of large number of plates each of large area is designed to have large capacitance when N plates are used there are (N - 1) individual capacitors in parallel. Mica is the dielectric.

- **Variable Capacitor:**

A variable capacitor is used for tuning radio sets. Two sets of semicircular aluminum or brass plates separated by air.

- **Electrolytic Capacitors:**

Capacitors of large capacitance up to 1000 μF are made by using a very thin insulating layer of aluminum oxide. It consists of two sheets of aluminum equally separated by Muslin soaked in a special solution of ammonium borate.

PRACTICE SHEET # 01

1.Two charges when 10 cm apart, attracted each other with a force of (F) N. If they are placed 5cm apart, the same charges will attract each other with a force of:

A) F/2 B) F/2

C) 2F D) 4 F

2. The coulombs force between two charges is 28N. If paraffin wax of relative permittivity 2.8 is introduced between the charges as a medium, then the force reduces to:

A) 25N B) 20N

C) 15N D) 10N

3.If quantity of the charge on each of the two bodies is doubled, the force between them becomes:

A) Twice B) 4 times

C) 9times D) 16 times

4.The unit of charge in SI system is _______ while in CGS it is _________

A) Volt, Coulomb B) Ampere, Coulomb

C) Coulombs, ESU D) Watt, ESU

5.One coulomb is the quantity of charge which when placed one meter from an identical charge in vacuum (or air) will repel it with a force of:

A) 9×10^{10} N B) 9×10^{11} N

C) 9×10^{13} N D) 9×10^{9} N

6.How many electrons are there in one coulomb charge:

A) 6×10^{20} . B) 1.6×10^{18}

C) 6.25×10^{18} D) 9.1×10^{19}

7.The minimum charge on any object cannot be less than:

A) 1.0×10^{-19} C B) 1.6×10^{-19} C

C) 1.8×10^{-19}C D) 2.5×10^{-19} C

8.The space around any charge in which its influence could be felt by another charge placed there is

A) Electric field B) Magnetic field

C) Magnetic field intensity D) Electric field intensity

9.Electric field intensity E at any point due to the source charge (Q) is defined as:

A) The charge per unit time B) The force per unit positive charge

C) The force per unit area D) None of the above.

10.It is a vector quantity

A) electric potential B) electric charge

C) electric field intensity D) electric current

11.In SI unit electric field intensity is measured in

A) electric volt B) Nm^{-1}

C) NJ^{-1} D) NC^{-1}

12.The concept of electric lines was presented by

A) Newton B) Faraday

C) Einstein D) Coulomb

13.The potential at a point situated at a distance of 50cm from a charge of 5u C is

A) 9×10^{-4} volts B) 9×10^{-2} volts

C) $9 \times 10^{+4}$ volts D) none of these

14.Which of the following can be deflected by electric field

A) beta particles B) gamma rays

C) x-rays D) neutrons

15.An electric charge at rest produces

A) Only an electric field B) Only a magnetic field

C) Neither of the two fields D) Both electric and magnetic fields

16.Electric field intensity is a vector quantity and its direction is always:
A) anti parallel to the force B) perpendicular to the force
C) opposite to that of force D) along the direction of force.

17.Intensity of an electric field due to a point charge:
A) decreases inversely as the square of the distance.
B) increases directly as the square of the distance.
C) increases linearly by increasing the distance.
D) decreases inversely with the distance.

18.The force experience by a charge 10C when placed at a point is 10N. The electric field intensity at a point is:
A) 0.1 NC^{-1} B) 1 NC
C) 10 NC^{-1} D) 1 NC^{-1}

19.At an infinite distance from the electric charge, the electric intensity will be:
A) Maximum B) Infinite
C) Zero D) equal to the initial value

20.The number of electrical lines of forces passing through a certain area is called:
A) electric potential B) electric intensity
C) electric flux D) electric force

21.The dot product of electric field intensity and vector area is called:
A) electric flux B) electric intensity
C) electric potential D) electric flux density

22.Electric flux is:
A) A vector quantity B) A scalar quantity
C) Vector as well scalar quantity D) None of these

23.Electric flux through a surface depends upon
A) The electric intensity B) Area of the surface
C) Direction of the surface relative to the field. D) All of the above.

24.The current flow through a copper wire is due to the motion of
A) Neutrons B) Free electrons
C) Protons D) Protons & neutrons

25.The SI unit of electric flux is
A) Nm/C B) Nm^2/C^2
C) Nm/C^2 D) Nm^2/C

26.When angle between the surface of scalar area (ΔA) and the electric field intensity is 0^o, the flux through (ΔA) is?
A) Maximum B) (E)(ΔA)
C) Zero D) Infinity

27.When the angle between surface area ΔA and electric intensity is 90^o, the flux through ΔA is?
A) Infinite B) Maximum
C) Zero D) None of these

28.Gauss's Law is only applied to
A) A flat surface B) A curved surface
C) A closed surface D) A surface of any shape.

29.The electric flux through the surface of a sphere having a point charge at its center depends upon
A) Surface area of the shape B) Radius of shape
C) Quantity of charge inside the sphere D) All of these

30.The electric intensity inside a hollow sphere is

A) Infinite
B) Zero
C) Greater than zero
D) None of them

31.Electrons always flow from
A) Lower to Higher potential
B) Higher to Lower potential
C) Lower to Lower potential
D) Kahin bhe jaskte hn … as they are independent

32.The work done per unit charge in bringing a positive test charge from infinity to certain point in the given electric field, keeping the unit charge in equilibrium is called
A) Electrical Potential Energy
B) Potential Gradient
C) Absolute Electric Potential
D) Electric Field Intensity

33.In SI units, electric potential is measured in:
A) Coulombs
B) Ampere
C) Volts
D) NC^{-2}

34.1 Volt =
A) 1 JC^{-2}
B) 1 JC^{-1}
C) 1 JC^{1}
D) 1 NC

35.Electric potential at a distance r from a charge q is given by:
A) V(r) = 1/q
B) $V(r) = 1 / 4\pi\epsilon_0 \frac{q}{r}$
C) V(r) = F / q
D) None of these

36.The quantity ($\Delta V / \Delta r$) is called
A) Electric potential
B) Electric field intensity
C) Potential gradient
D) Electrostatic induction

37.The unit of electric field intensity "E" (N/C) is equivalent to
A) N / m
B) V / m
C) N / J
D) None of these

38.The amount of energy acquired or lost by the electrons when they are accelerated by 1 Volts Potential Difference is called:
A) 1 joule
B) 1 calories
C) 1 electron volt
D) 1 kwh

39. 1 eV=
A) 1.60×10^{-19} J
B) 1.60×10^{-11} J
C) 1.60×10^{-9} J
D) 1.60×10^{19} J

40.The earth is regarded as
A) Zero potential reference
B) Positive potential
C) Negative potential
D) Infinite potential

41.A charge of 100 micro coulomb is accelerated through a potential difference of 1000 V. It acquires energy equal to
A) 1 J
B) 10 J
C) 0.1 J
D) 0.01 J

42.A capacitor behaves as an insulator for
A) Alternating current
B) Direct current
C) Both A & B
D) None of these

43.A capacitance of a parallel plate capacitor depends upon
A) The insulating material between the plates
B) Area of the plates
C) Distance between the plates
D) All of the above

44.If a dielectric is placed between the plates of a capacitor, then its capacitance will
A) Increase
B) Decrease
C) Remain the same
D) None of these

45.Three capacitors of capacitance 2 μF each are connected in parallel. Their equivalent capacitance is:

A) 0.66 μF
B) 4 μF
C) 6 μF
D) 4.5 μF

46. Three capacitors of capacitance 3 μF each are connected in series. Their equivalent capacitance is:

A) 9 μF
B) 4 μF
C) 3 μF
D) 1 μF

47.When an insulator (dielectric material) is placed between the plates of a charged capacitor in an electric field, it:

A) Gets charged
B) Is polarized
C) Remains unchanged
D) None of these

48.The electric field between the plates of a parallel-plate capacitor is E. What is the field between the plates after immersing the capacitor in a liquid of relative permittivity 2?

A) 2 E
B) $E/\sqrt{2}$
C) $\sqrt{2}E$
D) E/2

49.Choose the incorrect relationship from the following

A) Ampere = Coulomb per Second
B) Volt = Coulomb per Joule
C) Ohm = Volt per Ampere
D) 1 Coulomb = Charge on 6.25×10^{18} electrons

50.During electrolysis the current in the electrolyte is maintained by the flow of

A) Electrons only
B) Negative ions only
C) Positive ions only
D) Both positive and negative ions

51.In an external circuit the direction of flow of conventional current is

A) Along the direction of flow of electrons
B) From negative to positive
C) From positive to negative
D) None of these

ANSWER KEY # 01

1→D	8→A	15→A	22→B	29→C	36→C	43→D	50→D
2→D	9→B	16→D	23→D	30→B	37→B	44→A	51→C
3→B	10→C	17→A	24→B	31→A	38→C	45→C	
4→C	11→D	18→D	25→D	32→C	39→A	46→D	
5→D	12→B	19→C	26→A	33→C	40→A	47→B	
6→C	13→C	20→C	27→C	34→B	41→C	48→D	
7→B	14→A	21→A	28→C	35→B	42→B	49→B	

PRACTICE SHEET # 02

1. **The value of Coulomb's constant K is:**
   a. 9×10^{-9}N-m^{2}C^{-2} b. 9×10^{9}N-m^{2}C^{-2} c. 8.85×10^{-12}N-m^{2}C^{-2} d. 8.85×10^{12}N-m^{2}C^{-2}

2. **If the distance between the two charged bodies is halved, the force between them becomes:**
   a. Doubled b. Half c. Four times d. One half

3. **The value of ε_o permittivity for free space is:**
   a. 1 b. 8.85×10^{-12}C^2(N^{-1}-m^{-2}) c. 9×10^{7}N-m^{2}C^2 d. 10^{-6} C

4. **Two charges are placed at a certain distance. If the magnitude of each charge is doubled, the force will become:**
   a. 1/4th of its original value b. 1/8th of its original value
   c. 16 times of its original value d. 4 times of its original value

5. **The electric force of repulsion between two electrons at a distance of 1 m is:**
   a. 1.8 N b. 1.5×10^{-9}N c. 2.30×10^{-28}N d. 2.30×10^{-27}N

6. **The unit of electric field strength (E) is:**
   a. Newton b. Coulomb c. Joule/coulomb d. Newton/coulomb

7. **Electric field intensity is a vector quantity and its direction is:**
   a. Perpendicular to the direction of field b. Opposite to the direction of force
   c. Along the direction of force d. At a certain angle

8. **The electric intensity at infinite distance from the point charge is:**
   a. zero b. infinite c. 1 volt-m^{-1} d. positive

9. **The electric lines of force:**
   a. Physically exist around the charges b. physically exists near the charges
   c. Physically exist everywhere d. imaginary

10. **According to the statement of Gauss's law, the flux through any closed surface:**
    a. $\phi_c = \varepsilon_o Q$ b. $\phi_c = Q/\varepsilon_o$ c. $\phi_c = \varepsilon_o/Q$ d. $\phi_c = Q^2/\varepsilon_o$

11. **If a closed surface contains two equal and opposite charges, the net electric flux from the surface will be:**
    a. Positive b. Negative c. Positive as well as negative d. Zero

12. **The magnitude of the electric intensity (E) at a point near an infinite sheet of positive charge is:**
    a. $E = \sigma/\varepsilon_o$ b. $E = \sigma/2\varepsilon_o$ c. $E = \phi_c/A$ d. $E = \varepsilon_o/\sigma$

13. **The work done in moving a unit positive charge from one point to another against the electric field is a measure of:**
    a. Intensity of electric field b. Resistance between two points
    c. Capacitance d. Potential difference between two points

14. If an electron is accelerated through a potential difference V, it will acquire energy:
a. Ve b. V/2 c. E/V d. Ve^2

15. The potential at a point situated at a distance of 50cm from a charge of 5 μC is:
a. 9×10^4volts b. 9×10^{-2}volts c. 9×10^{-4}volts d. 9×10^2volts

16. A 50 μF capacitor has a potential difference of 8V across it. The charge on the capacitor is:
a. 4×10^{-4}C b. 4×10^{-3}C c. 6.25×10^{-6}C d. 6.25×10^{-5}C

17. The value of permittivity in free space is:
a. $8.85\times10^{12}N^{-1}m^{-2}C^2$ b. $8.85\times10^{-10}N^{-1}m^2C^{-2}$
c. $8.85\times10^{10}N^{-1}m^2C^{-2}$ d. $8.85\times10^{-12}N^{-1}m^{-2}C^2$

18. The electric field intensity at a point due to a point charge:
a. Falls of inversely as the distance b. Falls of inversely as the square of distance
c. Remains unchanged with distance d. Increases directly as square of distance

19. If F represents the force between two-point charges in free space (air), then the force between the same two charges in a medium of relative permittivity ϵ_r will be:
a. F' = F b. $F' = \frac{\epsilon_r}{F}$ c. $F' = \epsilon_r F$ d. $F' = \frac{F}{\epsilon_r}$

20. The ratio of the gravitational force F_g to the electrostatic force F_e between two electrons the same distance apart is approximately:
a. 9.8 b. 24×10^{19} c. 24×10^{12} d. 24×10^{-44}

21. The force between two charges each of charge 1μC placed 1m apart in air will be:
a. 9×10^9N b. 9×10^{-12}N c. zero d. 9×10^{-3}N

22. One coulomb of charge is created by:
a. 10 electrons b. 1.6×10^{-19}electrons
c. 6.25×10^{18}electrons d. 6.25×10^{21}electrons

23. 1 kg mass of a substance is equivalent to the mass of:
a. 1.1×10^{30} electrons b. 11×10^{19} electrons
c. 1.6×10^{31} electrons d. 9.1×10^{-19} electrons

24. The SI unit of electric flus is:
a. Weber b. Nm^2C^{-1} c. NmC^{-1} d. $Nm^{-2}C$

25. When an electron is accelerated through a P.D. of one volt, it will acquire energy equal to:
a. one joule b. one erg c. one electron volt d. none of these

26. The energy stored in an electric field between the plates of a capacitor per unit volume is:
a. Energy density = $\frac{1}{2}\epsilon_o\epsilon_r E^2$ b. Energy density = $\frac{1}{2\epsilon_o}\epsilon_r E^2$
c. Energy density = $\frac{1}{2\epsilon_o\epsilon_r}E^2$ d. Energy density = $\frac{1}{2}\epsilon_o\epsilon_r E$

27. If time constant in R.C circuit is small, the capacitor is charged or discharged:
a. Rapidly b. Slowly c. At constant rate d. Intermittently

28. The electric intensity between two oppositely charged parallel plates is given by the relation:
a. $E = \frac{\sigma}{2\varepsilon_o}\hat{r}$ b. $E = \frac{1}{4\pi\epsilon_o}\frac{q}{r}\hat{r}$ c. $E = \frac{\sigma}{\epsilon_o}\hat{r}$ d. None of these

29. One joule is equal to:
a. 1.6×10^{-19} eV b. 1.6×10^{19} eV c. 6.25×10^{-18} eV d. 6.25×10^{18} eV

30. Value of dielectric constant for air or vacuum is:
a. less than one b. greater than one c. one d. zero

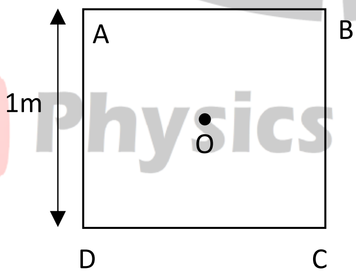
31. The electric flux through any closed surface depends upon:
a. the charge only b. the medium only
c. the medium and charge enclosed by the closed surface d. the shape of the surface

32. Two-point charges +2 coulomb and +6 coulomb repel each other with a force of 12N. If a charge of −4 coulomb is given to each of these charges, the force will be:
a. 4N (repulsive) b. 4N (attractive) c. 8N (repulsive) d. 8N (attractive)

33. The electrostatic force between two-point charges q_1 and q_2 at separation r is given by $F = \frac{Kq_1q_2}{r^2}$. The constant K:
a. Depends on the system of units only
b. Depends on the medium between the charges only
c. Depends on both the system of units and medium between the charges
d. Is independent of both the system of units and the medium between the charge

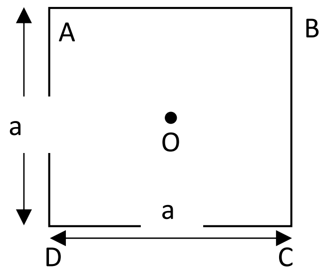
34. Three charge q, Q and 4q are placed in a straight line of length l at points distance 0, l/2 and l respectively from one end. In order to make the net force on q zero, the charge Q must be equal to:
a. −q b. -2q c. $-\frac{q}{2}$ d. q

35. Three charges, each of +4μC, are placed at the corners B, C, D of a square ABCD of side 1m. The electric field at the center O of the square is:



a. 7.2×10^4 N/C towards A b. 7.2×10^4 N/C towards C
c. 3.6×10^4 N/C towards A d. 3.6×10^4 N/C towards C

36. Four charges +q, +q, −q and −q are placed respectively at the corner A, B, C and D of a square of side a. The potential at the center O of the square is $1/4\pi\epsilon_o$ times:



a. 4q b. zero c. $\frac{4\sqrt{2}}{a}q$ d. $\frac{4\sqrt{2}q}{a}$

37. A capacitor having a capacity of 2.0 microfarad is charged up to 200V and its plates are joined to a wire. The heat produced in joule will be:

a. 4×10^{4} b. 4×10^{10} c. 4×10^{-2} d. 2×10^{-2}

38. Two capacitors of capacitances 0.3μF and 0.6μF are connected in series across a battery of 6V. The ratio of energies stored in them is:

a. ¼ b. 1/2 c. 2 d. 4

39. The SI unit of permittivity of free space (ϵ_o) is:

a. C/N-m b. $N\text{-}m^2/C^2$ c. $C^2/(N\text{-}m)^2$ d. $C^2/N\text{-}m^2$

40. An electric charge is placed at the center of a cube of side a. The electric flux through one of its faces will be:

a. $\frac{q}{6\epsilon_o}$ b. $\frac{q}{\epsilon_o a^2}$ c. $\frac{q}{4\pi\epsilon_o a^2}$ d. $\frac{q}{\epsilon_o}$

41. Two-point charges placed at a distance r in air exert a force F on each other. The value of distance R at which they experience the same force when placed in a medium of dielectric constant k is:

a. rk b. $\frac{r}{k}$ c. $\frac{r}{\sqrt{k}}$ d. $r\sqrt{k}$

42. A charged conductor has charge on its:

a. outside surface b. surrounding c. middle point d. inner surface

43. In comparison with the electrostatic force between two electrons, the electrostatic force between two protons is:

a. zero b. smaller c. same d. greater

44. No current flows between two charged bodies when connected if they have same:

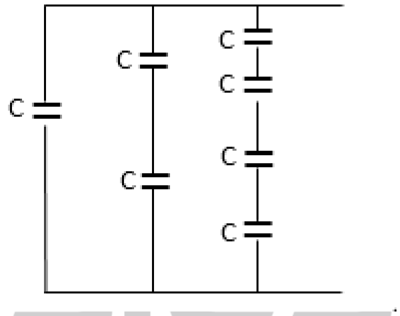
a. capacity b. charge c. potential d. none of these

45. The force between two charged particles is given by $F = \frac{1}{4\pi\varepsilon_o}\frac{Q_1Q_2}{r^2}$, where the symbols have their usual meaning. The dimensions of ε_o is free space in MKSQ system are:

a. $M^{-1}L^{2}T^{2}Q^{4}$ b. $ML^{-3}T^{4}Q^{3}$ c. $M^{-1}L^{-3}T^{4}Q^{2}$ d. $M^{-1}L^{-3}T^{2}Q^{2}$

46. **Branch of physics that deals with the study of charges at rest is called:**
   a. Electrostatics b. Electrodynamics
   c. Electromagnetism d. Modern Physics

47. **In the capacitor network shown each capacitance is C. Fine C_{eq}:**



   a. $\frac{7C}{4}$ b. $\frac{C}{2}$ c. $\frac{3C}{2}$ d. 2C

48. **A 100μF capacitor is charged to 200 volts. It is discharged through a 2Ω resistance. The amount of heat generated will be:**
   a. 0.4 J b. 0.2 J c. 2 J d. 4 J

49. **Farad is not equivalent to:**
   a. CV^2 b. J/V^2 c. Q^2/J d. Q/V

50. **The distance between the plates of a parallel plate air condenser is d. If the distance between the plates is reduced by half, then the new capacitance will become:**
   a. doubled b. half c. one fourth d. remain unchanged

51. **The number of electrons in one coulomb charge is equal to:**
   a. 6.2×10^{18} b. 1.6×10^{-19} c. zero d. 6.2×10^{21}

52. **In Coulomb's Law, the SI unit of constant of proportionality $k = 1/4\pi\epsilon_o$ is:**
   a. N b. N–m^2 c. Nm^2/C^2 d. NC^2/m^2

53. **The magnitude of $1/4\pi\epsilon_o$ is:**
   a. 9×10^9 b. 9×10^{-9} 8.85×10^{-12} d. 8.85×10^{12}

54. **When a solid body is negatively charged by friction, it means that the body has:**
   a. Acquired excess of electron
   b. Lost some protons
   c. Acquired some electron and lost a lesser number of protons
   d. Lost some positive ions

55. **A suitable unit for expressing electric field strength is:**
   a. V/C b. A-m c. C/m^2 d. N/C

56. **A force of 0.01N is exerted on a charge of 1.2×10^{-5} C at a certain point. The electric field at that point is:**
   a. 5.3×10^4 N/C b. 8.3×10^4 N/C c. 5.3×10^2 N/C d. 8.3×10^2 N/C

57. The electric intensity at a point 20 cm away from a charge of 2×10^{-5} C is:
a. 4.5×10^{6} N/C b. 3.5×10^{5} N/C c. 3.5×10^{6} N/C d. 4.5×10^{5} N/C

58. Work done is moving a unit positive charge through a distance of x meter on an equipotential surface is:
a. x joule b. 1/x Joule c. zero d. x^2 Joule

59. Two charges are placed at a certain distance apart in vacuum. If a slab is placed between them, the force between them:
a. Will increase
b. Will decrease
c. Will remain unchanged
d. May increase or decrease depending on the material of the slab

60. Four electric charges A, B, C, D are arranged as shown. The electric force will be least between charges:

a. A and B b. A and D c. B and D d. A and C

61. A and B are two points in an electric field. If the work done in carrying 4.0 coulomb of the electric charge from A to B is 16.0 joule, the potential difference between A and B is:
a. zero b. 2.0 V c. 4.0 V d. 16.0 V

62. Two particles having charges Q_1 and Q_2, when kept at a certain distance, exert a force F on each other. If the distance between the two particles is reduced to half and the charge on each particle is doubled, the force between the particles would be:
a. 2F b. 4F c. 8F d. 16F

63. A positively charged particle of mass m kg and charge Q coulomb travels from rest through a P.D of V volt. Its kinetic energy in joule is:
a. QV b. mQV c. mQ/V d. m/QV

64. Equal charges are given to two spheres of different radii. The potential will be:
a. More on smaller sphere b. More on bigger sphere
c. Equal on both the spheres d. Dependent on nature of material of the spheres

65. An electron volt is equal to:
a. 0.62×10^{13} J b. 1.6×10^{-13} J c. 0.62×10^{19} J d. 1.6×10^{-19} J

66. Two-point charges +2 coulomb and +6 coulomb repel each other with a force of 12N. If a charge of −2 coulomb is given to each of these charges, the force will now be:
a. zero b. 8N (attractive) c. 8N (repulsive) d. none of these

67. A hollow sphere of copper is positively charged. Then the electric field inside the sphere is:
a. the same as the field at the surface b. greater than the field at the surface
c. less than the field at the surface, but not zero d. zero

68. A and B are two points in an electric field. If 8.0 joule of work is done is taking 2.0 coulomb of electric charge from A and B, then the potential difference between A and B is:
a. zero b. 2.0 V c. 4.0 V d. 16.0V

69. Electric lines of forces about a negative point charge are:
a. circular, anticlockwise b. circular, clockwise
c. radial, inwards d. radial, outwards

70. Two plates are 1 cm apart and the potential difference between them is 10V. The electric field between the plates is:
a. 10N/C b. 250N/C c. 500 N/C d. 1000 N/C

71. As the electric charge on the surface of a hollow metal sphere increases, the electric field intensity inside the sphere:
a. Decreases
b. Increases
c. Remains the same
d. May increase or decrease depending on the radius of the sphere

ANSWER KEY # 02

1.	B	31.	C	61.	C
2.	C	32.	B	62.	D
3.	B	33.	C	63.	A
4.	D	34.	A	64.	A
5.	C	35.	A	65.	D
6.	D	36.	B	66.	A
7.	C	37.	C	67.	D
8.	A	38.	C	68.	C
9.	D	39.	D	69.	C
10.	B	40	A	70	D
11.	D	41.	D	71.	C
12.	B	42.	A	72.	
13.	D	43.	C	73.	
14.	A	44.	C	74.	
15.	A	45.	D	75.	
16.	A	46.	A	76.	
17.	D	47.	A	77.	
18.	B	48.	C	78.	
19.	D	49.	A	79.	
20.	D	50.	A	80.	
21.	D	51.	A	81.	
22.	C	52.	C	82.	
23.	A	53.	A	83.	
24.	B	54.	A	84.	
25.	C	55.	D	85.	
26.	A	56.	D	86.	
27.	A	57.	A	87.	
28.	C	58.	C	88.	
29.	D	59.	B	89.	
30.	C	60.	D	90.	

CHAPTER # 13: CURRENT ELECTRICITY

ELECTRIC CURRENT

"The charge per unit time passing through any cross section of a conductor is called electric current".

If a net charge 'ΔQ' passes through any cross section of a conductor in time Δt, the magnitude of the current I is

$$I = \frac{\Delta Q}{\Delta t}$$

Units:

The SI unit of current is an ampere (A) or Coulomb per second (CS^{-1}).

Ampere

The current is one ampere, when one coulomb of charge passes in one second through the cross section of conductor:

i.e. $$1 \text{ ampere} = \frac{1 \text{ coulomb}}{1 \text{ second}}$$

Note:

- Electric current flows in closed circuit only. In order to cause electric charge, move in the circuit, electromotive force or PD is required between the positively and negatively charged plates.
- Electric current passing through any conductor is due to the motion of charge particles generally known as charge carrier.
- In case of metallic conductors, the charge carriers are electrons.
- The charge carriers in electrolyte (liquids) are positive and negative ions, e.g. in a $CUSO_4$ solution the charge carriers are Cu^{++} and SO_4^{--} ions.
- In gases the charge carriers are electrons and ions.

CONVENTIONAL CURRENT (Imaginary Current)

The conventional current in a circuit is defined as,

"The current which passes from a point at higher potential to a point at lower potential, as if it represented a movement of positive charges".

ELECTRONIC CURRENT (Actual Current)

"The electric current through a conductor in which free electrons of the conductor drift from lower potential, (negative terminal) to a higher potential (positive terminal) opposite to the direction of applied field, is called electronic current".

DRIFT VELOCITY

"Additional component of velocity gained by free electrons inside the metallic conductor, in opposite direction of $\vec{E}$, when steady current flows through the conductor, is called drift velocity"

The value of drift velocity depends upon the value of electric field $\vec{E}$ (set up inside the metallic conductor) and it depends upon the lattice structure of metallic conductor. Magnitude is 0.01 meters per second. Drift velocity attained by the free electrons is responsible for the generation of electric current in the wire.

$$v = \frac{I}{eAn}$$

I=current, e=electronic charge, A= cross sectional area, n= Charge Density (Number of electrons per unit volume of the conductor)

EFFECTS OF CURRENT

The presence of electric current can be detected by the various effects which it produces.

The following are the effects caused by electric currents.

- **Heating Effect**
  The heat 'H' produced by the current 'I' in the wire of resistance 'R' during a time interval 't' is given by,
  $$H = I^2Rt$$
  The heating effect of current is utilized in electric heater, kettle, toaster and electric iron etc.

- **Magnetic Effect**
  The electric current passing through a conductor produces magnetic field in the region around it. The strength of the field depends upon the value of current and the distance from the current element.
  Magnetic effect is utilized in the detection and measurement of current. All machined involving electric motors also use the magnetic effect of current.

- **Chemical Effect**
  Certain liquids such as dilute sulphuric acid and copper sulphate are used as electrolyte. Which conduct electricity due to some chemical reactions that take place within them. The study of this process is known as electrolysis.

OHM'S LAW

This law states that,

"The current flowing through a conductor is directly proportional to the potential difference across its ends provided the resistance of the conductor remains constant".

Symbolically Ohm's law can be written as,

$$I \propto V$$

$$I = KV$$

$$V = IR$$

Where, 'R' is the constant of proportionality, called as the resistance of the conductor (Unit is Ohms). While, 'K' is the conductance of the conductor (Unit is Mho, Siemens, Ohm^{-1}).

ELECTRICAL RESISTANCE

It is defined as,

"The opposition offered by the conductor to flow of electric current through it".

The value of the resistance depends upon the nature, dimensions and physical state of the conductor.

To define electrical resistance, we use the mathematical expression of Ohm's law as;

$$R = \frac{V}{I}$$

Units:

The SI unit of resistance is ohm. It is represented by a Greek letter Ω.

Ohm

The resistance of a conductor is one ohm if a current of one ampere flows through it when a potential difference one volt is applied across its ends.

i.e.
$$\text{One ohm} = \frac{\text{One volt}}{\text{One ampere}}$$

OR

$$1\,\Omega = \frac{1\,V}{1\,A}$$

Ohmic and Non – Ohmic Devices

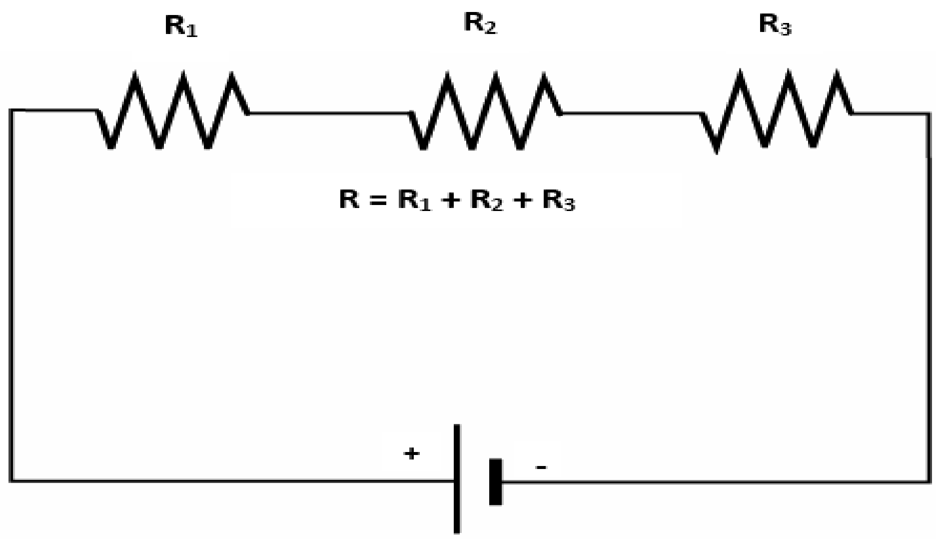
Such devices for which Ohm's law hold good (Resistance is constant) are called Ohmic, whereas the materials which do not obey ohm's law are called Non – Ohmic (Resistance is variable).

SERIES AND PARALLEL COMBINATION OF RESISTORS

In an electrical circuit, usually a number of resistors are connected together. There are two arrangements in which resistors can be connected with each other, one is known as series arrangement and other is known as parallel arrangement.

- **Resistors in Series**

  In series combination, the Resistors are connected end to end as shown in figure.



In this case, the same current I flow through all resistors. Therefore, the PD across each resistor is given by Ohm's law:

$$V_1 = IR_1,\ V_2 = IR_2 \text{ and } V_3 = IR_3$$

The total potential drop across the series combination of R_1, R_2 and R_3 is given by:

$$V = V_1 + V_2 = V_3$$

OR

$$IR = I_1R_1 + I_2R_2 + I_3R_3$$

$$R = R_1 + R_2 + R_3$$

Thus, the equivalent resistance for a series combination is equal to the sum of all the resistances connected in series.

- **Resistors in Parallel**

In parallel arrangement a number of resistors are connected side by side with their ends joined together at common points (Bundled together / Shunted together).

In parallel combination of three resistances, the value of electric current passing through individual resistance is not same. It is divided into three parts, I_1, I_2 and I_3 flowing through the resistors R_1, R_2 and R_3 respectively, such that,

$$I = I_1 + I_2 + I_3 \ldots\ldots \text{(i)}$$

The same value of PD across each resistance is written by using Ohm's law as follow,

$$\text{P.D. across } R_1 = V = I_1R_1$$
$$\text{P.D. across } R_2 = V = I_2R_2$$
$$\text{P.D. across } R_3 = V = I_3R_3$$

Therefore, we can write,

$$I_1 = \frac{V}{R_1},\ I_2 = \frac{V}{R_2} \text{ and } I_3 = \frac{V}{R_3}$$

Putting, these values in eq (i) we can get,

$$I = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

OR

$$\frac{I}{V} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

OR

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ (\because V = IR)$$

Thus, the reciprocal of equivalent resistance for a parallel combination is equal to the sum of the reciprocals of all the resistances connected in parallel.

Note:

1. If 'n' number of resistances are connected in series than equivalent resistance R_e is given by,
$$R_e = R_1 + R_2 + R_3 + \ldots + R_n$$
2. If 'n' number of resistances are connected in series than equivalent resistance R_e is given by,
$$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots\ldots + \frac{1}{R_n}$$

RESISTIVITY

Definition:

Resistivity is defined as,

"The resistance wire having unit cross sectional area and unit length" OR "Resistance of Unit Cube is defined as Resistivity"

$$\rho = \frac{RA}{L}$$

Units:

The unit of resistivity is ohm meter Ω m.

CONDUCTANCE

"The ability of the circuit to conduct electricity is called conductance".

In fact, conductance is the reciprocal of resistance i.e.

$$\text{Conductance} = \frac{1}{\text{Resistance (R)}}$$

The unit of conductance is ohm or Siemens.

CONDUCTIVITY

The opposite of resistivity is known as conductivity of the material. It is denoted by σ. If ρ is resistivity of a material then its conductivity is given by:

$$\sigma = \frac{1}{\rho}$$

The SI unit of conductivity are $ohm^{-1}m^{-1}$ or ohm m^{-1}.

EFFECT OF TEMPERATURE ON RESISTANCE AND RESISTIVITY

The resistance and resistivity of a substance depends upon the temperature.

We know that the resistance offered by a conductor to a flow of electric current is due to the collisions of the free electrons with the atoms of the lattice.

As the temperature of the conductor rises, atoms in its lattice vibrate with large amplitude and hence the chances of the collisions between the free electrons and atoms increases.

Temperature Co efficient of Resistance

Let R_0 be the resistance of conductor at 0 °C and R_t be its resistance at temperature 't'°C

$$\alpha = \frac{R_t - R_0}{R_0 t}$$

It is formula for temperature coefficient of resistance. It is defined as,

"The change in resistance per unit original resistance per unit charge in temperature".

Units:

The unit of temperature of coefficient of resistance is C^{-1} or K^{-1}.

Temperature Co efficient of Resistance in terms of Resistivity

$$\alpha = \frac{\rho_t - \rho_0}{\rho_0 t}$$

When $'\rho_0'$ Is the resistivity 0°C and $'\rho_t'$ is the resistivity at t°C.

THERMISTORS

"There are temperature dependent resistors, are called thermistors".

Most thermistors have negative co efficient of resistance, i.e., the resistor of such thermistors decreases when their temperature is increased. Thermistors with positive temperature co efficient are also available.

ELECTRICAL POWER AND POWER DISSIPATION IN RESISTORS

Electrical Power:

"The rate at which the battery is supplying electrical energy is called electrical power of the battery".

OR

$$\text{Electrical Power} = \frac{\text{Energy}}{\text{Time}}$$

OR

$$\text{Electrical Power} = \frac{(V)(\Delta Q)}{\Delta t}$$

OR

$$\text{Electrical Power} = VI \quad \left(\because I = \frac{\Delta Q}{\Delta t}\right)$$

It is the general relation for the power delivered by the battery to an external circuit.

The power supplied by the battery is lost in the resistor. By the principle of conservation of energy, the power dissipated across a resistor is same as supplied by the battery i.e.,

$$\text{Power dissipated } (P) = VI$$

Alternative equations for calculating power are given as:

$$P = VI$$

OR

$$P = V\left(\frac{V}{R}\right) \qquad (\because V = IR)$$

$$P = \frac{V^2}{R}$$

We can also write power dissipated in a resistor as:

$$P = I^2R$$

Unit:

If V is expressed in volts and I in amperes the power is expressed in "Watts".

ELECTROMOTIVE FORCE

- The energy required to drive the charge around the circuit is called electromotive force.
- When battery is being discharged (supplying a load):

$$E = IR + Ir.$$

- The potential difference between the two terminals of the battery is V.
- When battery is being driven as a load (Charging Phase)

$$V_T = E + Ir$$

- In an open circuit, when no potential drop occurs across internal resistance is given as $V_T = E$.

MAXIMUM POWER OUTPUT

$$P_{out} = \frac{E^2R}{(R-r)^2+4Rr}$$

It is the formula for power output of the cell or battery of EMF (E)

Special Case

When R = r,

The value of denominator becomes minimum. Thus, value of the power output becomes maximum possible,

$$(P_{out})_{max} = \frac{E^2\,r}{4r^2}$$

OR

$$(P_{out})_{max} = \frac{E^2}{4r}$$

KIRCHHOFF'S FIRST RULE

It states that the sum of the currents meeting at a point in the circuit is zero.

Mathematically, it can be expressed as:

$$\Sigma I = 0$$

Using, the equation Kirchhoff's first rule can be stated in other words as:

"The sum of all the currents flowing towards a point equal to the sum of all the currents flowing away from the point".

Note:

The Kirchhoff's first rule is also called,

"Law of conservation of electric charge"

It is also known as junction or point rule.

If there is no sink or source of charge at the point, the total charge flowing towards a point is equal to the sum of all the currents flowing away from the point".

KIRCHHOFF'S SECOND RULE

"This law states that the algebraic sum of voltage changes in a loop or circuit is equal to zero".

OR

"The algebraic sum of potential changes for a complete circuit is zero".

According to Kirchhoff's 2nd rule $\Sigma V = 0$

Note:

The Kirchhoff's second rule is also called,

"Law of conservation of energy"

PRACTICE SHEET # 01

1. **One coulomb per second is equal to:**
   a. One Volt b. One Ampere c. One-Watt d. One Ohm
2. **The graphical representation of Ohm's law is:**
   a. Hyperbola b. Ellipse c. Parabola d. Straight line
3. **The resistance of a conductor of length L, cross-sectional area A and resistivity ρ is given by:**
   a. $R = \rho A/L$ b. $R = \rho L/A$ c. $R = \rho/LA$ d. $R = A/\rho L$
4. **The resistance of a unit meter cube of the substance is called:**
   a. Conductivity b. Permittivity c. Resistivity d. Susceptibility
5. **A wire of uniform area of cross-section 'A', length L and resistance R is cut into two equal parts. The resistivity of each part:**
   a. Is doubled b. Remains the same c. Is halved d. Is one-fourth
6. **The fractional change in resistivity per unit original resistivity per Kelvin is known as:**
   a. Temperature co-efficient of resistance
   b. Temperature co-efficient of conductance
   c. Temperature co-efficient of conductivity
   d. Temperature co-efficient of resistivity
7. **Heat energy dissipated in a resistor (R) when connected to a battery of (V) volts and current (I) ampere flowing through it for time (t) is given by:**
   a. I^2R b. IRt c. VIt d. V^2/Rt
8. **The resistance of a 60-watt bulb in a 120-volt line is:**
   a. 20 ohms b. 0.5 ohms c. 240 ohms d. 2.0 ohms
9. **Drift velocity of electrons in a conductor is of the order of:**
   a. $10^{-3}\ ms^{-1}$ b. $10^{3}\ ms^{-1}$ c. None d. $10^{4}\ ms^{-1}$
10. **Kirchhoff's first rule is the manifestation of law of conservation of:**
    a. Mass b. Energy c. Momentum d. Charge
11. **Which one of the following statements is correct?**
    a. The current flowing from the negative towards positive terminal of the battery is called electronic current.
    b. Electronic current is constituted by the flow of electrons
    c. Electronic current always flows from a lower to higher potential
    d. All the above
12. **The temperature coefficient of resistance is expressed as:**
    a. $\alpha = \frac{R_t - R_o}{R_o t}$ b. $\alpha = \frac{R_t - R_o}{t}$ c. $\alpha = \frac{R_t - R_o}{R_t t}$ d. $\alpha = \frac{R_t t}{R_t - R_o}$
13. **The resistance of a conductor one metre in length and one square metre in area of cross-section is called its:**
    a. Reactance b. Conductance c. Resistivity d. Conductivity
14. **If a wire of resistance R is stretched to double its length, its resistance becomes:**
    a. $\frac{R}{2}$ b. 4R c. 2R d. $\frac{R}{4}$
15. **The amount of heat energy displaced in a resistance is directly proportional to:**
    a. The square of the current only
    b. The resistance of conductor only
    c. The time of current flow only
    d. The square of the current, resistance and time of current flow
16. **Kirchhoff's second rule (KVL) is related to:**
    a. IR drops b. Battery EMFs c. Junction voltages d. Both (a) & (b)
17. **Resistance of a conductor depends upon:**
    a. The quantity of current passing through it

b. The voltage applied between its ends
c. Its dimensions, physical state and nature of material
d. All of the above

18. A flow of 10^7 electrons per second in a conduction wire constitutes a current of:
a. 1.6×10^{-26} A b. 1.6×10^{12} A c. 1.6×10^{-12} A d. 1.6×10^{26} A

19. Which of the following statements is not true?
a. Conductance is the reciprocal of resistance and is measured in Siemens
b. Ohm's law is not applicable at very low and very high temperature
c. Ohm's law is applicable to semiconductors
d. Ohm's law is not applicable to electron tubes, discharge tubes and electrolytes

20. Kirchhoff's first law, i.e., $\sum I = 0$ at a junction, deals with conservation of:
a. charge b. energy c. momentum d. angular momentum

21. Kirchhoff's second law, i.e., $\sum V = 0$ in a closed loop, deals with conservation of:
a. charge b. energy c. momentum d. angular momentum

22. The resistivity of a wire depends on its:
a. length b. area of cross-section
c. shape d. material and temperature

23. The conductivity of a superconductor is:
a. infinite b. very large c. very small d. zero

24. Ampere-second stands for the unit of:
a. EMF b. energy c. charge d. power

25. Two unequal resistances are connected parallel across a battery. Which of the following statement is true?
a. same current will flow through both resistances
b. current through smaller resistance is higher
c. current through larger resistance is higher
d. current can be higher in any resistance depending on EMF of the cell

26. A 100 W bulb rated at 220 V is connected to a 110 V supply. The power consumed is nearly equal to:
a. 100 W b. 50 W c. 25 W d. 12.5 W

27. The heating element of an electric heater should be made of a material which should have:
a. high specific resistance and high melting point
b. low specific resistance and low melting point
c. high specific resistance and low melting point
d. low specific resistance and high melting point

28. You are given three bulbs of 25, 40 and 60 watts. Which of them has lowest resistance?
a. 25 W bulb b. 40 W bulb c. 60 W bulb d. none of these

29. The maximum current that can be allowed to pass through 100 W / 250 V lamp is:
a. 0.25 A b. 0.40 A c. 2.5 A d. 1.00 A

30. If a charge 'Q' flows through any cross-section of the conductor in time 't' second, the current 'I' is given by:
a. $I = Qr$ b. $I = Q/t$ c. $I = t/Q$ d. $I = Q^2/t$

31. A steady current is flowing in a conductor of non-uniform cross-section. The charge passing through any cross-section per unit time is:
a. Directly proportional to the area of cross-section
b. Inversely proportional to the area of cross-section
c. Proportional to square of the area of cross-section
d. Independent of the area of cross-section

32. A copper wire of length 4m and area of cross-section 3.4×10^{-6} m² has a resistance of 2×10^{-2} ohm. The resistivity of copper is:

a. 1.7×10^{-8} ohm-metre b. 1.9×10^{-8} ohm-metre
c. 2.1×10^{-7} ohm-metre d. 2.3×10^{-7} ohm-metre

33. If the length of a wire is made three times and its cross-section is also tripled, then its resistance will:
a. Become four times b. Become one-fourth
c. Become two times d. Remain unchanged

34. Two wires of the same material have length 6cm and 10cm and radii 0.5mm and 1.5mm respectively. They are connected in series across a battery of 32V. The P.D. across the shorter wire is:
a. 5V b. 13.5V c. 10V d. 27V

35. The specific resistance of a wire:
a. varies with its length b. varies with its cross-section
c. varies with its mass d. does not depend on its length or cross-section

36. A current of 8.0 A is flowing in a conductor. The number of electrons passing through any cross-section per second is:
a. 5×10^{19} b. 3×10^{20} c. 7.68×10^{19} d. 7.68×10^{30}

37. A wire of length 5m and radius 1mm has a resistance of 1Ω. What length of a wire of the same material but of radius 2mm will also have a resistance of 1Ω?
a. 1.25m b. 2.5m c. 10m d. 20m

38. A current of 4.0 A passes through a cell of EMF 3.0V, having internal resistance 0.15Ω. The potential difference, in volts, across the ends of the cell will be:
a. 2.70 b. 3.00 c. 1.20 d. 2.40

39. The resistances R_e and R_t a metallic wire at temperatures 0^oC and t^oC are related as (α is the temperature coefficient of resistance):
a. $R_t = R_o(1 + \alpha t)$ b. $R_t = R_o(1 - \alpha t)'$ c. $R_t = R_o^2(1 + \alpha t)$ d. $R_t = R_o^2(1 - \alpha t)$

40. The reciprocal of specific resistance is:
a. conductive resistance b. specific conductance
c. conductive reactance d. plate resistance

41. Metals are good conductors of Electricity than insulator because:
a. Their atoms are relatively apart b. They contain free electrons
c. Their atoms collide frequently d. They have reflecting surface

42. The current density vector due to flow of electrons (Use eqn. of Drift Velocity):
a. +nev b. –nev c. nv/e d. ev/n

43. When no current is through a conductor:
a. The average of thermal velocities of all the free electrons at an instant is zero
b. The free electrons do not move
c. The average speed of a free electron over a large period of times is zero
d. None of these

44. In a dry cell electrical energy is obtained due to the conversion of:
a. Mechanical energy b. Heat energy
c. Chemical energy d. Solar energy

45. In an alternating current generator electrical energy is obtained due to the conversion of:
a. Mechanical energy b. Heat energy
c. Chemical energy d. Solar energy

46. The equivalent resistance of a series combination of resistance is:
a. Lower than the highest resistance b. Higher than the highest resistance
c. Lower than the lowest resistance d. Higher than the lowest resistance

47. Two unequal resistances are connected in series across a battery. Which of the following statement is true?
a. Potential difference across each resistance is same
b. Potential difference can be higher or lower in any resistance depending upon E.M.F. of the battery

c. Potential difference across smaller resistance is higher
d. Potential difference across smaller resistance is lower

48. The appropriate material to be used in the construction of resistance boxes out of the following is:
a. Copper b. Iron c. Manganin d. Aluminum

49. As the temperature of a metallic conductor increases its resistivity and conductivity change. The ratio of resistivity to conductivity:
a. Increases
b. Decreases
c. Remain constant
d. May increase or decrease depending on the actual temperature

50. As the temperature of a metalloid conductor (Semi-Conductor) increases, its resistivity and conductivity change. The ratio of resistivity to conductivity:
a. Increases
b. Decreases
c. Remain constant
d. May increase or decrease depending on the actual temperature

51. The resistance of a wire of uniform diameter d and length L is R. the resistance of another wire of the same material but diameter 3d and length 9L would be:
a. R/9 b. R/3 c. R d. 3R

52. Which of the following quantities do not change when a resistor connected to a battery is heated due to the current?
a. Drift speed b. Resistivity
c. Resistance d. Number of free electrons

53. The equivalent resistance of a parallel combination of resistance is:
a. Higher than the highest component resistors
b. Less than the lowest component resistors
c. In between the lowest and highest of components resistors
d. Equal to some of the component resistors

54. In order to obtain maximum resistance from some given resistors, they should be joined in:
a. parallel b. series
c. mixture of series and parallel combinations d. none of these

55. If R_1 and R_2 are the filament resistance of 200 watt and 100 watt bulb respectively, both designed to run at the same voltage, then:
a. R_1 is four times R_2 b. R_2 is four times R_1
c. R_1 is two times $3R_2$ d. R_2 is two times R_1

56. Ohm's law does not hold good for:
a. Current through an N-P-N transistor b. Current through a column of mercury
c. Current flowing in a diode value d. A and C both

57. The reciprocal of specific resistance is:
a. Conductive resistance b. Conductivity (Specific Conductance)
c. Conductive reactance d. Plate resistance

58. If the resistance of a material increases with increase in temperature then it is a:
a. Metal b. Insulator c. Semiconductor d. Semi-metal

59. The S.I unit of resistivity is:
a. Ohm b. Ohm/m c. Ohm-m d. Ohm-m^2

60. The current through a metallic conductor is due to the motion of:
a. Free electrons b. protons
c. neutrons d. still under controversy

61. Resistance of a conductor depends upon:
a. nature of conductor b. dimension of conductor
c. physical state of the conductor d. all of the above

62. A wire having very high value of conductance is said to be:

a. very good conductor
b. moderately good conductor
c. an insulator
d. no specific criterion available

63. Production of heat due to an electric current flowing through a conductor is given by:

a. Bilal's effect
b. Joule Thomson's effect
c. Compton's effect
d. seebeck effect

64. When same current passes for the same time through a thick and thin wire:

a. more heat is produced in thick wire
b. more heat is produced in thin wire
c. no heat is produced in wire
d. equal heat is produced in thick & thin wire

65. Thermocouples convert:

a. heat energy into electrical energy
b. heat energy into light energy
c. heat energy into mechanical energy
d. mechanical energy into heat energy

66. An electric heater draws a current of 4A from a 250V supply when operating normally, how long would it take the heater to convert 400000 J of electrical energy:

a. 400 sec
b. 1000 sec
c. 4000 sec
d. 1600 sec

67. An immersion heater of 400 watts kept on for 5 hours will consume electrical energy of:

a. 2KWh
b. 20KWh
c. 6KWh
d. 12KWh

68. Resistance of a super conductor is:

a. finite
b. infinite
c. zero
d. changes with every conductor

69. Resistance of an ideal insulator is:

a. infinite
b. zero
c. finite
d. depends upon nature

70. Which of the following describe the EMF of a cell:

a. the difference in energy between that needed to drive unit charge through the load resistors and through cell
b. the energy used to drive the unit charge through all load resistors in the circuit
c. the energy used to drive the unit charge through the resistance of the cell
d. the total energy used to drive unit charge round complete circuit

71. Reciprocal of resistivity is called:

a. Resistance
b. Inductance
c. Conductivity
d. Flexibility

72. Circuit which gives continuously varying potential is called:

a. complex network
b. wheat some bridge
c. potential divider
d. all of above

73. Which out of the following can be used as the unit of energy:

a. watt x second
b. volt x meter
c. volt/coulomb
d. newton/meter

74. Resistance of a metallic wire on increasing its temperature will:

a. increase
b. decrease in rise in temperature
c. will remain same
d. depends upon altitude of experimentation

75. Specific resistance of a wire:

a. will depend on its length
b. will depend on its radius
c. will depend on the type of material of the wire
d. will depend on none of the above

76. An electric iron is marked 20 volts/500W. The units consumed by it in using if for 24 hours will be:

a. 12
b. 24
c. 5
d. 1100

77. In liquids and gases, the current is due to the motion:

a. negative charges b. positive charges
c. both negative and positive charges d. neutral particles

78. A 100W, 200V bulb is connected to a 160V supply. The actual power consumption would be:

a. 64W b. 72W c. 100W d. 90W

79. * The lower part of the cloud has positive. The cloud discharges in flash of lighting, in which direction do electrons and conventional current flow

	Electron flow	Conventional current
a	Downwards	downwards
b	Upwards	Downwards
c	Downwards	upwards
d	Upwards	upwards

80. The resistance of a metallic conductor at absolute zero (0K) is:

a. zero almost b. infinite almost
c. no prediction at all d. may increase or decrease

81. Why should a resistance be introduced in a circuit in series deliberately?

a. to increase current b. None
c. to control current d. just to give a good luck to current

82. For commercial purposes electrical energy is measured in:

a. watt hour b. horse power c. kilo watt d. kilowatt

83. Electrical energy is converted into heat at the rate of:

a. IRt b. I^2R c. I^2Rt d. VIt

84. Which one of the following bulbs has the least resistance?

a. 100 watt b. 200 watt c. 300 watt d. 60 watt

85. A fuse is placed in series with the circuit to protect against:

a. high power b. high voltage c. high current d. over heating

86. If 1 ampere current flows through 2m long conductor, the charge flow through it in 1 hour will be:

a. 3600C b. 7200C c. 1C d. 2C

87. A current of 25A is passing through a metallic wire of cross-section area 4 x 10^{-6} m^2. If the density of the charge carries in the wire is 5 x 10^{26}/m^3, the drift velocity of the electrons is:
(Eqn. of Drift Velocity is: I=VenA)

a. 5/16 ms^{-1} b. 5/32 ms^{-1} c. 5/64 ms^{-1} d. 5/128ms^{-1}

88. When current I flows through a wire, the drift velocity of the electrons is υ. When current 2I flows through a wire of the same material having double the length and cross-section area, the drift velocity of the electron will be:

a. υ/4 b. υ/2 c. υ d. 2 υ

89. Slope of Ohms law graph represents:

a. Conductance b. Resistance c. None d. Both

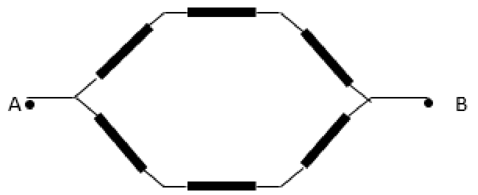
P.S: All Questions That Are Marked with (*) Are Placed to Clear the Concepts. You Can Ignore Them (If You Want to) As They Will Never Come in an Aptitude Exam.

ANSWER KEY # 01

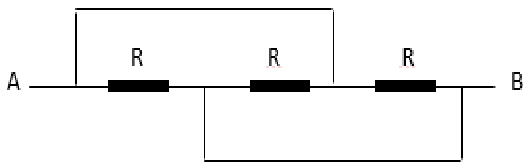
1	B	31	A	61	D
2	D	32	A	62	A
3	B	33	D	63	B
4	C	34	D	64	B
5	B	35	D	65	A
6	D	36	A	66	A
7	C	37	D	67	A
8	C	38	D	68	C
9	A	39	A	69	A
10	D	40	B	70	D
11	D	41	B	71	C
12	A	42	B	72	C
13	C	43	A	73	A
14	B	44	C	74	A
15	D	45	A	75	C
16	D	46	B	76	A
17	C	47	D	77	C
18	C	48	C	78	A
19	C	49	A	79	B
20	A	50	B	80	A
21	B	51	C	81	C
22	D	52	D	82	D
23	A	53	B	83	B
24	C	54	B	84	C
25	B	55	D	85	C
26	C	56	D	86	A
27	A	57	B	87	C
28	C	58	A	88	C
29	B	59	C	89	A
30	B	60	A	90	-

PRACTICE SHEET # 02

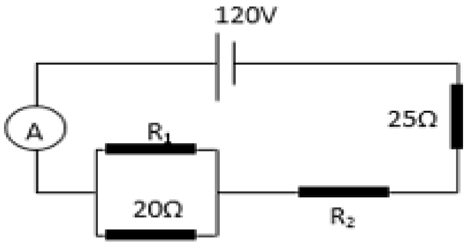
1. **If the resistors are connected in parallel, then:**
   a. The current through each is the same
   b. The total resistance is the sum of individual resistors
   c. The voltage across each is the same
   d. The total resistance is the product of the individual resistors
2. **Three resistance 5000, 500 and 50 ohms are connected in series across 555 volts mains. The current flowing through them will be:**
   a. 1 A b. 100 mA c. 10 mA d. 10 A
3. **The electromotive force of a battery or cell is the voltage between its terminals when:**
   a. The circuit is open b. The circuit is closed
   c. Its internal resistance is minimum d. Its internal resistance is maximum
4. **The SI unit of electromotive force is:**
   a. Coulomb per second b. Joule per coulomb
   c. Coulomb per volt d. Volt per ampere
5. **Six identical resistors, each of 1 ohm, are connected as shown. The equivalent resistance between A and B is:**



   a. 1 Ω
   b. 1.5 Ω
   c. 2.5 Ω
   d. 3.0 Ω
6. **N identical resistors each of resistance R are connected in parallel. The equivalent resistance of the combination will be:**
   a. NR b. $\frac{R}{N}$ c. $\frac{N}{R}$ d. None of these
7. **Terminal P.D. of a battery of internal resistance (r) and E.M.F. (E) is:**
   a. $V_t = E + Ir$ b. $V_t = E - Ir$ c. $V_t = \frac{E-r}{r}$ d. $V_t = \frac{E-r}{t}$
8. **Three resistors each of one ohm are connected to form triangle. The resistance between any two terminals is:**
   a. $\frac{2}{3}\,\Omega$ b. $\frac{3}{2}\,\Omega$ c. 3 Ω d. 1 Ω
9. **Two resistance, 4Ω and 6Ω, are is series and a 10Ω resistor is in parallel to the combination. The resultant resistance is:**
   a. 5Ω b. 8Ω c. 12Ω d. 20Ω
10. **Electromotive force is most closely related to:**
   a. electric field b. magnetic field c. potential difference d. mechanical force
11. **In given network the equivalent resistance between A and B is:**



   a. R Ω
   b. R/3 Ω
   c. 3R Ω
   d. 2R/3 Ω
12. *** In the given circuit, the P.D. across R_2 is 40V and the ammeter reads 2A. The value of R_1 is:**



a. 20 Ω
b. 60 Ω
c. 40 Ω
d. 80 Ω

13. Combining the five resistances each of value $\frac{1}{5}$ ohm, the maximum resistance that can be obtained is:
a. 1 ohm b. ½ ohm c. 2/5 ohm d. none of these

14. A man has five resistors each of value 1/5 ohm. The minimum resistance he can obtain by combining them is:
a. 1/50 ohm b. 1/25 ohm c. 1/10 ohm d. none of these

15. A resistance of 6 ohms is connected in series with another resistance of 4 ohm across a battery of 20V. The P.D. across the 6 ohms resistance is:
a. 3V b. 6V c. 9V d. 12V

16. Three resistors of 2 ohm, 3 ohm and 5 ohm are connected in parallel across a battery of 10V and of negligible internal resistance. The P.D. across the 3 ohm resistor is:
a. 2V b. 3V c. 9V d. 10V

17. A wire has resistance 16Ω. It is bent in the form of a circle. The effective resistance between two points across a diameter is:
a. 4Ω b. 8Ω c. 16Ω d. 32Ω

18. The equivalent resistance of two wires is parallel is 6/5 Ω. If the resistance of one of the wires is 2Ω, that of the other is:
a. 3/5 b. 2 c. 5/3 d. 3

19. The resistance of a wire is R. It is cut into four equal parts and all the parts are bundled together side by side. The resistance of the bundle is:
a. R/16 b. R/8 c. R/4 d. R

20. Three resistances, each of 4Ω, are connected is form a triangle. The resistance between any two terminals is:
a. 2Ω b. 8/3Ω c. 6Ω d. 12Ω

21. A cell of negligible resistance and E.M.F. 2V is connected across a series combination of 2, 3 and 5 ohm. The P.D. across the 3Ω resistor is:
a. 0.6V b. 2/3V c. 1/3V d. 4/3V

22. Terminal potential of a battery is greater than its electromotive force when:
a. the battery is discharged
b. the battery is being charged
c. the internal resistance of the battery is zero
c. all of the above

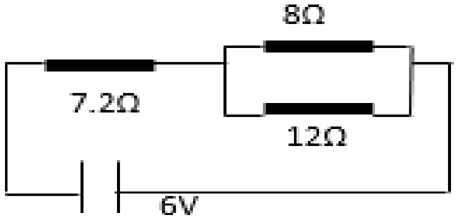
23. Terminal potential of a battery is less than its electromotive force when:
a. the battery is being discharged
b. the battery is charged
c. the internal resistance of the battery is zero
c. all of the above

24. If the terminal P.D. of a battery of E.M.F. $\in_0$ is V, its internal resistance is given by:
a. $\frac{\in - V}{I}$ b. $\frac{\in + V}{I}$ c. $\frac{\in - I}{V}$ d. $\in - Ir$

25. The EMF of the battery in a thermocouple is doubled. The rate of heat generation at one of the junction will:
a. Become double
b. Became half
c. Become four times
d. Remain unchanged

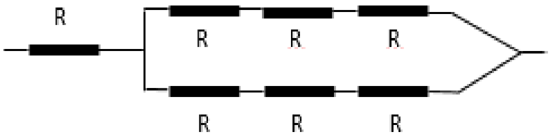
26. The resistance of 6Ω is connected in series with another resistance of 4Ω across a battery of 20V. The P.D. across the 4Ω resistor is:
a. 3V b. 6 V c. 12 V d. 8 V

27. In the given circuit the current through the battery is?



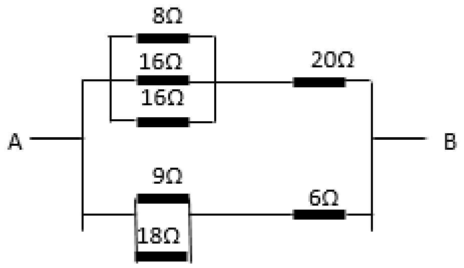
a. 1 A
b. 0.5 A
c. 3 A
d. 2.5 A

28. The effective resistance of the network shown in the figure is:



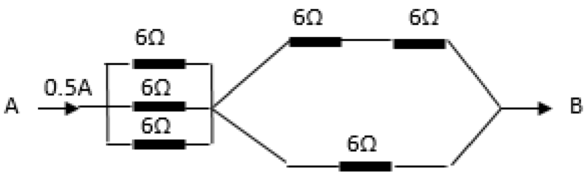
a. 4 R
b. 5R/2
c. 10 R
d. 3 R

29. The equivalent resistance of the network shown in adjoining figure between the points A and B is:



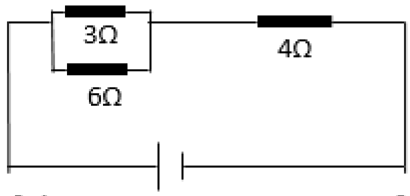
a. 6Ω
b. 8Ω
c. 16Ω
d. 27Ω

30. The potential difference between points A and B in the given network is:



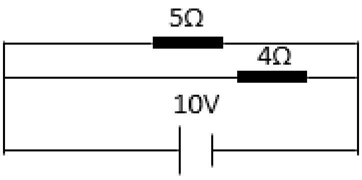
a. 3.6V
b. 3.0V
c. 6.0V
d. 7.2V

31. In the given circuit, the current through the 3Ω resistor is 0.8A. The P.D. across the 4Ω resistor is:



a. 3.6V
b. 4.8V
c. 2.4V
d. 1.2V

32. * In the given circuit the internal resistance of the battery is 1Ω. The current through the 5Ω resistor is:



a. 20/29A
b. 40/29A
c. 30/829A
d. 50/29A

33. A copper wire of resistance R is cut into 10 parts of equal length. Two pieces each are joined in series and then five such combination in parallel will have a resistance:

a. R b. R/4 c. R/5 d. R/25

34. When 2Ω, 4Ω and 6Ω resistor connected in parallel, their resultant equivalent resistance will be:

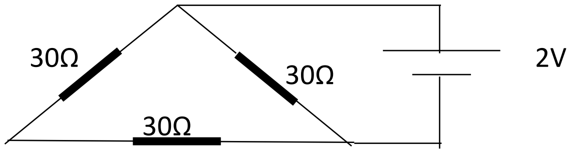
a. 12Ω b. 11/12Ω
c. 12/11Ω d. data is insufficient

35. Internal resistance is the resistance offered by:

a. source of EMF b. conductor
c. resistor d. capacitor

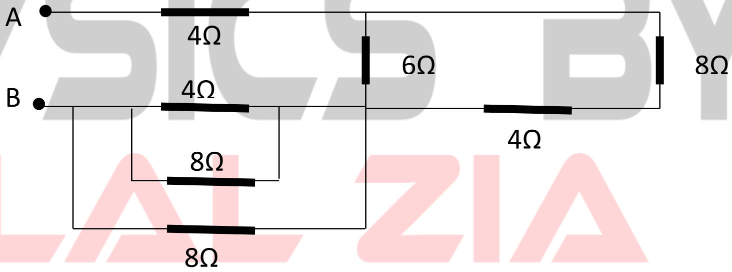
36. What will be the current in the circuit shown in figure?

a. 1/45A b. 1/10A c. 1/5A d. 5A



37. Resistance between A and B in the circuit shown in figure is:

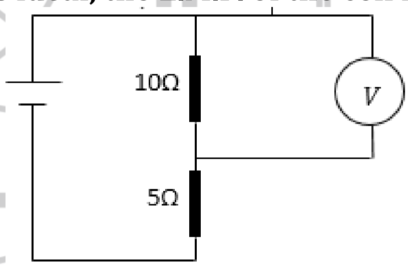
a. 4Ω
b. 6Ω
c. 10Ω
d. 8Ω



38. Resistance of 12Ω, 10Ω and 8Ω are connected in parallel to a battery of 10V, the current in 10Ω resistor is:

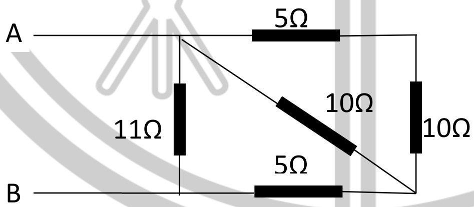
a. 2A b. 100A c. 1A d. 0.5A

39. In the given circuit the voltmeter reads 8V. Assuming that the internal resistance of the cell is zero and the voltmeter is ideal, the E.M.F. of the cell is:



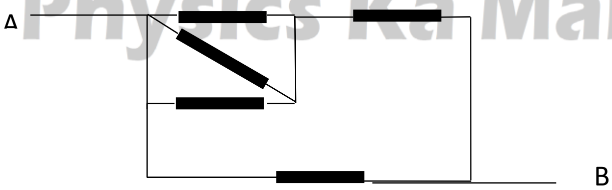
a. 8V b. 10V c. 12V d. 15V

40. The effective resistance between the terminals A and B in the given the circuit is:



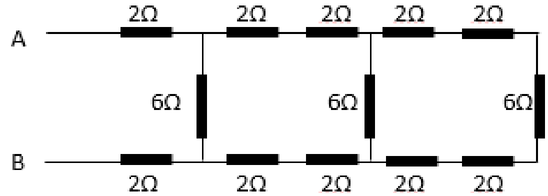
a. 35Ω b. 25.5Ω c. 10.5Ω d. 5.5Ω

41. Five identical wires are connected in a network as shown. The resistance measured between A and B is 1Ω. The resistance of each wire is:



a. 1/4Ω b. 4/7Ω c. 7/4Ω d. 8/7Ω

42. The equivalent resistances between the terminals A and B in the given network is:



a. 30Ω b. 40Ω c. 16Ω d. 8Ω

43.* The equivalent resistance of (n) identical resistors connected in parallel is (x) ohms. If the resistors are connected in series, the equivalent resistance would be:

a. nx b. n^2x c. x/n d. x/n^2

44. The equivalent resistance of two wires in parallel is 8/5Ω. If the resistance of one of the wires is 2Ω, that of the other in ohms is:

a. 3/5 b. 8 c. 5/3 d. 3

45. The resistance of a wire is R. It is cut into 6 equal parts and all parts are bundled together side by side. The resistance of the bundle is:

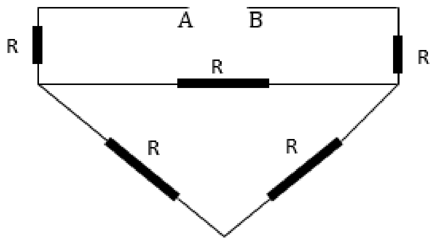
a. R/36 b. R/86 c. R/46 d. R

46. A copper wire is connected across a battery. The drift velocity of the electrons is υ . If another wire of same length and double the radius is connected across the same battery, the drift velocity will be:

a. υ b. 2υ c. υ /4 d. 4υ

47. In the given network, the equivalent resistance across A and B is:

a. 3R b. 4R c. 5R/3 d. 8R/3



48. Resistances of 1Ω, 2Ω and 3Ω are connected in the form of a triangle. If a 1.5V battery of negligible internal resistance is connected across the 3Ω resistor, the current flowing through this resistor (3 Ohms) is:

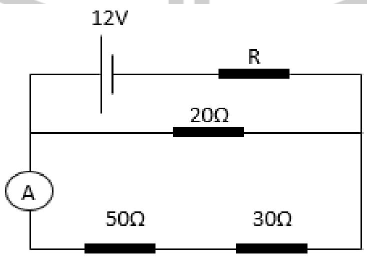
a. 0.25A b. 0.5A c. 1.0A d. 1.5A

49. A cell of negligible resistance and E.M.F. of 2V is connected across a series combination of 2, 3 and 5 ohms. The P.D. across the 5Ω resistor is:

a. 0.6V b. 1V c. 1/3V d. 4/3V

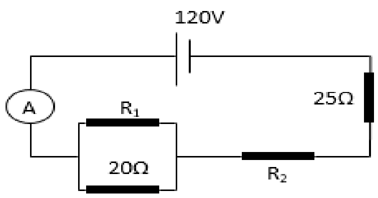
50.* In the given circuit the ammeter A, assumed to have negligible resistance, reads 0.1A. The value of R is:

a. 6Ω b. 8Ω c. 16Ω d. 20Ω



51. In the given circuit, the P.D. across R_2 is 40V and the ammeter reads 2A. The value of R_2 is:

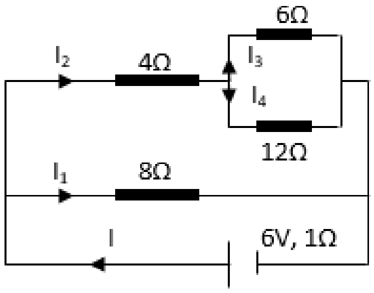
a. 20Ω b. 40Ω c. 60Ω d. 80 Ω



52.* When a resistor of 40Ω is connected across a battery, the current is 1.0 A. When a resistor of 20Ω is connected across the same battery, the current is 1.60A. The E.M.F. and internal resistance of the battery:

a. 80V, 20/3Ω b. 80V, 40/3Ω c. 160/3V, 20/3Ω d. 160/3V, 40/3Ω

53. * In the given circuit the value of I, I_1, I_2, I_3 and I_4 are (in ampere)



a. 1.2, 0.6, 0.6, 0.4, 0.2
b. 1.2, 0.6, 0.6, 0.2, 0.4
c. 1.5, 0.8, 0.7, 0.3, 0.4
d. 1.5, 0.6, 0.9, 0.4, 0.5

54. A cell has an E.M.F. of 2.5V. When short-circuited, it gives a current of 5A. The internal resistance of the cell is:

a. 0.5Ω b. 2.0Ω c. 4.5Ω d. ¼.5Ω

55. A primary cell has an E.M.F. of 4.5V. When a 5Ω resistor is connected across it, the current is 0.6 A. The internal resistance of the cell is:

a. 0.5Ω b. 1.25Ω c. 2.5Ω d. 3.0Ω

56.* Five cells, each of E.M.F. E and resistance r, are connected in series. If, by mistake, one of the cells is connected wrongly, the equivalent E.M.F. and internal resistance of the combination are:

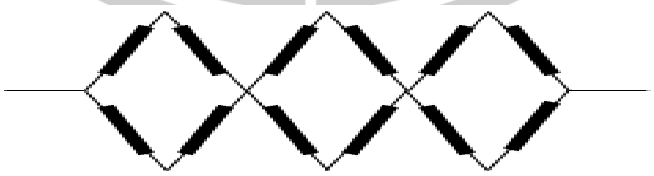
a. 5E, 5r b. 3E, 5r c. 5E, 3r d. 3E, 3r

57. The temperature at which the resistance of a copper wire would be double its value at 0°C is (temperature coefficient of resistance of Cu= 3.9×10^{-3} /°C)

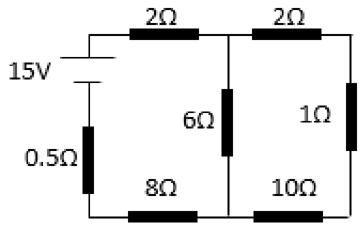
a. 128°C b. 256°C c. 512°C d. 740°C

58. In the given network each resistor is equal to 3Ω. The effective resistance between A and B is:

a. 9Ω b. 18Ω c. 36Ω d. 54Ω



59. * The current from the battery in the given circuit is:



a. 1A b. 15A c. 2A d. 3A

60. Three resistances, each of 1Ω, are joined in parallel. Three such combinations are put in series. The resultant resistance is:

a. 9Ω b. 3Ω c. 1Ω d. 1/3Ω

61. A wire of length 5m and diameter 1mm has a resistance of 1Ω. What length of a wire of the same material but of radius 1mm will also have a resistance of 1Ω?

a. 1.25m b. 2.5m c. 10m d. 20m

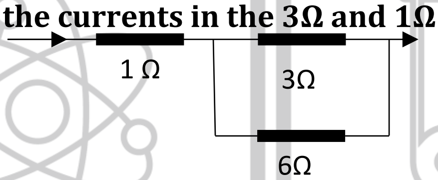
62. 6.25×10^{18} electrons are flowing per second through a wire of cross-section $0.1m^2$. The current in the wire is:

a. 0.1A b. 0.11A c. 1A d. 10A

63. A technician has two resistors. By using them singly, in series and in parallel, he is able to obtain resistances of 6, 9, 18 and 27 Ω. The value of the two resistances are:

a. 18 & 4 ohms b. 3 & 18 ohms c. 9 & 18 ohms d. 9 & 9 ohms

64. In the figure the ratio of the currents in the 3Ω and 1Ω resistors is:



a. 1/3 b. 2/3 c. ¼ d. 1/2

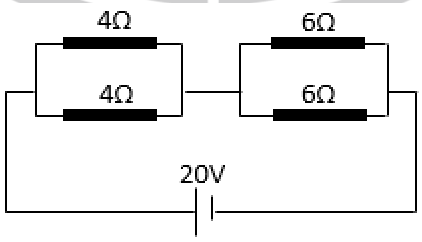
65. Manganin is used for making standard resistances (Ohmic Resistors) because it has:

a. High specific resistance b. Low specific resistance
c. Negligible temperature coefficient of resistance d. High melting point

66.* When a resistor of 4Ω is connected across a source of E.M.F. 1.5V, the current is 0.3A. If another identical resistor is connected across the source without disconnecting the former, the current through source will be:

a. 0.4A b. 0.5A c. 0.6A d. 0.3A

67. Four resistances are connected in a circuit as shown. The electric currents through the 4Ω and 6Ω are:



a. 2A and 4A b. 1A and 2A c. 1A and 1A d. 2A and 2A

68. An electrical wire of length L and area of cross-section A has resistance R. Another wire of the same material having the same length and cross-section 4A has a resistance:

a. 4R b. R/4 c. R/16 d. 16R

69. Two wires of the same material are given. The first wire is twice as long as the second and has twice the diameter of the second. The resistance of the first wire is:

a. twice that of the second b. half that of the second
c. equal to that of the second d. four times that of the second

70. A cell of E.M.F 4.0V and internal resistance 0.2Ω is connected with a resistance of 7.8 ohm. The voltage across the cell terminals will be:

a. 0.5V b. 1.95V c. 3.90V d. 2.00V

71. A wire of resistance R is stretched to four times its length. Its new resistance will be:

a. 4R b. 64R c. R/4 d. 16R

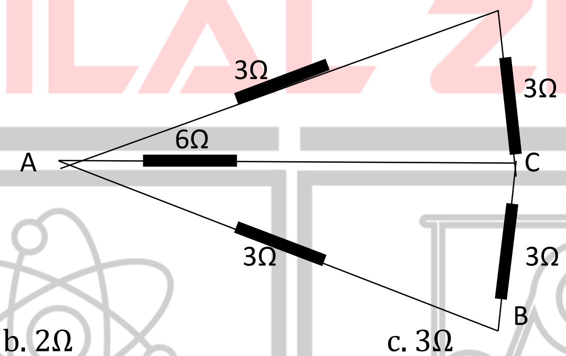
72. An electric iron draws 5A, a TV set draws 3A and a refrigerator draws 2A from a 200V main line. The three appliances are connected in parallel. If all the three are operating at the same level. The fuse used may be of:

a. 2A b. 5A c. 15A d. 10A

73. A flow of 10^8 electrons per second in a conduction wire constitutes a current of:

a. 1.6×10^{-27}A b. 1.6×10^{11}A c. 1.6×10^{-11}A d. 1.6×10^{27}A

74. The effective resistance between points A and B in the figure is:



a. 5Ω b. 2Ω c. 3Ω d. 4Ω

75. Two resistance, 8Ω and 12Ω, are is series and a 20Ω resistors is in parallel to the combination. The resultant resistance is:

a. 10Ω b. 16Ω c. 18Ω d. 20Ω

76. A student has 10 resistors, each of resistance r. The minimum resistance that can be obtained by him using these resistors is:

a. 10r b. r/10 c. r/100 d. r/5

77. The electromotive force of a primary cell is 2 volts. When it is short-circuited, a current of 4 ampere flows through it. The internal resistance of the cell, in ohms, is:

a. 0.5 b. 5.0 c. 2.0 d. 8.0

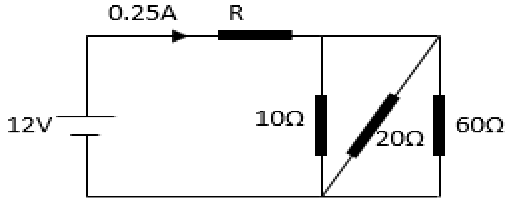
78. When a P.D. is applied across a copper wire, the drift velocity of the electron is (υ). If the same P.D. is applied across another copper wire of the same length but double the diameter, the drift velocity will be:

a. 2 υ b. υ/2 c. υ d. υ/4

79. Three copper wires have lengths and cross-sectional areas (L, A), (2L, A/2) and (L/2, 2A). Resistance is minimum for:

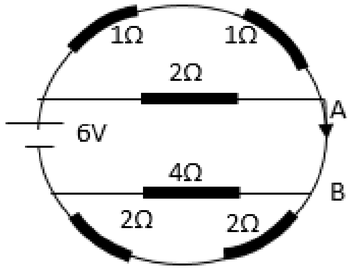
a. wire of cross-sectional area A/2 b. wire of cross sectional area A
c. wire of cross-sectional area 2A d. same in all three cases

80. In the given circuit the value of R is:



a. 42Ω b. 62Ω c. 72Ω d. 82Ω

81.* The current in the branch AB is:

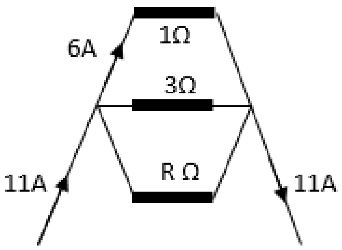


a. 1A b. 2A c. 1.5A d. 3A

82. When a resistance of 4 ohm is connected across the terminals of a cell, the current is 1.0A; but when the resistance across the cell is 10 ohm the current is 0.5A. The E.M.F. of the cell is:

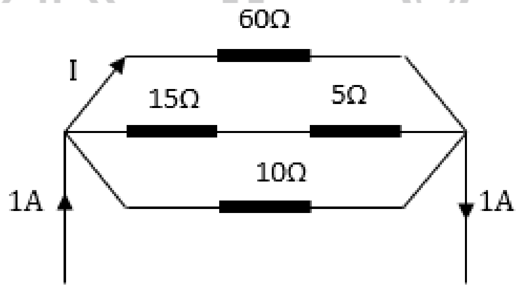
a. 3.0V b. 6.0V c. 1.5V d. 12V

83. The value of the resistance R in the electric circuit given below is (in Ω)



a. 2 b. 1 c. 5 d. 3

84. The value of the current I in the circuit shown below is:



a. 1/3A b. 1/6A c. 0.1A d. 0.5A

85. A uniform wire of resistance R is uniformly compressed along its length until its radius becomes n times the original radius. Now the resistance of the wire becomes:

a. nR b. R/n c. R/n^2 d. R/n^4

86. The resistance of a conductor is 4 ohm at 50°C and 5 ohm at 100°C. Its resistance at 0°C is:

a. 1 ohm b. 2 ohm c. 4 ohm d. 3 ohm

87. A certain wire 50 cm long and one square millimeter cross-section carries a current of 8A when connected to a 4V battery. The resistivity of material of wire in ohm meter is:

a. 1×10^{-6} b. 4×10^{-7} c. 3×10^{-7} d. 2×10^{-7}

88. Three conductors draw respectively currents of 1A, 2A and 4A when connected in turn with a battery. If they are connected in series across the same battery, the current drawn will be:
a. 2/7A b. 3/7A c. 4/7A d. 5/7A

89. A copper wire is connected across a battery. The drift velocity of the electron is υ . If another wire of same length and double the radius is connected across the same battery, the drift velocity will be:
a. υ/2 b. 2υ c. υ /4 d. 4υ

90.* A wire has resistance 10Ω. It is stretched by one-tenth of its original length. Then its resistance becomes:
a. 9Ω b. 10Ω c. 11Ω d. 12.1Ω

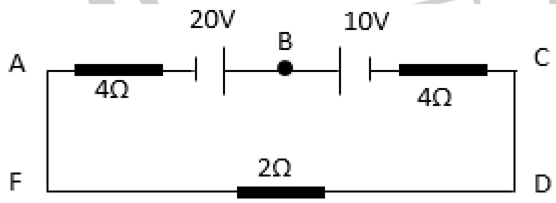
91.* A cell of emf E is connected across a resistance r. The potetial difference between the terminasls of the cell is found to be V. The internal resistance of the cell must be:
a. $\frac{2(E-V)V}{r}$ b. $\frac{2(E-V)r}{E}$ c. $\frac{(E-V)r}{V}$ d. (E-V)r

92. A cell has an emf of 6.0V. When short-circuited, it gives a current of 12A. The internal resistance of the cell is:
a. 0.5Ω b. 2.0Ω c. 4.5Ω d. ¼.5Ω

93. A bettery of 6V is connected to the terminals of a 3 m long wire of uniform thickness having a resistance of 100Ω. The difference of potentials betwwen two points seperated by 50 cm on the wire is:
a. 1.0V b. 1.5V c. 2.0 V d. 3.0 V

94.* You are given several identical resistors each of value 10Ω and each capable of carrying a maximum current of 2A. It is required to make a suitable combination of these resistances to produce a resistance of 5Ω which can carry a current of 4A. The minimum number of resistors required for this job is:
a. 4 b. 2 c. 10 d. 20

95. * In the given circuit, the current is:

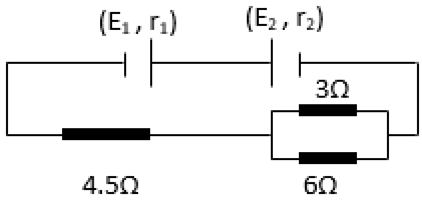


a. 1.0A from A to C via B
b. 1.0A from C to A via B
c. 3.0A from A to C via B
d. 3.0A from C to A via B

96.* When an unknown resistance is connected across a series combination of two identical batteries, each of 1.5V, the current through the resistor is is 1.0A. When it is conneceted across a parallel combination of the same batteries, the current through it is 0.6A. The internal resistance of each battery is:
a. 1/5Ω b. ¼ Ω c. 1/3Ω d. ½ Ω

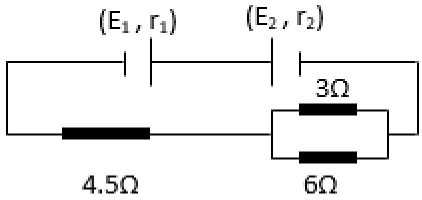
97. The temperature at which the resistance of a copper wire would be three times its value at 0°C is (Temperature coefficient of resistance of Cu = 4.0 x 10^{-3}/°C approximately)
a. 125°C b. 250°C c. 500°C d. 750°C

98.* In the given circuit, E_1 = 4V, r_1 = 0.5Ω; E_2 = 8V, r_2 = 1Ω. The terminal voltages across E_1 and E_2 are: (One of the best questions)



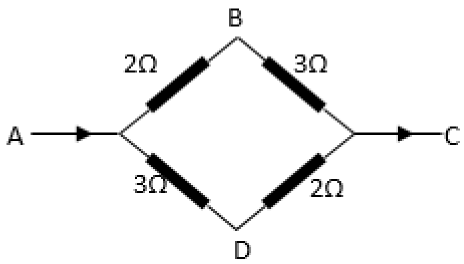
a. 3.75V, 8.5V b. 4.25V, 8.5V c. 3.75V, 7.5V d. 4.25V, 7.5V

99.* In the given circuit, $E_1 = 8V$, $r_1 = 0.5\Omega$; $E_2 = 12V$, $r_2 = 1\Omega$. The terminal voltages across E_1 and E_2 are: (One of the best questions)



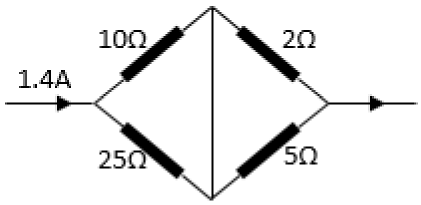
b. 7.75V, 12.5V b. 8.25V, 12.5V c. 7.75V, 11.5V d. 8.25V, 11.5V

100. In the given network, the P.D. between B and D is (Current entering from point A is 1 Ampere):



a. + 2 V
b. – 1 V
c. + 1 V
d. – 2 V

101. In the circuit shown in the figure, the current through the 2Ω resistor is:



a. 1.2 A
b. 1.0 A
c. 0.8 A
d. 0.4 A

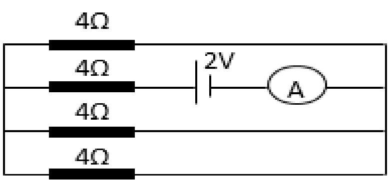
102. Two wires of the same material are given. The first wire is twice as long as the second and has half the diameter of the second. The resistance of the first wire is:

a. Twice that of the second b. Eight times that of the second
c. Equal to that of the second d. Four times that of the second

103. Two identical cells send the same current through a 2Ω resistor, whether connected in series or parallel. The internal resistance of each cell is:

a. 0.5Ω b. 1Ω c. 2Ω d. 2.5Ω

104. * In the given circuit, the internal resistance of the cell is negligible. The reading of the ammeter is:



a. 1/8A b. 1/4A c. 3/8A d. 2A

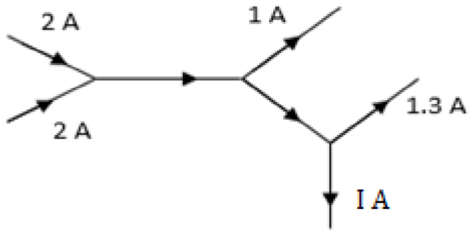
105. * If the resistance across a 12V source is increased by 4Ω, the current drops by 0.5A. The original resistance was:

a. 8Ω b. 4Ω c. 16Ω d. 5Ω

106. * A battery of 6 cells, each of EMF 2V and internal resistance of 0.5Ω, is being charged by a 220V supply using an external resistance of 10Ω in series. The P.D. across the battery is:

a. 30V b. 60V c. 90V d. 120V

107. The figure shows the current in a part of an electrical circuit. The current I is:

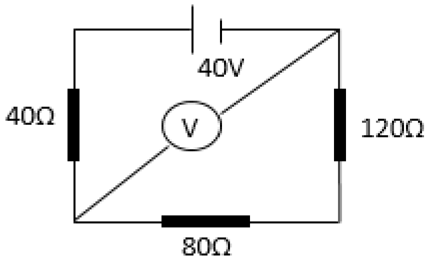


a. 1.7 A
b. 3.7 A
c. 1.3 A
d. 1.0 A

108. * Two resistors of 500Ω and 300Ω are connected in series with a battery of EMF 20V. A voltmeter of resistance 500Ω is used to measure the P.D. across the 500Ω resistor. The error in the measurement is:

a. 1.4V b. 2.4V c. 3.4V d. 4.4V

109. In the given circuit the resistance of the voltmeter is 800Ω. Its reading is:

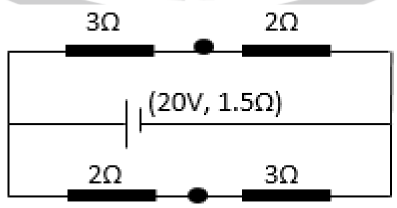


a. 8V b. 16V c. 24V d. 32V

110. Two resistances of 100Ω and 200Ω are connected in series with the battery of EMF 4V. A voltmeter of resistance 200Ω is used to measure the voltages across the two resistors in turn. The value are:

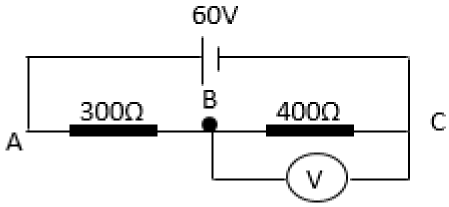
a. 1V, 2V b. 1.5V, 3V c. 4/8V, 8/3V d. 2V, 2V

111. In the given circuit. Point after 3 Ohms is (A) and point after 2 ohms in the lower branch is (B):



a. A and B are at the same potential
b. A is 2.5V higher than B
c. B is 2.5V higher than A
d. The current through the battery is 5A

112. * In the given circuit the reading of the voltmeter is 30V. If the same voltmeter is connected across the 300Ω resistor, its reading will be:

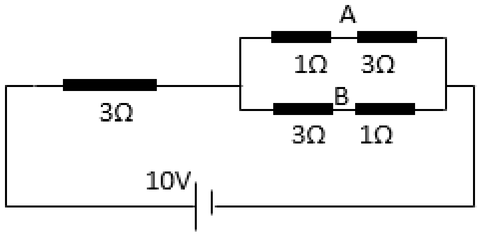


a. 18V b. 22.5V c. 30V d. 50V

113. Three 5Ω resistors are connected in the form of an equivalent triangle. Total resistance between any two corners is:

a. 8Ω b. 3/8Ω c. 10/3Ω d. 4/3Ω

114. In the given circuit the P.D. between the points A and B is:



a. -2V b. 2V c. 5V d. 20/11V

115. Four wires AB, BC, CD and DA, each of resistance 4Ω, and a fifth wire BD of resistance 8 ohm are joined to form a rectangle of which BD is a diagonal. The effective resistance between the points A and B is:

a. 24Ω b. 16Ω c. 4/3Ω d. 8/3Ω

116. * The resistance of a wire of iron is 10 ohm at 20°C and temperature coefficient of resistance is 5 x 10^{-3}/°C. At 20°C it carries 30 mA of current. Keeping constant potential difference between its ends, the temperature of the wire is raised to 120°C. The current in mA that flows in the wire now is:

a. 20 b. 15 c. 10 d. 40

117. A wire 50 cm long and 1 mm^2 in cross-section carries a current of 4A when connected to a 2V battery. The resistivity of the wire is:

a. 2 x 10^{-7}Ωm b. 5 x 10^{-7}Ωm c. 4 x 10^{-6}Ωm d. 1 x 10^{-6}Ωm

118. A metal wire of specific resistance 64 x 10^{-6} Ω-m and length 196 cm has a resistance of 8 ohms. The radius of the wire is:

a. 2.24 cm b. 0.224 cm c. 0.0224 cm d. 224 cm

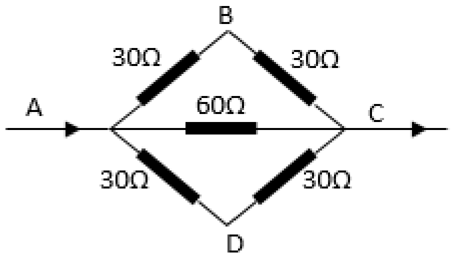
119. A new flash light cell of EMF 1.5V gives a current of 15A when connected directly to an ammeter of resistance 0.04Ω. The internal resistance of the cell is:

a. 0.04Ω b. 0.10Ω c. 0.06Ω d. 10Ω

120. Which of the following statements is not true?

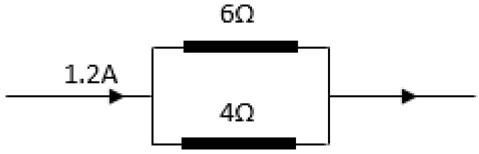
a. Conductance is the reciprocal of resistance and is measured in Siemens.
b. Ohm's law is not applicable at very low and very high temperatures.
c. Ohm's law is applicable to semiconductors.
d. Ohm's law is not applicable to electron tubes, discharge tubes and electrolytes.

121. In the given circuit:



a. Currents through AB and AD are less that through AC
b. Currents through AB and AD are more than that through AC
c. Currents through the three branches are equal
d. Currents through the three branches are not related

122. In the given circuit the current passing through the 6Ω resistor is:



a. 0.40A b. 0.48A c. 0.72A d. 0.80A

123. When a resistance of 9.5 ohm is connected across a battery, the voltage across the resistance is 11.4V. If the resistance connected across the same battery is 11.5 ohm, the voltage across the resistance is 11.5V:

a. The EMF of the battery is 12.0V
b. The internal resistance of the battery is 0.5 ohm
c. The EMF of the battery is 11.45V
d. The EMF of the battery is 11.50V
e. Both (a) & (b) are correct

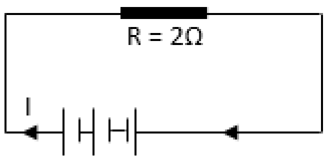
124. A wire of radius r has resistance R. If it is stretched uniformly to a wire of radius r/2, then the resistance of the wire becomes

a. 2R b. 4R c. 16R d. 8R

125. Resistance of (Cu) coil is 4.64Ω at 40°C and 5.6Ω at 100°C. Then its resistance at 0°C is (in Ω)

a. 5.12 b. 4.2 c. 4 d. 0.96

126. * In the electric circuit shown, each cell has an EMF of 2V and internal resistance of 1Ω. The external resistance is 2Ω. The value of the current I is (in A)



a. 3 b. 0.4 c. 1.2 d. 2

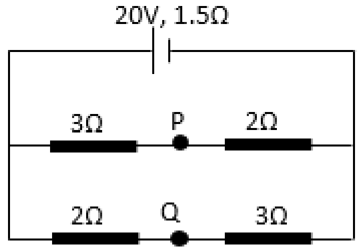
127. Resistance of a coil is 4.2Ω at 100°C and the temperature coefficient of resistance of its material is 0.004/°C. Then its resistance at 0°C is (Ω)

a. 4 b. 3.5 c. 5 d. 3

128. A car battery has EMF 12V and internal resistance 5 x 10^{-2} ohm. If it draws 60A current, the terminal voltage of the battery will be:

a. 15V b. 3V c. 5V d. 9V

129. * If in a circuit shown below, the internal resistance of the battery is 1.5Ω and V_P and V_Q are the potentials at P and Q respectively, what is the potential difference between the points P and Q?



a. 2.5 volts ($V_P > V_Q$)
b. 4 volts ($V_P > V_Q$)
c. 4 volts ($V_Q > V_P$)
d. 2.5 volts ($V_Q > V_P$)

130. A rod of a certain metal is 1.0 m long and 0.6 cm in diameter. Its resistance is 3.0×10^{-3} Ω. Another disc made of the same metal is 2.0 cm in diameter and 1.0 mm thick. What is the resistance between the round faces of the disc?
a. 1.35×10^{-8} ohm
b. 2.70×10^{-7} ohm
c. 4.05×10^{-6} ohm
d. 8.10×10^{-5}ohm

131. * An electron (charge = 1.6×10^{-19} coulomb) is moving in a circle of radius 5.1×10^{-11}m at a frequency of 6.8×10^{15}revolution/sec. The equivalent current is approximately:
a. 5.1×10^{-3}A
b. 6.8×10^{-3}A
c. 1.1×10^{-3}A
d. 2.2×10^{-3}A

132. A uniform wire of resistance R is uniformly compressed along its length until its radius becomes (n) times the original radius. Now the resistance of the wire becomes:
a. nR
b. R/n
c. R/n^2
d. R/n^4

133. 5 rows, of 10 identical cells, connected in series, send a current I through an external resistance of 18Ω. If the EMF and internal resistance of each cell is 1.5V and 1Ω, then the value of I (amp) is:
a. 0.25
b. 0.14
c. 0.68
d. 0.75

134. The resistance of a conductor is 5 ohm at 50°C and 6 ohm ate 100°C. Its resistance at 0°C is:
a. 1 ohm
b. 2 ohm
c. 3 ohm
d. 4 ohm

P.S: All Questions That Are Marked with (*) Are Placed to Clear the Concepts. You Can Ignore Them (If You Want to) As They Will Never Come in an Aptitude Exam.

ANSWER KEY # 02

1	C	31	B	61	D	91	C	121	C
2	B	32	B	62	C	92	A	122	B
3	A	33	D	63	C	93	A	123	E
4	B	34	C	64	B	94	B	124	C
5	B	35	A	65	C	95	A	125	C
6	B	36	B	66	B	96	C	126	B
7	B	37	C	67	D	97	C	127	D
8	A	38	C	68	B	98	D	128	D
9	A	39	C	69	B	99	D	129	D
10	C	40	D	70	C	100	C	130	B
11	B	41	C	71	D	101	B	131	C
12	B	42	D	72	C	102	B	132	D
13	A	43	B	73	C	103	C	133	D
14	B	44	B	74	B	104	C	134	D
15	D	45	A	75	A	105	A		
16	D	46	C	76	B	106	B		
17	A	47	D	77	A	107	A		
18	D	48	B	78	D	108	C		
19	A	49	B	79	C	109	D		
20	B	50	B	80	A	110	A		
21	A	51	A	81	B	111	D		
22	B	52	D	82	B	112	B		
23	A	53	A	83	A	113	C		
24	A	54	A	84	C	114	B		
25	A	55	C	85	D	115	D		
26	D	56	B	86	D	116	A		
27	B	57	B	87	A	117	D		
28	B	58	A	88	C	118	B		
29	B	59	A	89	C	119	C		
30	B	60	C	90	D	120	C		

- When electric charges are at rest, they exert electrostatic forces of attraction or repulsion on each other (Coulombs Equation).
- When the charges are in motion, they still exert these electrostatic forces but, in addition, magnetic forces appear because of motion (Moving charge has a magnetic field along with its electric field).

FORCE ON A MOVING CHARGE IN A MAGNETIC FIELD:

A magnetic field is a region in which a force is experienced on a moving charge or a magnet. Magnetic force acts on the charge This force depends upon:

- Magnitude of charge q
- Speed of the moving charge ϑ
- Magnetic field of Induction B

The magnetic Induction B is a Vector quantity defined from the relation: $\vec{F} = q\,(\vec{v} \times \vec{B})$

The magnitude of B is given by: $B = \dfrac{F}{q\,\vartheta \sin\theta}$

Unit of B is Tesla (T).

The direction of force is perpendicular to both the direction of motion of charge and the direction of B given by cross product law (Right Hand Screw Turning Rule or Palm Rule).

Cases of Maximum and Minimum Force

- If the particles move perpendicular to the magnetic field, the angle between $\vec{V}$ and $\vec{B}$ is 90° then force on moving charge is maximum.
  i.e., $F = qvB \sin 90° = qvB$
- If the particles move parallel to the magnetic field, the angle between $\vec{V}$ and $\vec{B}$ is 0° to 180° then force on moving charge is minimum,
  i.e., $F = qvB \sin 0° = 0$
  OR
  $F = qvB \sin 180° = 0$

MOTION OF A CHARGED PARTICLE IN AN ELECTRIC AND MAGNETIC FIELD (Lorentz Force)

When a charged particle 'q' is moving with velocity 'v' in a region where there is no electric field $\vec{E}$ and magnetic field $\vec{B}$, the total force $\vec{F}$ is the vector sum of the electric field ($F_e = q\,.\,\vec{E}$) and magnetic force ($\vec{F_B} = q\,(\vec{V} \times \vec{B})$),

i.e.,
$$\vec{F} = \vec{F_a} + \vec{F_b}$$
OR
$$\vec{F} = q\,\vec{E} + q\,(\vec{V} \times \vec{B})$$

This force $\vec{F}$ is known as Lorentz force. The magnetic force does no work, only the electric force does work, while the magnetic force is simply a deflecting force.

Note:

If the charge is free to move in an electric field (where it experiences a force $\vec{F} = q\,\vec{E}$), then it will accelerate according Newton's second law as,

$$\vec{a} = \frac{\vec{F}}{m} = \frac{q\,\vec{E}}{m}$$

This acceleration along the direction of $\vec{E}$ and if $\vec{E}$ is uniform then the acceleration 'a' is also uniform.

MAGNETIC FIELD DUE TO CURRENT IN A STRAIGHT WIRE

A magnetic field is set up in the region surrounding a current carrying wire. The magnetic field lasts only as long as the current is flowing through the wire. The lines of force are circular and their direction depends upon the direction of current.

Direction of Magnetic Field Lines

The direction of the lines of force can be found by a rule known as "right hand rule", which is stated as follows:

"If the current is carrying straight conductor is grasped with our right hand, in such a way that thumb pointing in the direction of current, then the direction of curling fingers will point in the direction of lines of magnetic field".

Force on a Current Carrying Conductor in a Uniform Magnetic Field

Thus, $$F = ILB\,\text{Sin}\theta$$

The force on a current carrying conductor in a uniform magnetic field in vector form is written as follow:

$$\vec{F} = I\,(\vec{L} \times \vec{B})$$

Direction of this Force

The magnetic force acting on current carrying conductor is along normal (perpendicular) to the direction of magnetic field and length of the conductor.

It is given by the right-hand rule of the cross product of vectors $\vec{L}$ and $\vec{B}$.

i.e, rotates $\vec{L}$ to coincide with $\vec{B}$ through the smaller angle. Curl the fingers of right hand in the direction of rotation, the thumb points in the direction of force.

Right Hand Palm Rule

If we stretch the palm of our right hand such that the thumb points in the direction of the current 'I' in the conductor and stretched four fingers in the direction of magnetic field B, then the force F on the conductor will be perpendicular to the palm in the direction of pushing the palm (palm face).

Fleming's Left-Hand Rule

If the forefinger, the central finger and the thumb of the left hand are stretched mutually perpendicular to each other such that the fore finger point along the direction of magnetic field $\vec{B}$ and the central finger in the direction of current 'I' passing through the conductor, then thumb will be directed in the direction of magnetic force on the conductor.

Note:

Consider a straight current carrying conductor held at right angle to a magnetic field. It is customary to represent a current flowing towards the reader by a symbol dot (.) and a current flowing away from him by a cross (×)

TORQUE ON A CURRENT CARRYING COIL

The torque on a current carrying coil (having length 'L' & Width 'a') is given by

$$\tau = (\text{Force})\ (\text{Moment arm})$$

$$\tau = (ILB)(a)$$

The area of rectangular coil = A = (Length) (Width) = La

Therefore, we can write,

$$\tau = IBA$$

It is the value of the torque when the field 'B' is in the plane of the coil.

If however, the plane of the coil makes an angle 'α' with the direction of the magnetic field, then the perpendicular distance between the equal and opposite parallel force is (a Cos α), and the torque on the coil is given as:

$$\tau = (ILB)(a \cos\alpha)$$

OR

$$\tau = IBA \cos\alpha$$

When they are N numbers of turns of coil then torque on a current carrying coil is given as:

$$\tau = NIBA \cos\alpha$$

MAGNETIC INDUCTION

The strength of the magnetic field is called magnetic induction. It is defined as,

"The force acting on one meter length of the conductor, placed at right angle to the magnetic field when one ampere current is passing through it is called magnetic induction or flux density".

It is denoted by 'B' and $\left(B = \frac{F}{IL}\right)$

The SI unit of magnetic induction is Tesla (T) or Weber/m^2.

Tesla:

A magnetic field is said to have a strength of one "tesla", when it exerts a force of one newton on one metre length of the conductor placed at right angles to the field when a current of 1 A passes through the conductor.

i.e,

$$1\ \text{Tesla} = \frac{\text{Newton}}{\text{Ampere Meter}}$$

OR

$$T = \frac{N}{A\,m}$$

$$T = N\,A^{-1}\,m^{-1}$$

MAGNETIC FLUX

The number of lines of magnetic induction passing through an area (which is placed in the magnetic field) is called magnetic flux.

Magnetic flux is denoted by ϕ_0.

The magnetic flux through a surface depends upon:

- The flux density (B) of the magnetic field.
- The area of the surface (A).
- The orientation of the surface relative to the field direction. (This orientation is determined by the angle (θ) between the field direction and outward to the normal to the surface).

Mathematically, the magnetic flux (ϕ_0) through the surface can be expressed in the form of scalar product as:

$$\phi_0 = \vec{B} \cdot \vec{A}$$

OR

$$\phi_0 = BA \cos\theta$$

Where, θ is the angle between $\vec{B}$ and $\vec{A}$

Unit:

The SI unit of magnetic flux is NmA^{-1}, which is called weber (wb).

Examples

When we place an element of area in a magnetic field, some of the lines of force pass through it.

The magnetic flux is maximum when the field is directed along the normal to the area (i.e., Angle between $\vec{B}$ and $\vec{A}$ is zero).

When the field is parallel to the plane of the area (angle between $\vec{B}$ and $\vec{A}$ is 90°) then flux is minimum (i.e, zero).

In case of curved surface in a non –uniform magnetic field, the curved surface is divided into a number of small elements, each element being assumed plane, and the flux through the whole curved surface is calculated by sum of the contribution of all the elements of the surface.

FORMULA TO FIND MAGNETIC FIELD AT ANY POINT, DUE TO A CURRENT CARRYING CONDUCTOR (Biot & Savart Law):

The flux density 'B' at any point due to a long straight conductor is directly proportional to the strength of current I, and inversely proportional to the distance 'r' of the point from the conductor.

i.e., $B \propto 2I$

and $B \propto \frac{1}{r}$

Thus, we can write,

$$B \propto \frac{I}{r}$$

$$B = \left(\frac{\mu_0}{4\pi}\right)\frac{2I}{r}$$

Where, $\left(\frac{\mu_0}{4\pi}\right)$ is the constant of proportionality. Its value is 10^{-7}.

CHARGE TO MASS RATIO OF AN ELECTRON

It was determined by Sir J.J. Thomson.

If 'v' and 'r' are known, e/m of electron is determined

$$e/m = \frac{v}{Br}$$

This is required formula to find out e/m of an electron, when V (potential difference) is given

$$e/m = \frac{2V}{B^2\,r}$$

It is another formula to find charge over mass ratio of an electron, when E (electron field) is given:

$$e/m = \frac{E}{B^2 r}$$

$$e/m = 1.7588\times10^{11}\,\frac{c}{kg}$$

AMPERE'S CIRCUITAL LAW

This law states that,

"Sum pf quantities $\vec{B}\,.\,\overrightarrow{\Delta L}$ for all elements over a closed path due to a current, is equal to μ_0 times the total steady current enclosed by the closed path".

Mathematically, we can write,

$$\sum_{r=1}^{N}(\vec{B}\,.\,\overrightarrow{\Delta L}) = \mu_0 I$$

Where, μ_0 is called the permeability of free space and its value is ($4\pi \times 10^{-7}$ Weber/Am).

Note:

Ampere's circuital law is valid under the condition that current passing through the conductor is constant, and this law is applicable to all kinds of closed path (any possible geometry) around current carrying current.

APPLICATION OF AMPERE'S LAW

Field due to Current Carrying Solenoid

$$B = \mu_0\ nl$$

It is the value of magnetic field 'B' due to current carrying solenoid.

The direction of field is along the axis of the solenoid.

The direction of the field $\vec{B}$ along the axis of the solenoid which is given by the right hand rule, i.e., hold the solenoid in the right hand with fingers curling in the direction of the current, the thumb will point in the direction of the field.

Field due to Current Carrying Toroid (Circular Solenoid)

A toroid or a circular solenoid is a coil or insulting copper wire wound on a circular core wire with close turns. A uniform magnetic field of induction is produced which is confined in the space occupied by the core i.e.

$$B = \frac{\mu_o NI}{2\pi r}$$

ELECTROMAGNETIC INDUCTION

An EMF is produced in the loop of a wire, if the magnetic flux through it changes, the EMF produced in this loop is called induced EMF, and the current generated is called the induced current. This phenomenon is known as electromagnetic induction.

INDUCED EMF AND INDUCED CURRENT

The induced current can be increase by using following methods:

- Using a stronger magnetic field.
- Moving the loop faster.
- By increasing the number of loops.
- By increasing the area of the loop.

MOTIONAL EMF

The EMF induced by the motion of the conductor across magnetic field is called motional EMF.

The magnitude of motional EMF is given by the following equation. If the angle between 'v' and 'B' is θ, then

$$\in = -vBL \sin\theta$$

This equation shows that when $v = 0$, $\in = 0$ that means no motional EMF is developed in the stationary rod.

FARADAY'S LAW OF ELECTROMAGNETIC INDUCTION

The Faraday's law states that,

"The average value of induced EMF in a conducting coil of N loops is equal to the negative of the rate at which the magnetic flux through the coil is changing with time".

Mathematically we can write,

$$\in = -N\frac{\Delta\phi}{\Delta t}$$

LENZ'S LAW AND DIRECTION OF INDUCED EMF

This law (used to find the direction of Induced Current) states that,

"The direction of the induced current is always so as to oppose the change of flux which causes the current to be induced".

- When N pole of a bar magnet is approaching the face of a coil, it becomes a North face by the induction of a current in anticlockwise direction to oppose the movement.
- When N pole of a bar magnet is receding the face of a coil (moving away), it becomes a South face by the induction of a current in clockwise direction to oppose the movement.
- In case the flux increases, induced face and approaching face will be same.
- In case the flux decreases, induced face and approaching face will be opposite.
- This law is in accordance with law of conservation of energy

MUTUAL INDUCTION

The phenomena in which a changing current in one coil (Primary) induces an EMF in another coil (Secondary) is called the mutual induction.

$$\epsilon_s = -M\frac{\Delta I_0}{\Delta t}$$

Where, 'M' is the constant of proportionality called the mutual inductance of the coils.

Mutual Inductance

It is defined as,

"The ratio of induced EMF in the secondary coil to the rate of change of current in the primary coil".

Mathematically it can be written as,

$$M = \frac{-\epsilon_s}{\Delta I_0/\Delta t}$$

$$M = \frac{\text{Induced emf iin the secondary coil}}{\text{Rate of change of current in primary coil}}$$

Unit:

The SI unit for the mutual inductance 'M' is "henry" (H) or VsA^{-1}

Henry

The mutual inductance is said to be one henry, if the current changing at the rate of one ampere per second in the primary causes an induced EMF of one volt in the secondary.

Note:

Mutual inductance (M) depends upon the number of turns of the coils, their area of cross section, their closeness together and the nature of the core material upon which the two coils are wound.

SELF-INDUCTION

The phenomena in which a changing current in a coil induces an EMF itself is called self-induction.

$$\epsilon_L = -L\frac{\Delta I}{\Delta t}$$

Where, 'L' is the constant of proportionality called the self-inductance of the coil.

Self-Inductance

It is defined as, the ratio of induced EMF to the rate of change of current in the coil.

Mathematically it can be written as,

$$M = \frac{-\epsilon}{\Delta I/\Delta t}$$

Unit:

The unit of self-inductance is also henry (H) or VsA^{-1}.

Note:

Self-inductance (L) depends upon the number of turns of the coil, its area of cross section and the cross material.

ENERGY STORED IN AN INDUCTOR

As we know energy can be stored in the electric field between the plates of a capacitor. In a similar manner, energy can be stored in the magnetic field of an inductor.

Principle

"When electric current passes through an inductor, then inductor becomes a magnet so it holds energy in the form of magnetic field".

$$U = \frac{1}{2} LI^2$$

Energy Stored in terms of Magnetic Field

$$U_m = \frac{1}{2\mu_0} B^2 (Al)$$

Energy Density

"Energy density can be defined as the energy stored per unit volume inside the solenoid".

So dividing the above equation by the volume (Area * Length), we get energy density.

$$U_m = \frac{1}{2}\frac{B^2}{\mu_0}$$

ALTERNATING CURRENT GENERATOR (Dynamo)

It is a device which converts mechanical energy into electrical energy in the form of alternating current.

Principle

The working of an AC generator is based on Faraday's law of electromagnetic induction. When a coil is rotated in a magnetic field by some mechanical means, magnetic flux through the coil changes and consequently an EMF is induced in the coil.

Construction and Working

An AC generator consists of following main parts

- **Armature**
  An armature consists of a coil of insulated copper wire. This coil can rotate about an axis in the magnetic field.
- **Magnetic Field**
  The armature is placed in a uniform magnetic field which is produced due to a permanent magnet or an electromagnet.
- **Slip Range**
  There are two slip rings with which the two ends of the coil are touched.
- **Carbon Brushes**
  Carbon brushes touching the slip rings are used to collect current from the armature.

Calculation of Induced EMF

$$E = N\omega AB \sin(\omega t)$$

This equation shows that induced EMF varies sinusoidally with time.

It has maximum value when Sin (ωt) = 1. Thus maximum EMF of AC generator is given by,

$$E_0 = N\omega AB$$

Comparing above two equations we can write,

$$E = E_0 \, Sin\,(\omega t)$$

OR

$$I = I_0 \, Sin\,(\omega t)$$

$$(Since,\ I = \frac{E}{R},\ I_0 = \frac{E_0}{R_0})$$

Concluding,

$$\varepsilon = \varepsilon_0 \, Sin\,(2\pi ft)\ (Since,\ \omega = 2\pi/T = 2\pi f)$$

$$I = I_0 \, Sin\,(2\pi ft)$$

D.C. GENERATOR

It is a device which converts mechanical energy into electrical energy in the form of direct current.

Principle

The working of a DC generator is based upon the fact that when magnetic flux changes through a coil and EMF is induced in it.

Construction and Working

Split Rings

A D.C. generator is similar to the A.C. generator in construction with difference that **"split rings"** are replaced by **"split rings"**. The split rings are fixed to the two ends of the coil which rotates in a magnetic field. When current in the coil is zero, and it is going to change its direction, the split rings interchange their connection with the brushes**.** In this way electric potential of one brush remains permanently positive and that of the other remains permanently negative.

Note:

Multiple coils are wound around a cylindrical core form the armature. Each coil is connected to a separate commutator and the output of every coil is tapped only as it reaches its peak EMF. Thus, the EMF in the outer circuit is almost constant.

BACK MOTOR EFFECT IN GENERATORS

When circuit is closed, a current is drawn through the coil. The magnetic field exerts force on the current carrying coil.

One of the Force say $\overrightarrow{F_1}$ is acting on the left side of the coil whereas an equal and opposite force $\overrightarrow{F_2}$ acts on the right side of the coil. These forces are such that they produce a counter torque that opposes the rotational motion of the coil. This effect is sometimes referred to as **"back motor effect in the generators"**.

The larger is load the larger the current drawn, the greater is the counter torque is produced. That means more mechanical energy is required to keep the coil rotating with constant angular speed. This is in accordance with law of conservation of energy. So, the energy consumed by the load must come from the energy source used to drive the turbine.

D.C. MOTOR

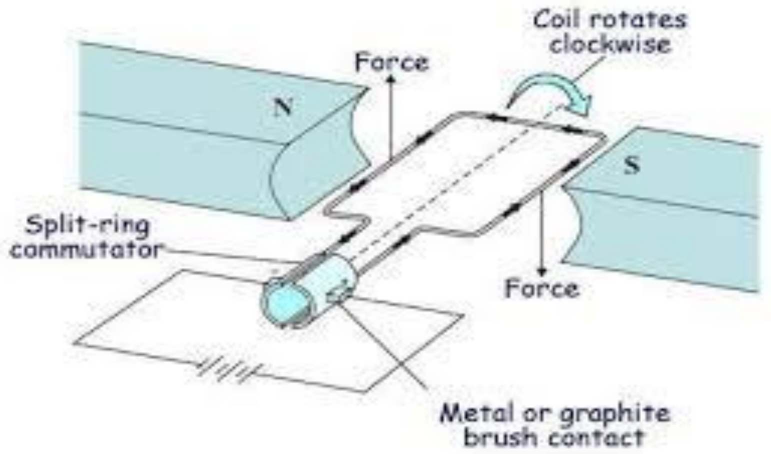
"It is a device which convert electrical energy into mechanical energy".

Principle

The working of D.C. Motor depends upon the fact that when a current carrying coil is placed in a magnetic field it experiences a torque which causes the rotation of the coil.

Theory

In construction a D.C. Motor is similar to a D.C. generator. In D.C. generator, the armature is rotated in the magnetic field and current is the output. But in the D.C. motor electric current is led into the coil which then rotates. In the D.C. motor, the brushes are connected to a D.C. supply or battery as shown in figure.



Note:

The windings of the electromagnet are called **"field coils"**. These coils are either in series or in parallel with armature coils.

Back EMF Effect in Motors

When the coil of the motor rotates across the magnetic field by the applied potential difference **V**, and EMF **E** is induced in it. The induced EMF is in such a direction to oppose the EMF running the motor. Due to this reason the induced EMF is called back EMF of the motor.

Since **V** and **E** are opposite in polarity, the net EMF in the circuit **V – E**. If **R** is the resistance of the coil and **I** the current drawn by the motor, then by Ohm's law,

$$I = \frac{V - E}{R}$$

OR

$$V = E + IR$$

When the motor is just started, back EMF is almost zero and hence a large current pass through the coil. As the motor speeds up, the back EMF increases and the current becomes smaller and smaller. However, the current is sufficient to provide torque on the coil to drive the load and to overcome losses due to friction.

If the current motor is overloaded, it slows down. Consequently, the back EMF decreases and allows the motor to draw more current. If the motor is overloaded beyond its limits, the current could be so high that they burn the motor out.

TRANSFORMER

A transformer is an electrical device which changes a given alternating EMF into a larger or smaller alternating EMF. A transformer works on the principle of mutual induction between two coils.

$$\frac{V_S}{V_P} = \frac{N_S}{N_P}$$

Above stated equation (Turn Ratio) is the relation between the applied voltage and the voltage induced in the secondary in terms of the number of turns in the two coils.

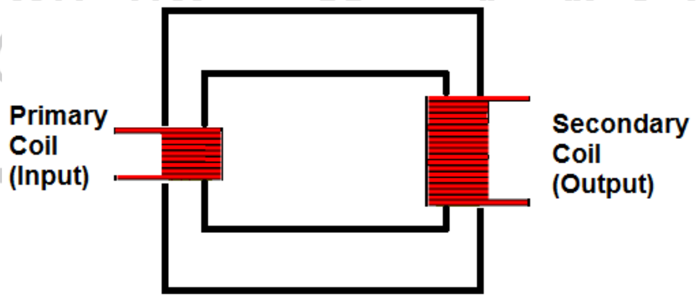
Types of Transformer

There are two types of transformer,

- Step up Transformer
- Step down Transformer

Step Up Transformer

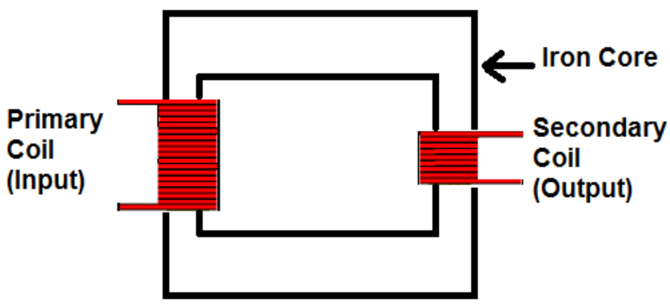
A transformer in which voltage across secondary is greater than the primary voltage, is called step up transformer. In step up transformer number of turns in the secondary coils is greater than the number of turns in primary as shown in figure. i.e.,



$N_S > N_P$

Step Down Transformer

A Transformer in which voltage across secondary is less than the primary voltage is called a step down transformer. In step down transformer number of turns in the secondary is less than the number of turns in primary as shown in figure. i.e.,



$N_S < N_P$

Uses

- Step up transformers are used to transmit powers form a power house to the streets and factories etc.
- Step down transformers are used to step down the voltage up to 220 V in the streets and factories etc.

Note:

As we know, the relation:

$$\frac{V_1}{V_P} = \frac{N_1}{N_P}$$

- If $N_s > N_P$ then $V_s > V_P$ & $I_S < I_P$ (Step up transformer)
- If $N_s < N_P$ then $V_s < V_P$ & $I_S < I_P$ (Step up transformer)

Transmission of Power by Transformers

Transformer transforms electrical power from its primary to the secondary by means of changing flux. In case of an "ideal transformer" the power output to the primary is nearly equal to the power output from the secondary i.e.,

Power input = Power output

OR

$$V_P I_P = V_S I_S \text{ ..... (i)}$$

Where I_P is the current and I_s is the current in secondary.

From eq (i) we can write

$$\frac{V_S}{V_P} = \frac{I_S}{I_P}$$

The relations show that, the currents are inversely proportional to the respective voltages. Therefore, in a step up transformer when the voltage across the secondary is raised, the value of the current is reduced. This is the principle used in the electric supply where transformer increase the voltage and reduce the current so that it can be transmitted over long distances without losing such energy.

Power Losses in Transformers

Only in an ideal transformer the output power is equal to the input power. But in an actual transformer, this is not the case. In an actual transformer, the output is always less than input due to power losses.

- Heat is dissipated in coils of copper. This power loss in given by I^2R. This loss is reduced by using low resistive wires in the coils.
- Eddy currents induced on the surface of iron core due to variation of magnetic flux producing heat and therefore reduce the amount of power that can be transferred to the secondary coil. To reduce the heat dissipation, the iron core is laminated.
- Each time the direction of magnetization is reversed, some energy is wasted and is called hysteresis loss. This is minimized by using special alloys for core (soft iron core). The loss of energy during each cycle of A.C. can be decreased by using such a material for the core whose hysteresis loop is of small area.
- Some loss of energy occurs because a small amount of the flux associated with primary coil fail to pass through secondary (Flux Leakage).

Efficiency of Transformer

The efficiency of a transformer is defined as,

"The ratio of output power to the input power".

Mathematically it is written as,

$$E = \frac{\text{Output Power}}{\text{Input Power}} \times \frac{100}{100}$$

PRACTICE SHEET # 01

1. **The SI unit of the flux density is:**
   a. Weber-m^2 b. Tesla c. $Nm^{-1}A^{-1}$ d. All of them
2. **Which of the following quantities is not affected by a magnetic field?**
   a. moving charge b. change in magnetic flux
   c. current flowing in a conductor d. stationary charge
3. **A magnetic field:**
   a. always exerts a force on a charged particle
   b. never exerts a force eon a charged particle
   c. exerts a force on a charged particle if it is moving across the magnetic lines of force
   d. exerts a force on a charged particle if it is moving along the magnetic lines of force
4. **The phenomenon of production of magnetic field on passing an electric current in a straight conducting wire is based on the law of:**
   a. coulomb b. oersted c. ampere d. faraday
5. **The permeability of free space, in (Wb/Am), is:**
   a. $\frac{1}{4\pi \times 10^{-7}}$ b. $\frac{1}{4\pi \times 10^{7}}$ c. $4\pi \times 10^{-7}$ d. $4\pi \times 10^{7}$
6. **One Wb/m² is equal to:**
   a. 10^4 gauss b. 10^2 gauss c. 10^{-2} gauss d. 10^{-4} gauss
7. **A moving charge produces:**
   a. an electric field only b. a magnetic field only
   c. both electric and magnetic fields d. neither an electric nor a magnetic field
8. **Two free parallel wires carrying currents in opposite directions:**
   a. does not affect each other b. attract each other
   c. repels each other d. get rotated to be perpendicular to each other
9. **Two free parallel wires carrying currents in same directions:**
   a. does not affect each other b. attracts each other
   c. repels each other d. get rotated to be perpendicular to each other
10. **The magnetic force acting on a unit positive charge moving perpendicular to the magnetic field with a unit velocity is called:**
    a. Magnetic flux b. Electric field intensity
    c. Magnetic induction d. Self-inductance
11. **Magnetic flux and flux density are related by:**
    a. Magnetic flux = Flux density / Area b. Magnetic flux = Flux density × Area
    c. Flux density = Magnetic flux / Area d. Flux density = Magnetic flux × Area
12. **Moving electric charges will interact with:**
    a. Electric field only b. Magnetic field only
    c. Both of these d. None of these
13. **Two streams of electrons moving parallel to each other in the same direction**
    a. Attract each other b. Repel each other
    c. Cancel the electric field each other d. Cancel the magnetic field each other
14. **A direct current flows through a metallic rod. The magnetic field produced due to it:**
    a. Exists outside only b. Exists inside only
    c. Exists both inside and outside d. Exists neither inside nor outside
15. **Which one of the following relations is correct?**
    a. 1 Wb-m^2 = $Nm^{-1}A^{-1}$ b. 1 tesla = 10^4 gauss
    c. 1 Wb-m^{-2} = 1 tesla d. All of the above
16. **Which of the following is scalar?**
    a. Magnetic flux b. Flux density c. EMF d. Both (a) and (c)
17. **No force is exerted by magnetic field on a stationary:**
    a. Current carrying conductor b. Magnetic dipole

c. Current loop d. Electric dipole

18. If a current is passed in a spring, it:

a. gets compressed b. gets expanded
c. Oscillates d. Remains unchanged

19. A magnet needle is kept in a non-magnetic field. It experiences:

a. A force and a torque b. A force but not a torque
c. A torque but not a force d. Neither a force nor a torque

20. Magnetic lines of force

a. intersect at infinity b. cannot intersect at all
c. intersects with in the magnet d. intersect at the neutral points

21. A magnetic compass will be deflected if it is kept near a:

a. charge in motion b. charge at rest c. both d. none

22. Which one the following material is most suitable for making core of an electromagnet?

a. air b. steel c. Cu-Ni alloy d. soft iron

23. The standard vector symbol for flux density is:

a. M b. L c. H d. B

24. The value of $(\mu_0/4\pi)$?

a. $10^{-7}TA^{-1}m^{-1}$ b. $10^{4}TA^{-1}$ c. $10^{-3}TA^{-1}m^{-1}$ d. $10^{-7}TA^{-1}m$

25. The magnetic force experienced by a charged particle moving in a magnetic field will be minimum when it moves:

a. perpendicular to the field b. parallel or antiparallel to field
c. inclined at some angle to the field d. inclined at an angle of 45°

26. The direction of the force experienced by a charged particle moving in a magnetic field will be:

a. Parallel to the field
b. Opposite to the field
c. Parallel to its direction motion
d. Perpendicular to both the field and the velocity vector

27. The force experienced by a charged particle moving in a magnetic field will be maximum when it moves:

a. Parallel to the field b. Perpendicular to the field
c. Anti-parallel to its direction of motion d. At an angle 45° to the field

28. The magnetic force on an electron travelling 10^8 m/sec parallel to a field of strength 10 web/m² is:

a. zero b. 10^2 N c. 10^{-12} N d. 16×10^{-12} N

29. An electron travels from left to right in the plane of the paper in a magnetic field perpendicular to and directed out of the paper. It is deflected:

a. Up b. Down c. Into paper d. Out of paper

30. A proton travels from left to right in the plane of the paper in a magnetic field perpendicular to and directed out of the paper. It is deflected:

a. Up b. Down c. Into paper d. Out of paper

31. An electron is accelerated by a potential difference of 12000 V. It then enters a uniform magnetic field to 10^{-3} T applied perpendicular to the path of electron. What is the radius of path? Given mass of electron = 9.11×10^{-31} Kg.

a. 36.7 m b. 36.74 cm c. 3.67 m d. 3.67 cm

32. An electron moves with speed 2×10^5 m/s along the positive x-direction in the presence of a magnetic induction B = i + 4j – 3k (in tesla). The magnitude of the force experienced by the electron in newton is:

a. 1.18×10^{-12} b. 1.28×10^{-13} c. 1.6×10^{-13} d. 1.72×10^{-13}

33. A proton enters a magnetic field of flux density 1.5 Wb/m² with a speed of 2×10^7 m/s at angle of 30° with the field. The force on the proton will be:

a. 0.24×10^{-12} N b. 2.4×10^{-12} N c. 24×10^{-12} N d. 0.024×10^{-12} N

34. A proton is accelerated by a potential difference of 6×10^5 Volts. It then enters a uniform field of B = 0.3 Tesla in a direction making an angle of 45° with the magnetic field. What will be the radius of the circular path?
a. 2.26 m b. 0.26 m c. 3.26 m d. 4.26 m

35. A proton is accelerated by a potential difference of 8×10^4 Volts. It then enters a uniform field of B = 0.707 Wb/m² in a direction making an angle of 45° with the magnetic field. What will be the radius of the circular path?
a. 2.04 m b. 0.04 m c. 3.04 m d. 4.04 m

36. Which of the following does not affect the motion of a moving electron?
a. Electric field applied in the direction of motion
b. Magnetic field applied in the direction of motion
c. Electric field applied perpendicular to the direction of motion
d. Magnetic field applied perpendicular to the direction of motion

37. An electron is moving in a circle of radius (r) in a uniform magnetic field (B). Suddenly the field is reduced to (B/2). The radius of the circle now becomes:
a. r/2 b. r/4 c. 2r d. 4r

38. A strong magnetic field is applied on a stationary electron. Then the electron:
a. moves in the direction of the field b. moves opposite to the field
c. starts spinning d. remains stationary

39. A neutron enters a magnetic field of flux density 1.5 Wb/m² with a speed of 2×10^7 m/s at angle of 30° with the field. The force on the particle will be:
a. 2.4×10^{-12} N b. 0 N c. 24×10^{-12} N d. 0.024×10^{-12} N

40. A charged particle is projected into a uniform magnetic field with its velocity perpendicular to the direction of the field. Which of the following quantities of the particle will not change:
a. Momentum b. Speed c. Velocity d. None

41. The radius of the circular path or helical path followed by the test charge (q_0) moving in magnetic field (B) with same velocity (v), is:
a. $mv\sin\theta/q_0B$ b. $mv\cos\theta/q_0B$ c. $mv\tan\theta/q_0B$ d. mv/q_0B

42. The time rate of work done by the magnetic field on the charge particle moving on a helical path, is:
a. qB b. q B/v c. qBv^2 d. zero

43. If an electron describes half a revolution in a circle or radius r in magnetic field B, the energy acquired by it is:
a. zero b. ½ mv² c. ¼ mv² d. πrBev

44. A proton enters in a magnetic field of (B) Weber/m² making an angle of 30° with the direction of magnetic field with velocity (v). The force acting on the portion is:
a. evB b. zero c. ∞ d. evB/2

45. A charged particle enters into a magnetic field perpendicular to the direction of field. The path followed by charged particle is:
a. A straight line b. Circular c. Hyperbolic d. Spiral

46. The radius of the orbit of a charged particle in a magnetic field is proportional to the:
a. Strength of the magnetic field b. Kinetic energy of the particle
c. Momentum of the particle d. Charge of the particle

47. A charged particle of charge q moving with velocity v enters along the axis of a current carrying solenoid. The magnetic force on the particle is:
a. 0 b. qvB c. Finite but not qvB d. Infinte

48. An electron enters region where magnetic field B and electric field E are mutually perpendicular to one another then.
a. It will always move in the direction of E b. it will always go in the direction of B
c. It always possess circular motion d. it can go undeflected also

49. A proton moves with a velocity V in x-direction. If a magnetic field acts on it in y-direction, the force on the proton acts in:
a. x-direction b. y-direction c. z-direction d. arbitrary direction

50. A proton moving with a velocity of 10^4 m/s enters a magnetic field first at 45° and then at 90° to the field. The forces acting on the proton in two cases are in the ratio.
a. $\sqrt{2}:1$ b. $1:\sqrt{2}$ c. $1:\sqrt{3}$ d. $\sqrt{3}:1$

51. An electron moving with a velocity of 2×10^5 m/s enters a magnetic field at an angle of 30° to it. Another electron moving at 10^5 m/s enters the same magnetic field at 60° to it. The forces acting on electron are in ratio.
a. $2:\sqrt{3}$ b. $\sqrt{3}:2$ c. $1:\sqrt{3}$ d. $\sqrt{3}:1$

52. When a particle of charge (q) and mass (m) enters into a uniform magnetic field (B) moving with a velocity (v) perpendicular to the direction of field, it describes a circular path of radius:
a. R=qB/mV b. R=mV/qB c. R=qmV/B d. R=qmB/V

53. When a particle of charge q and mass m enters into a uniform magnetic field B moving with a velocity v perpendicular to the direction of field, the time required by the charged particle to make a complete revolution in a magnetic field is given by:
a. T=2πq/Bm b. T=2πm/qB c. T=2πB/qm d. T=qB/2πm

54. The charged particles enter the uniform magnetic field in such a way that its initial velocity is not perpendicular to the field, the orbit will be:
a. a circle b. None c. an ellipse d. a helix

55. When charge particle enters into a magnetic field then K.E:
a. remains same b. increases c. decreases d. none

56. The magnitude of force experienced by a stationary charged particle in a uniform magnetic field is:
a. maximum b. minimum
c. zero d. remain same as experienced by moving charged particle

57. When an electron moving with a uniform velocity enters a magnetic field in a direction perpendicular to the field, the subsequent path of the electron is:
a. A straight line parallel to the field
b. A parabola in a plane perpendicular to the field
c. A circle in a plane perpendicular to the field
d. A straight line along its initial direction

58. A particle of mass m charge q and speed V, enters a uniform magnetic field of flux density B. The path of particle in the field is a circle of radius r. The radius r of the circle is:
a. independent mass m b. directly proportional to m
c. directly proportional to q d. directly proportional to B

59. Which of the following particles would experience the largest magnetic force when projected with the same velocity perpendicular to the magnetic field:
a. Proton b. Electron c. He^+ d. Li^{++}

60. Charge to mass ratio (e/m) of an electron is given by the relation:
a. $\frac{e}{m}=\frac{2V}{Br^2}$ b. $\frac{e}{m}=\frac{2V}{B^2r}$ c. $\frac{e}{m}=\frac{2V}{B^2r^2}$ d. $\frac{e}{m}=\frac{2V}{2B^2r^2}$

61. The e/m of an electron moving with speed along a circular path in a magnetic field is given as:
a. $e/m = B^2R/E$ b. $e/m = E/B^2R$ c. $e/m = E^2/B^2R$ d. $e/m = B^2/ER$

62. An electron enters a region where the electric field E is perpendicular to the magnetic field B. It will suffer no deflection if:
a. E=BeV b. B=eE/V c. E=BV d. E=BeV/2

63. Tick the correct statement when the plane of the current carrying coil is at right angles to the uniform magnetic field:
a. torque is maximum and flux is zero b. Torque is zero and flux is maximum
c. Both torque and flux are maximum d. Both torque and flux are zero

64. A straight wire of length 0.5 m and carrying a current of 1.2 A is placed in a uniform magnetic field of induction 2T. The magnetic field is perpendicular to the length of the wire. The force on the wire is:
a. 2.4 N b. 1.2 N c. 3.0 N d. 2.0 N

65. A circular loop of area 0.01 m^2 and carrying a current of 10A is placed parallel to a magnetic field of intensity 0.1 T. The torque acting on the loop, in Nm, is:
a. zero b. 0.8 c. 0.001 d. 0.01

66. A 5-meter wire carrying a current of 2A is at right angles to the uniform magnetic field of 0.5 weber/m^2. The force on the wire is:
a. 2 N b. 4 N c. 5 N d. 1.5 N

67. A current (I) carrying conductor (length-ℓ) is placed in a magnetic field (B). The maximum force acting on the conductor is:
a. IB ℓ b. IB/ ℓ c. I/B ℓ d. B/I ℓ

68. A current carrying conductor is placed in a uniform magnetic field parallel to it. The magnetic force experienced by the conductor is:
a. F=1/B b. F=1/B sinθ c. F=0 d. F=1/Bcosθ

69. What is the value of the current in a wire of 10 cm long at the right angle to a uniform magnetic field of 0.5Wbeber/m^2, when the force acting on the wire is 5N?
a. 1A b. 10A c. 100A d. 1000A

70. The magnetic field inside the solenoid along an axis due to current is:
a. Zero b. Non-uniform c. Infinite line d. Strong and uniform

71. The practical illustration of the phenomenon of mutual induction is:
a. A.C generator c. Motor
b. D.C dynamo d. Transformer

72. The magnetic induction due to an infinite long straight conductor at a distance 2 cm from it is 10^{-6} Tesla. The current flowing in the conductor will be:
a. 10 A b. 1 A c. 0.1 A d. zero

73. The magnetic induction due to a current (I) passed in a straight conductor at a distance (d) from it is proportional to:
a. I/d b. d^2 c. I/d^2 d. d

74. The strength of the magnetic field due to a long straight conductor is:
a. the same everywhere around the conductor
b. inversely proportional to the distance from the conductor
c. inversely proportional to the square of the distance from the conductor
d. inversely proportional to the cube of the distance from the conductor

75. A straight wire of diameter 0.5 mm carrying a current of 1A is replaced by another wire of diameter 1 mm carrying same current. The strength of the magnetic field far away is:
a. twice the earlier value b. half of the earlier value
c. quarter of the earlier value d. not changed

76. The magnetic field lines in the middle of solenoid are:
a. circles b. parallel to the axis c. spirals d. perpendicular to the axis

77. The expression for magnetic induction inside a solenoid of length L, carrying a current I and having N turns is:
a. $\frac{\mu_0}{4\pi}\frac{N}{L}I$ b. μ_0 NLI c. $\frac{\mu_0}{4\pi}$ NL I d. $\mu_0\frac{N}{L}I$

78. In a current-carrying long solenoid the field produced does not depend upon:
a. number of turns per unit length b. current flowing
c. radius of the solenoid d. length of the solenoid

79. A long solenoid has 20 turns/cm. The current necessary to produce a magnetic field of 20 millitesla inside the solenoid is approximately:
a. 1 A b. 2 A c. 4 A d. 8 A

80. The magnetic field produced at a point by an infinite long current carrying straight conductor is given by:
a. $B = \mu_o I/2\pi r$ b. $B = 2\pi r/\mu_o I$ c. $B = 2\pi\mu_o/Ir$ d. $B = Ir/2\pi\mu_o$

81. Magnetic field inside a solenoid is:
a. Directly proportional to current
b. Inversely proportional to current
c. Directly proportional to its length
d. Inversely proportional to total number of turns

82. The magnetic field B (in tesla) within a long solenoid having n turns per meter and carrying a current of i ampere is given by:
a. $\mu_0 ni/4\pi$ b. $\mu_0 ni$ c. $4\pi\mu_0 ni$ d. ni

83. It is required to produce inside a Toroid a field of 2×10^{-3} Tesla. Toroid has a radius of 15 cm and 300 number of turns. The current for the required purpose will be:
a. 15 Amp. b. 5 Amp. c. 50 Amp. d. 0 Amp.

84. In the above question, if the Toroid is wound on an iron core of permeability 300 times the permeability of free space what increase in B will occur for the same current?
a. 15 times. b. 300 times. c. 50 times. d. 0 times.

85. Two parallel metal plates separated by 5 cm of air have a potential difference of 200 volts. A magnetic field of 0.005 Tesla is also produced perpendicular to the electric field. A beam of electrons travel undeflected through these crossed fields. Speed of the electrons will be:
a. 18×10^5. b. 8×10^5. c. 81×10^5. d. 25×10^5.

86. What is the Mutual Inductance of the pair of coils if a current change of 6 Amp. In one coil causes the flux in the second coil of 2000 turns to change by 0.0012 webers?
a.400mh b. 100mh c. 300mh d. 200mh

87. An EMF of 45 mV is induced in a coil of 500 turns, when the current in the neighboring coil changes from 10 to 4 amps in 0.2 seconds. What is the Mutual Inductance of the coils?
a.1.5mh b. 10mh c. 30mh d. 20mh

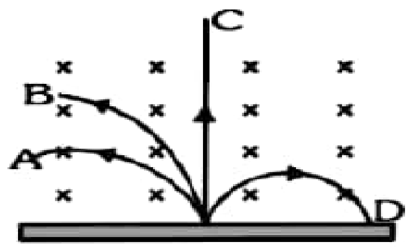
88. In the above question, the rate of change of flux (webers/second) in the second coil will be:
a. 9×10^{-5} b. 7×10^{-5} c. 8×10^{-5} d. 90×10^{-5}

89. An iron core solenoid with 400 turns has a cross sectional area of 4 cm^2. A current of 2 amps passing through it produces B = 0.5 Tesla. How large would be the EMF induced in it if the current is turned off in 0.1 seconds.
a. 0.8 V b. 0.3 V c. 0.6 V d. 0.5 V

90. In the above question, self-inductance of the coil will be:
a.40mh b. 10mh c. 30mh d. 20mh

91. A 100 turns coil in an AC generator, having an area of 500 cm^2, rotates in a field of 0.06 Tesla. How fast must the coil be rotated in order to generate a maximum voltage of 150 V?
a. 500 rad/sec b. 10 rad/sec c. 30 rad/sec d. 20 rad/sec

92. Neutron, Proton, Electron and an α-Particle enters a region of constant magnetic field (Field is along the inwards normal to the plane of the paper) with equal velocities. Tracks of the particles are shown in the fig. Relate the tracks to the particles.



a. A: Proton, B: α-Particle, C: Neutron, D: Electron
b. B: Proton, A: α-Particle, C: Neutron, D: Electron

c. A: Proton, B: α-Particle, D: Neutron, C: Electron

d. Cannot be predicted as the given information is not sufficient

93. An electron is emitted by a heated cathode and accelerated by PD of 2 kV enters a region with uniform magnetic field of 0.15 T. Determine the radius of the trajectory of electron if the field is transverse to its initial velocity.

a. 1 mm b. 2 mm c. 3 mm d. 4 mm

94. An electron is emitted by a heated cathode and accelerated by PD of 2 kV enters a region with uniform magnetic field of 0.15 T. Determine the radius of the trajectory of electron if the field is making an angle of 30° with its initial velocity.

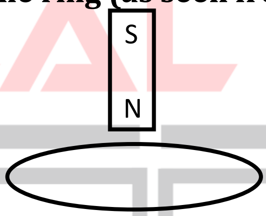
a. 0.5 mm b. 2 mm c. 3 mm d. 4 mm

ANSWER KEY # 01

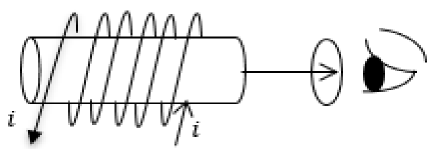
1	D	31	B	61	B	91	A
2	D	32	C	62	C	92	A
3	C	33	B	63	B	93	A
4	B	34	B	64	B	94	A
5	C	35	B	65	D	95	-
6	A	36	B	66	C	96	-
7	C	37	C	67	A	97	-
8	C	38	D	68	C	98	-
9	B	39	B	69	C	99	-
10	C	40	B	70	D	100	-
11	B	41	A	71	D	101	-
12	C	42	D	72	C	102	-
13	B	43	A	73	A	103	-
14	C	44	D	74	B	104	-
15	D	45	B	75	D	105	-
16	D	46	C	76	B	106	-
17	D	47	A	77	D	107	-
18	A	48	D	78	C	108	-
19	A	49	C	79	D	109	-
20	B	50	B	80	A	110	-
21	A	51	A	81	A	111	-
22	D	52	B	82	B	112	-
23	D	53	B	83	B	113	-
24	D	54	D	84	B	114	-
25	B	55	A	85	B	115	-
26	D	56	C	86	A	116	-
27	B	57	C	87	A	117	-
28	A	58	B	88	A	118	-
29	A	59	D	89	A	119	-
30	B	60	C	90	A	120	-

PRACTICE SHEET # 02

1. **A loop of wire is placed in a uniform magnetic field that is perpendicular to the plane of the loop. The electromotive force is induced in the loop when its area:**
   a. Shrinks at a constant rate
   b. Expands at a constant rate
   c. Neither expands nor shrinks
   d. Either expands or shrinks
2. **A step-up transformer is used on a 120V line to provide a potential difference of 2400V. If the primary coil has 75 turns, the number of turns in the secondary coil is:**
   a. 1500 b. 1200 c. 150 d. 1575
3. **If the EMF induced in a coil is 200V when the current changes from 1 A to 2 A in 0.05s, the self-inductance of the coil is:**
   a. 1H b. 10H c. 20H d. 30H
4. **The north pole of a magnet is brought near a metallic ring as shown in the figure. The direction of induced current in the ring (as seen from the top) will be:**



   a. anticlockwise b. clockwise
   c. first anticlockwise and then clockwise d. first clockwise and then anticlockwise
5. **Quantity that remains unchanged in a transformer is:**
   a. voltage b. current c. frequency d. none of these
6. **The unit of inductance is equivalent of:**
   a. $\frac{\text{volt}\times\text{ampere}}{\text{second}}$ b. $\frac{\text{ampere}}{\text{volt}\times\text{second}}$ c. $\frac{\text{volt}}{\text{ampere}\times\text{second}}$ d. $\frac{\text{volt}\times\text{second}}{\text{ampere}}$
7. **A two-meter wire is moving with a velocity of 1 m/sec perpendicular to a magnetic field of 0.5 weber/m². The EMF induced in it will be:**
   a. 0.5 volts b. 0.1 volts c. 1-volt d. 2 volts
8. **If the rotational velocity of a dynamo armature is doubled, then the induced EMF will:**
   a. become half b. become double c. become quadruple d. remain same
9. **Energy stored in the choke coil in the form of:**
   a. heat b. electric energy c. magnetic energy d. electro-magnetic energy
10. **The core of a transformer is laminated so that:**
    a. The ratio of the voltage in the secondary to that in the primary may be increased
    b. Energy losses due to eddy currents may be minimized
    c. The weight of the transformer may be reduced
    d. Rusting of the core may be prevented
11. **A current carrying solenoid is carried towards a conducting loop. The direction of induced current in the loop as observed by an observer on the other side will be:**



    a. towards west b. clockwise c. towards east d. anticlockwise

12. The turns ratio in a step-up transformer is 1 : 4. On passing a current of 4A in the primary, the current in the secondary will be:

a. 0.25A b. 1A c. 2A d. 8A

13. When a piece of wire is passed through the space between the pole pieces of a horse shoe magnet in 0.1 s then an EMF of 4×10^{-3}V is induced in it. The magnetic flux between the pole piece will be:

a. 4×10^{-4}Wb b. 0.1 Wb c. 10Wb d. 4×10^{2} Wb

14. The number of turns in the primary and secondary coils of an ideal transformer are 100 and 300 respectively. If the input power is 60W the output power will be:

a. 180W b. 3×10^{3}W c. 60W d. 20W

15. An inductor may store energy in:

a. in coil b. its magnetic field

c. its electric field d. both in electric and magnetic field

16. A 50mH coil carries a current of 2A, the energy stored in it in Joules is (E=1/2 LI^2) :

a. 5.05 b. 0.1 c. 0.5 d. 1

17. The value of current in the armature of a DC motor is maximum when the motor:

a. starts rotating with mean speed b. has gained full speed

c. is switched off d. just starts rotating

18. Two inductance coils, of same self-inductance, L are connected in parallel and the distance between them is large. The resultant self-inductance of the coil will be (Inductors in parallel behave like resistors in parallel combination):

a. L/2 b. L/4 c. 2L d. L

19. According to Faraday's law of electromagnetic induction, the induced EMF in a coil can be mathematically expressed as:

a. $E = -N\Delta t/\Delta\phi$ b. $E = -\Delta\phi/N\Delta t$ c. $E = -N\Delta\phi/\Delta t$ d. $E = -\Delta t/N\Delta\phi$

20. Mutual inductance of two coils is measure by the relation:

a. $M = -\varepsilon_o/\Delta I_p/\Delta t$ b. $M = -\varepsilon_o \Delta I_p/\Delta t$ c. $M = -\varepsilon_o/\Delta t$ d. $M = -\varepsilon_o/\Delta I_p$

21. Mutual inductance has a practical role in the performance of the:

a. Radio choke b. A.C generator c. D.C generator d. Transformer

22. The magnitude of the EMF induced in the coil of A.C generator is given by:

a. $\varepsilon = NBA \sin \omega t$ b. $\varepsilon = NBA \sin \omega t/\omega$ c. $\varepsilon = NBA\omega \sin\omega t$ d. $\varepsilon = B \sin\omega t/NA\omega$

23. A dynamo converts:

a. electrical energy into mechanical energy b. mechanical energy into electrical energy

c. heat energy into electrical energy d. magnetic energy into electrical energy

24. A transformer is used to change:

a. the voltage of direct current b. the voltage of alternating current

c. the electrical energy d. the magnetic field

25. If the secondary coil has N_s turns and the primary N_p turns, the relation between secondary and primary voltages is given by:

a. $V_s/V_p = N_p/N_s$ b. $V_s/V_p = N_s/N_p$ c. $V_p/V_s = N_s/N_p$ d. None

26. The induced EMF 'ε' produced during the phenomenon of self-inductance is given by the relation:

a. $\varepsilon_L = -L\frac{\Delta I}{\Delta t}$ b. $\varepsilon_L = -L\frac{\Delta I}{\Delta t}$ c. $\varepsilon_L = -L\Delta I \times \Delta t$ d. $\varepsilon_L = -\frac{\Delta I}{L\Delta t}$

27. The work is stored in the inductor as:

a. Elastic potential energy b. Kinetic energy

c. Potential energy d. Gravitational potential energy

28. The relation for EMF induced in an A.C. generator can be expressed by:

a. $\varepsilon = \varepsilon_o\cos(\omega t)$ b. $\varepsilon = \varepsilon_o\sin(\omega t)$ c. $\varepsilon = \varepsilon_o\tan(\omega t)$ d. $\varepsilon = \varepsilon_o/\sin(\omega t)$

29. Slip rings are used in:

a. A.C. Dynamo b. D.C. Dynamo c. Rectifier d. Electric motor

30. The induced EMF in a motor which opposes the external EMF running the motor is called:
a. Induced EMF of a motor
b. Back EMF of a motor
c. EMF
d. Forward EMF of battery

31. According to Faraday's law, the EMF induced in a coil depends on the:
a. Maximum magnetic flux
b. Rate of change of magnetic flux
c. Change in magnetic flux
d. Internal magnetic flux

32. The SI unit of self-inductance is the same as that of:
a. Capacitance b. Mutual inductance c. EMF d. Reactance

33. The direction of induced current is determined by:
a. Faraday's law b. Ohm's law c. Ampere's law d. Lenz's law

34. Lenz's law is a consequence of the law of conservation of:
a. charge b. current c. momentum d. energy

35. The current in a coil changes from 0 to 2A in 0.05s. If the induced EMF is 80V, the self-inductance of coil is:
a. 1H b. 0.5H c. 1.5H d. 2H

36. The mutual inductance of a pair of coils is 2H. If the current in one of the coil changes from 10A to zero in 0.1s, the EMF induced in the other coil is:
a. 2V b. 20V c. 0.2V d. 200V

37. The mutual inductance of a pair of coils, each of N turns, is M henry. If a current of I A in one of the coil is brought to zero in t seconds, the average induced EMF in the other coil, in volt, will be:
a. $\frac{MI}{t}$ b. $\frac{NMI}{t}$ c. $\frac{MN}{It}$ d. $\frac{MI}{Nt}$

38. An EMF of 5 mV is induced in a coil when, in a nearby placed another coil, the current changes by 5A in 0.1 s. The mutual inductance between the two coils will be:
a. 1H b. 0.1 H c. 0.1 mH d. 0.001 mH

39. Eddy currents are produced in a material when it is:
a. heated
b. placed in a time varying magnetic field
c. placed in an electric field
d. placed in a uniform magnetic field

40. Faraday's law of electromagnetic induction is related to the:
a. Law of conservation of charge
b. Law of conservation of energy
c. Third law of motion
d. Law of conservation of angular momentum

41. When a direct current i is passed through an inductance L, the energy stored is:
a. zero b. Li c. $\frac{1}{2}Li^2$ d. $L^2/2i$

42. When the current in a coil changes from 6A to 8A in 0.05s, an EMF of 8V is induced in the coil. The coefficient of self-inductance of the coil is:
a. 0.1 H b. 0.2 H c. 0.4H d. 0.8H

43. The self-inductance of a coil is 15H. A current of 7.5A changes to 8.5A within 5s through the coil. The value of induced EMF will be:
a. 10V b. 0.1V c. 3.0V d. 100V

44. The direction of induced Current during electromagnetic induction is given by:
a. Faraday's law b. Lenz's law c. Maxwell's law d. Ampere's law

45. To induce an EMF in a coil, the linking magnetic flux:
a. must decrease
b. must increase
c. must remain constant
d. can either increase or decrease

46. An ideal transformer is used to step up an alternating EMF of 220 V to 4.4kV to transmit 6.6 kW of power. The current rating of the secondary is:
a. 30A b. 3A c. 1.5A d. 1A

47. A current of 2A flowing through a coil of 100 turns gives rise to a magnetic flux of 5×10^{-5} Wb per turn. The magnetic energy associated with the coil is:
a. 5 J b. 0.5 J c. 0.05 J d. 0.005 J

48. The current passing through a choke coil of 5H is decreasing at the rate of 2 A/s. The EMF developed across the coil is:
a. 10V b. – 10V c. 2.5V d. – 2.5V

49. The current passing through a choke coil of 5H is increasing at the rate of 2 A/s. The EMF developed across the coil is:
a. 10V b. – 10V c. 2.5V d. – 2.5V

50. In a step-up transformer, the turns ratio of primary and secondary is 1:2. A Leclanche cell (Battery supplying DC) of EMF 1.5V is connected across the primary. The voltage developed across the secondary would be:
a. zero b. 3.0V c. 1.5V d. 0.75V

51. One henry is equal to:
a. 1 ohm×1 sec b. 1 ohm× 1-meter c. 1 oh×1 coulomb d. 1 ohm/1 meter

52. When the plane of the coil of an A.C. generator is placed perpendicular to the magnetic field, the EMF produced will be:
a. Maximum b. Minimum c. Zero d. None of these

53. For transmission of electricity to far-off places, from the A.C. power generating plant, we always use:
a. step-down transformer b. Step-up transformer
c. Transformer with several secondaries d. All of the above

54. For distribution of electricity to consumers, from the Transmission line, we always use:
a. step-down transformer b. Step-up transformer
c. Transformer with several secondaries d. All of the above

55. Which one of the following is correct for a step-down transformer?
a. $N_p > N_s$ b. $N_p < N_s$ c. $N_p = N_s$ d. $N_s = 2N_p$

56. An alternating current pass through one complete cycle in 1μs, its frequency is:
a. 10^{-4} Hz b. 10^{9} Hz c. 10^{6} Hz d. 10^{-3} Hz

57. Induced EMF produced in a coil rotating in a magnetic field will maximum when the angle between the axis of coil and direction of magnetic field is:
a. 0° b. 90° c. 45° d. 180°

58. Which of the following phenomenon is independent of direction of the current in the circuit:
a. Mutual induction b. Electrolysis
c. Joule's heating d. None of these

59. The self-inductance of a coil is the measure of:
a. Electrical inertia b. Electrical friction
c. Induced EMF d. Induced current

60. An electric motor:
a. Creates electrical energy
b. Creates mechanical energy
c. Converts mechanical energy into electrical energy
d. Converts electrical energy into mechanical energy

61. When a number of turns in a coil is double without any change in the length of the coil, it self-inductance becomes:
a. Four times b. Double c. Halved d. Squared

62. Henry is equal to:
a. 1 (weber/ampere) b. 1 (weber/volt)
c. 1 weber-Ampere d. 1 Weber-volt

63. **Which of the following is not the unit of magnetic induction?**
a. Tesla b. Gauss c. Oersted d. Weber/meter^2

64. **To convert mechanical energy into electrical energy, one can use:**
a. A.C dynamo b. Transformer c. D.C dynamo d. A and C both

65. **A transformer is used to convert**
a. Mechanical energy into electrical energy
b. Alternating current into direct current
c. Direct current into alternating current
d. A.C of high voltage and low amperage into A.C. of low voltage and high amperage and vice versa

66. **In a step-down transformer the input voltage is 22KV and the output voltage is 550V. The ratio of the number of turns in the secondary to that in the primary is:**
a. 1 : 20 b. 20 : 1 c. 1 : 40 d. 40 : 1

67. **In a noiseless transformer an alternating current of 2A is flowing in the primary coil. The number of turns is the primary and secondary coil are 1000 and 200 respectively. The value of current in the secondary coil is:**
a. 0.08A b. 10A c. 0.4A d. 5A

68. **A low-loss transformer has 230V applied to the primary and gives 4.6V in the secondary. The secondary is connected to a load which draws 5A of current. The current in the primary is:**
a. 0.1 b. 1.0 c. 10 d. 250

69. **An ideal transformer is used to step up an alternating EMF of 220V to 30KV to transmit 45KW of power. The current rating of the secondary is:**
a. 30A b. 3A c. 1.5A d. 1A

70. **In a transformer, the number of turns in the primary and secondary coils are 1000 and 3000. If the primary is connected across 80V AC, the potential difference across each turn of the secondary will be:**
a. 240V b. 0.24V c. 0.8V d. 0.08V

71. **In an ideal transformer, the voltage and the current in the primary are 220V, 2A and those in the secondary are 440V, I A. The value of I is:**
a. 4 b. 1 c. 20 d. 2

72. **Weber is the unit of:**
a. Magnetic field intensity b. magnetic induction
c. magnetic flux d. self-inductance

73. **EMF generated by A.C dynamo depends upon:**
a. number of turns in the coil b. magnetic field strength
c. frequency of rotation d. all of the above

74. **An alternating current or voltage:**
a. fluctuates off and on
b. varies in magnitude only
c. changes its direction again and again
d. changes its magnitude continuously and reverses its direction of flow after regularly recurring intervals

75. **If the coil is wound on an iron core, the flux through it:**
a. decreases b. becomes zero c. remains same d. increases

76. **Which of the following uses electric energy and does not convert it into any other form?**
a. transformer b. motor c. D.C generator d. A.C generator

77. **The only difference between construction of D.C generator and A.C generator is that of:**
a. carbon brushes b. coil
c. commutator d. magnetic field

78. **The answer to which question will distinguish between magnetic and non-magnetic materials:**
a. Is it a metal or a non-metal
b. Is it a conductor or insulator
c. Can it be given an electric field
d. Does it affect the direction in which a compass needle points.

79. The EMF induced in a coil by a changing magnetic flux may have unit as:

a. $ms^{-1}A$ b. $ms^{-2}A^{-1}$ c. $kgms^{2}A^{-1}$ d. $kgm^{2}s^{-3}A^{-1}$

80. The EMF induced in a conductor of unit length moving with unit velocity at right angles to a magnetic field is equal to:

a. Magnetic flux density b. Torque
c. Mutual induction d. Motional EMF

81. A STEP UP transformer has transformation ratio of 3:2, what is the voltage of the secondary coil if the primary voltage is 30V

a. 20V b. 60V c. 45V d. 15V

82. In an electromagnetic wave the electric field vector E and the magnetic field vector B are:

a. Perpendicular to each other b. Parallel to each other
c. 45° to each other d. can have any angle between them

83. A.C cannot be used for:

a. Producing heat b. producing light
c. Electroplating d. producing magnetic field

84. A charged particle moving in uniform magnetic field then:

a. Its momentum changes but total energy remain conserved
b. Both momentum and total energy remain same
c. Both changes
d. Total energy change but momentum remain same

85. The alternating current has frequency of 10^6Hz, in such a way that time period for completion of cycle is:

a. 1μs b. 1.5 μs c. 10^6sec d. 1 sec

86. The output voltage of a transformer is 3 times the input voltage then turns ratio will be:

a. 1:3 b. 3:1 c. 1:1 d. 6:1

87. Self-inductance of a long solenoid having length (ℓ) is:

a. $\mu_0 N^2 \ell A$ b. $\mu_0 N^2 A/\ell$ c. $\mu_0 N^2 \ell A$ d. BA

ANSWER KEY # 02

1	D	31	B	61	B
2	A	32	B	62	A
3	B	33	D	63	C
4	A	34	D	64	D
5	C	35	D	65	D
6	D	36	D	66	C
7	C	37	A	67	B
8	B	38	C	68	A
9	C	39	B	69	C
10	B	40	B	70	D
11	B	41	C	71	B
12	B	42	B	72	C
13	A	43	C	73	D
14	C	44	B	74	D
15	B	45	D	75	D
16	B	46	C	76	A
17	D	47	D	77	C
18	A	48	A	78	D
19	C	49	B	79	D
20	A	50	A	80	A
21	D	51	A	81	C
22	C	52	C	82	A
23	B	53	B	83	C
24	B	54	A	84	A
25	B	55	A	85	A
26	A	56	C	86	A
27	C	57	B	87	B
28	B	58	C	88	-
29	A	59	A	89	-
30	B	60	D	90	-

CHAPTER # 15: ELECTRICAL MEASURING INSTRUMENTS

GALVANOMETER

It is an instrument which is used for the detection or measurements of small currents of the order of micro-amps or milli-amps

Principle

The working of a galvanometer depends upon the torque exerted on a coil suspended in a magnetic field when a current is passed through the coil.

Working

When a current 'I' is passed through the coil, it is deflected through an angle 'α' with respect to the field. Let the coil of galvanometer have 'N' turns and its area be 'A', then the torque acting on it is given by:

$$\text{Deflecting Coil} = \text{BINA Cos } \alpha$$

As, the field is radial so, $\alpha = 0$. Therefore,

$$\text{Deflecting Coil} = \text{BINA}$$

Due to this torque coil rotates and therefore twist is produced in the suspension string, due to which string provides restoring torque whose value is given by following relation.

$$\text{Restoring Torque } \alpha \ \theta$$

$$\text{Restoring Torque} = c\theta$$

Where, 'c' is suspension constant and is known as torsional constant (couple per unit twist), and is known as torsional couple and is equal to the torque required to produce unit twist in the suspension.

Since in the equilibrium position deflecting torque is equal to the restoring torque, therefore we can write,

$$\text{BINA} = c\theta$$

$$I = \frac{c}{\text{BNA}}\theta$$

$$I = (\text{constant})\ \theta$$

$$I \propto \theta$$

This shows that the angle of deflection of the coil is directly proportional to current flowing in coil, it is called principle of the moving coil galvanometer.

Sensitivity of the Galvanometer

The current sensitivity of a galvanometer is defined as, "deflection per unit current", or

$$\text{Current sensitivity} = \frac{\theta}{I}$$

The theory of galvanometer gives,

$$\frac{I}{\theta} = \frac{C}{\text{BNA}}$$

Stable Galvanometer or Dead Beat Galvanometer:

When the current passing through the galvanometer is discontinued, the coil will not come to rest as soon as the current flowing through the coil is stopped. It keeps on oscillating about its mean position before coming to rest.

In the same way if the current is established in a galvanometer, the coil will shoot beyond its final equilibrium position and will oscillate several times before coming to rest at its equilibrium.

Artificial ways are employed to make the coil come to rest quickly. Such galvanometer in which the coil comes to rest quickly after the current passed through it or the current is stopped from flowing through it, is called stable or a dead-beat galvanometer.

AMMETER

An ammeter is an electrical instrument which is used to measure current in amperes. It is always connected in series with the circuit through which the current is passing.

An ammeter is basically a galvanometer. A galvanometer is used to detect the current in a circuit and it gives full scale deflection for a very small current. So an ordinary galvanometer cannot be used for measuring large current without proper modification. A galvanometer can be converted into an ammeter by connecting a suitable low resistance in parallel with its coil. The low resistance is called as "shunt".

Conversion of a Galvanometer into an Ammeter

$$R_s = \frac{I_g}{I - I_g} R_g$$

It is the value of the shunt resistance'R_g' which is to be used to convert the galvanometer into an ammeter to read current 'I'.

VOLTMETER

A voltmeter is an electronic device which measures a voltage of a source or potential difference between any two points of a circuit. It is always connected in parallel with the circuit.

A galvanometer can be converted into a Voltmeter by connecting a suitable resistance in series with its coil. This high resistance is called as multiplier.

Conversion of Galvanometer into Voltmeter

$$R_x = \frac{V}{I_g} - R_g$$

It is the value of high resistance 'R_x' which is to be used for converting the galvanometer into a voltmeter. The scale is graduated to read voltage from '0' to 'V'

WHEATSTONE BRIDGE

It is an electric circuit that is used to measure the value of an unknown resistance accurately,

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

This is the condition for the bridge to be balance and is called the principle of Wheatstone bridge. In this equation, if any three resistances are already known, then the fourth one can be calculated.

Whenever this condition is satisfied, no current flows through the galvanometer and it shows no deflection.

METER BRIDGE OR SLIDE WIRE BRIDGE

The meter bridge, also called slide-wire bridge is an instrument based on Wheatstone Principle. A uniform wire (of manganin or constantan) of one-meter-long and of fairly high resistance is used.

POST OFFICE BOX (P.O.BOX)

Post Office Box is another instrument based on Wheatstone Principle. It is so named because it was first introduced for finding the resistances of telegraph wires and of fault-finding work in the post and telegraph office. It is more compact and easier to use.

THE OHMMETER

- The Ohmmeter is a useful device for quick measurement of resistance."
- The scale of the Ohmmeter, however, is not linear.

POTENTIOMETER

- A Potentiometer is a device for measuring the potential difference (or voltage) between two points of a circuit or E.M.F. of a current source.
- In a potentiometer the length of the wire may be 1 meter or 5 or 10 meters.
- The larger the length, the greater is the accuracy of measurement.

AVO METER

- The circuit which can be used to measure the currents, the voltages or the resistances of different ranges (or orders). This compact meter is usually called universal meter.

Note:

1. Potential difference is usually measured by an instrument called voltmeter. The voltmeter can read the potential difference only when it does not draw any current from the circuit across which it is connected.
2. An ideal voltmeter would have an infinite resistance.
3. Digital voltmeter and cathode ray oscilloscope are potential measuring instruments which practically do not draw any current from the circuit because of their large resistance and read the correct potential difference.
4. Digital voltmeter and cathode ray oscilloscope are very expensive instruments whereas a very simple instrument which can measure and compare potential differences accurately is a potentiometer.

PRACTICE SHEET # 01

1. **In a moving coil galvanometer, the current I is related to the deflection θ as:**
   a. $I \propto \theta$ b. $I \propto \tan\theta$ c. $I \propto \theta^2$ d. $I \propto \sqrt{\theta}$
2. **A galvanometer with resistance 100Ω gives full scale deflection with a current of 10 mA. The value of shunt, in order to convert it into an ammeter of 10 ampere range, will be:**
   a. 0.01 Ω b. 0.1 Ω c. 10 Ω d. 1 Ω
3. **A galvanometer with resistance 5Ω can read up to 5 mA. If this instrument is to be used to read up to 100 V, then the value of resistance to be used in its series will be:**
   a. 1999.95 Ω b. 199.995 Ω c. 19.9995 Ω d. 19995 Ω
4. **An ammeter reads up to 1A. Its internal resistance is 0.81Ω. To increase the range to 10A, the value of the required shunt is:**
   a. 0.3 Ω b. 0.9 Ω c. 0.09 Ω d. 0.03 Ω
5. **The coil of a galvanometer is suspended in a radial field so that the deflecting torque on the coil is always:**
   a. NIAB cos α b. NIAB sin α c. NIAB tan α d. NIAB
6. **The current passing through a coil of galvanometer is given by:**
   a. I = Cθ/BAN b. I = CθN/AB c. I = ANB/Cθ d. I = AN/BCθ
7. **In order to increase the range of an ammeter, the shunt resistance is:**
   a. Decreased b. Increased
   c. Kept constant d. Sometimes increased and sometime decreased
8. **To convert a galvanometer of resistance 50Ω and current limit 2 mA into an ammeter of range 1 ampere, the resistance required is:**
   a. 25 Ω b. 0.1 Ω c. 0.2 Ω d. 0.05 Ω
9. **The pole pieces of the magnet in galvanometer are made concave to make the field:**
   a. Strong b. Weak c. Radial only d. Radial and strong
10. **Such a galvanometer in which the coil comes to rest quickly after the current passed through it is called:**
    a. Sensitive galvanometer b. Stable galvanometer
    c. Dead beat galvanometer only d. Both stable and dead-beat galvanometer
11. **To convert a moving coil galvanometer into voltmeter, the series high resistance (Multiplier) is given by:**
    a. $R_x = \frac{V}{I_R} + R_g$ b. $R_x = \frac{V}{I_g} - R_g$ c. $R_x = \frac{V}{R_g} - I_g$ d. $R_x = \frac{V}{R_g} + I_g$
12. **When the coil of the galvanometer is in equilibrium, then the deflecting couple is:**
    a. zero b. equal to restoring couple
    c. smaller than the restoring couple d. greater than the restoring couple
13. **The Sensitivity (I/θ) of a Galvanometer is given by:**
    a. C/BAN b. CAN/B c. BAN/C d. ABC/C
14. **In a Multi Range ammeter, as the range increases:**
    a. shunt value decreases b. shunt value increases
    c. shunt value remains same d. none of these
15. **An ammeter measures the total current flowing through a circuit when it is connected:**
    a. in series with the circuit
    b. in parallel with the circuit
    c. in series with any of the parallel resistances in the circuit
    d. in parallel with any of the series resistances in the circuit
16. **To increase the measuring range of a voltmeter, the series resistance should be:**
    a. Increased
    b. Decreased
    c. Kept constant and R_g should increase
    d. Zero

17. A galvanometer basically is an instrument that is used to:
a. detect current in a circuit
b. measure current flowing through a circuit
c. measure voltage across a circuit
d. measure potential difference between two points in a circuit

18. The effective & practical way to increase the sensitivity of a moving coil galvanometer is to:
a. Use a very long and fine suspension
b. Use a coil of very large area
c. Use a coil with very large number of turns
d. Use a very strong magnetic field

19. The galvanometer constant in a moving coil galvanometer is given by:
a. K= NAB/C b. K=NB/CA c. K=NAC/B d. K=C/BAN

20. The S.I unit of galvanometer constant is:
a. N-m/Radian b. Amp/radian c. N-Amp/radian d. All the above

21. For a radial magnetic field, the angle α between plane of the coil and the magnetic field is:
a. 0° b. 30° c. 60° d. 90°

22. Principle of working of a Galvanometer is that:
a. A current carrying coil experiences attractive force in a magnetic field
b. A current carrying coil experiences repulsive force in a magnetic field
c. A current carrying coil experiences torque in magnetic field
d. None of these

23. The resistance of an ideal Ammeter is:
a. zero b. small c. very high d. infinite

24. If R_g is the resistance of coil of a galvanometer, R_s is the shunt resistance, then the resistance R_A of the ammeter is given by:
a. $R_A=R_g+R_s$ b. $\frac{1}{R_A}=\frac{1}{R_g}+\frac{1}{R_s}$ c. $R_A=\frac{1}{R_g}+\frac{1}{R_s}$ d. $\frac{1}{R_A}=\frac{1}{R_g}-\frac{1}{R_s}$

25. When a wheat stone bridge of resistance arms R_1, R_2, R_3 and R_4 is balanced.
a. No current flows through its arms
b. Some current flows through its arms
c. Some current flows through the galvanometer
d. There is some potential difference across the galvanometer

26. Meter bridge is based on the principle of:
a. Ohm's law b. Bilal's Manjan c. Wheat stone bridge d. Ampere's law

27. In the measurement of resistance by a meter bridge, the known and unknown resistances are interchanged to eliminate:
a. End-errors
b. The index errors
c. Error due to thermo-electric effect
d. Random error

28. When wheat stone bridge is balanced:
a. Current in resistance P = Current in resistance Q
b. Current in resistance R = Current in resistance S
c. Current through galvanometer = zero
d. All of the above

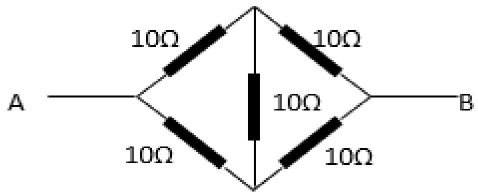
29. Wheat stone bridge is most sensitive when
a. P = Q and R = S b. P = Q = R = S c. P + Q = R + S d. P – Q = R – S

30. Slide wire bridge is used to measure
a. EMF b. potential c. resistance d. current

31. Post office box is a device for measuring the resistance based on the principle of:
a. potentiometer b. galvanometer c. Ohms mete d. Wheat stone bridge

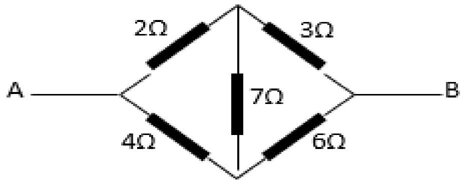
32. The wheat stone's bridge is a cyclic mesh:
a. Network of two resistances
b. Network of three resistances
c. Network of four resistances
d. Network of five resistances

33. In the given network, the effective resistance between points A and B is:



a. 25Ω
b. 10Ω
c. 20Ω
d. 30Ω

34. Five resistances are connected as shown in the figure. The effective resistance between the points A and B is:



a. 20/3 Ω
b. 10/3 Ω
c. 20Ω
d. 30Ω

35. * Four resistors P, Q, R and S having resistances 2, 2, 2, and 3 ohms respectively, are arranged to form a wheat stone bridge. The value of the resistance with which S must be shunted in order to balance the bridge is:

a. 2Ω b. 3Ω c. 4Ω d. 6Ω

36. In a Balanced Wheatstone network:

a. Ig = 0 b. Ig = Maximum c. Ig = Minimum d. None

37. Cary Foster's bridge, Callendar and Griffiths Bridge are the practical examples of:

a. Ohm's law b. Coulomb's law c. Wheat stone bridge d. Ampere's law

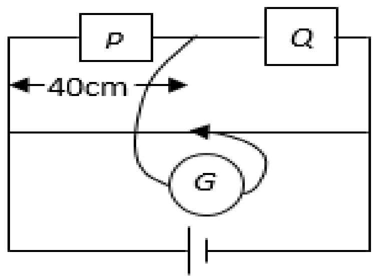
38. Uniform wire in Meter Bridge is usually made up of:

a. Constantan b. Manganin c. Both d. None

39. Scale of Ohm meter is:

a. Linear b. Non-Linear c. Both d. None

40. * In a meter bridge the gaps are closed by two resistances P and Q and the balance point is obtained at 40cm. When Q is shunted by a resistance of 20Ω, the balance point shifts to 50cm. The values of P and Q are:

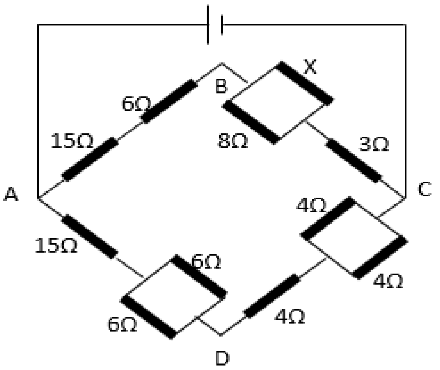


a. 10/3Ω, 5Ω
b. 20/3Ω, 10Ω
c. 10Ω, 20/3Ω
d. 5Ω, 10/3Ω

41. * In a typical Wheat stone's network, the resistances in cyclic order are P = 10Ω, Q= 5Ω, S= 4Ω and R= 4Ω. For the bridge to balance:

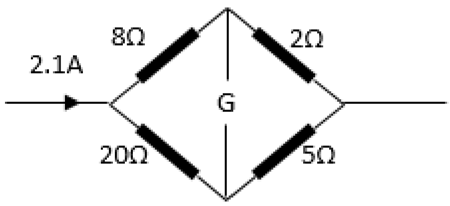
a. 10Ω should be connected in parallel with P
b. 10Ω should be connected in series with P
c. 5Ω should be connected in parallel with Q
d. 5Ω should be connected in series with Q
e. Both (a) and (d)

42.* In the given circuit the value of resistance X so that the potential difference between B and D is zero is:



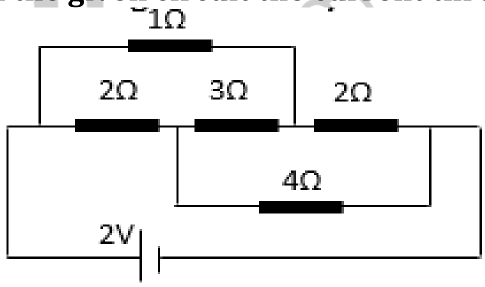
a. 4Ω
b. 6Ω
c. 8Ω
d. 9Ω

43.* In the given circuit, if the galvanometer shows no deflection, the current through the 5Ω resistor is:



a. 0.5A
b. 0.6A
c. 0.9A
d. 1.5A

44.* In the given circuit the current through the battery is:



a. 1.0A
b. 1.5A
c. 2.0 A
d. 3.0A

45. Sensitivity of a potentiometer can be increased by:
a. Increasing the EMF of the cell
b. Increasing the length of the wire
c. Decreasing the length of the wire
d. None of these

46. Potential gradient is defined as:
a. Fall of potential per unit length of the wire
b. Fall of potential per unit area of the wire
c. Fall of potential between two ends of the wire
d. Potential at any one of the wires

47. Electromotive force (EMF) is most closely related to:
a. Electric field
b. Magnetic field
c. Potential difference
d. Mechanical force

48. Potentiometer measures potential more accurately because:
a. It measures potential in the open circuit (Zero Current Principle)
b. It uses sensitive galvanometer for null detection
c. It uses high resistance potential wire
d. It measures potential in the closed circuit

49. The terminal potential difference of a battery exceeds its EMF when it is connected
a. In parallel with a battery of higher EMF
b. In series with a battery of lower EMF
c. In series with a battery of higher EMF
d. In parallel with a battery of lower EMF

50. When null point is obtained in the potentiometer the current is drawn from:
a. Cell only
b. Main battery only
c. Both the cell and the main battery
d. Neither cell nor main battery

51. Potentiometer is a better device for measuring the potential difference than the voltmeter because:

a. It uses a longer wire
b. It uses main battery of higher EMF
c. It is based on the principle of wheat stone bridge
d. It does no change the potential difference to be measured

52. In potentiometer experiments

a. The wire must be uniform and longer for increasing the sensitivity.
b. E.M.F of the battery in main circuit must be greater than E.M.F to be measured
c. Positive terminals of the battery and cell must be connected at the same point
d. All of these

53. The null point in a potentiometer with a cell of EMF E is obtained at a distance ℓ on the wire. Then:

a. $E \propto \ell$ b. $E \propto \ell^2$ c. $E \propto 1/\ell$ d. $E \propto 1/\ell^2$

54.* Two cells having EMFs E_1 and E_2 ($E_1 > E_2$), when placed in series produce Null deflection at a distance of 204 cm in a potentiometer. When placed in opposition, they produce Null deflection at a distance of 36 cm. If $E_2 = 1.4V$, E_1 is:

a. 14V b. 10V c. 4.2V d. 2V

55. A 2.0 Volt potentiometer is used to determine the internal resistance of 1.7 Volt cell. The balance point of the cell in open circuit is 75 cm. When a resistor of 10Ω is connected across the cell, the balance point shifts to 60 cm. The internal resistance of the cell is:

a. 1.5Ω b. 2.5Ω c. 3.5Ω d. 4.5Ω

56. * A potentiometer wire of length 100 cm has a resistance of 20Ω. It is connected in series with a resistance and an accumulator of 4V and of negligible internal resistance. A source of EMF 40 mV is balanced against a 40 cm length of the potentiometer wire. The value of the external resistance is:

a. 390Ω b. 780Ω c. 410Ω d. 820Ω

57.* Wire of Potentiometer is 10 m long and has a resistance of 20Ω. It is connected in series with a battery of EMF 3V and a resistance of 10Ω. The potential gradient along the wire in V/m is:

a. 0.01 b. 0.02 c. 0.1 d. 0.2

58. The electromotive force of standard cell balances across 150 cm length of the wire of a potentiometer. When a resistance of 2Ω is connected as a shunt with the cell. The balance point is obtained at 100 cm length. The internal resistance of the cell:

a. 0.1Ω b. 1Ω c. 2Ω d. 0.5Ω

59.* A potentiometer wire of length 10 m and resistance 15Ω is in series with a resistance of 5Ω and a cell of EMF 2V. The potential gradient along the wire is:

a. $\frac{1}{500}$ V/cm b. $\frac{3}{2000}$ V/cm c. $\frac{3}{5000}$ V/cm d. $\frac{1}{1000}$ V/cm

60. In a potentiometer experiment the galvanometer shows no deflection when a cell is connected across 60 cm of the potentiometer wire. If the cell is shunted by a resistance of 6Ω, the balance point is obtained across 50 cm of the wire. The internal resistance of the cell is:

a. 0.5Ω b. 0.6Ω c. 1.2Ω d. 1.5Ω

61. The resistivity of a potentiometer wire is 40×10^{-8} ohm-m and its area of cross-section is $8 \times 10^{-6} m^2$. If 0.2A current is flowing through the wire, the potential gradient will be:

a. 10^{-2} volt/m b. 10^{-1} volt/m c. 3.2×10^{-2} volt/m d. 1 volt/m

62.* In a potentiometer experiment two cells of EMF E_1 and E_2 are used in series and in conjunction and the balancing length is found to be 58 cm of the wire. If the polarity of E_2 is reversed, then the balancing length becomes 29 cm. The ratio E_1/E_2 of the EMFs of the two cells is:

a. 1 : 1 b. 2 : 1 c. 3 : 1 d. 4 : 1

63.* A 2 Volt battery, 15 Ohm Resistor and a Potentiometer of 100 cm length are all connected in series. If the resistance of Potentiometer wire is 5 Ohms, then the Potential Gradient of Potentiometer will be in (V/cm)

a. 0.005 b. 0.02 c. 0.05 d. 0.2

64. Potential Gradient along the length of a uniform wire is 10 Volt/metre. X and Y are two points at 40 cm and 70 cm points on a meter scale fitted along the wire. Potential difference between X and Y will be:

a. 3 Volts b. 7 Volts c. 4 Volts d. 0.4 Volts

65. Potentiometer can be used as:

a. Ohm meter b. Ammeter c. Galvanometer d. Potential divider

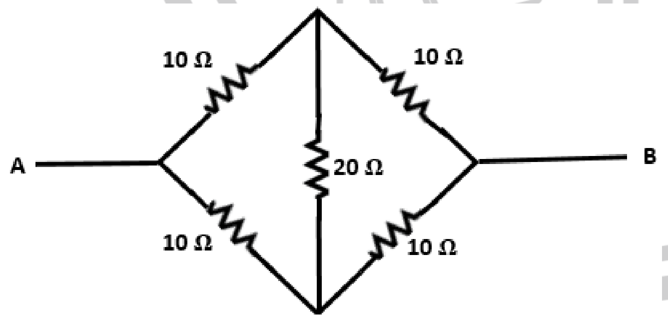
66.* An unknown resistance K_1 is connected in series with a resistance of 10 Ω. This combination is connected to one gap of a meter bridge, while a resistance K_2 is connected in the other gap. The balance point is at 50 cm. Now when the 10 Ω resistance is removed, the balance point shifts to 40 cm. The value of K_1 is:

a. 10 Ω
c. 40 Ω
b. 20 Ω
d. 60 Ω

67. Constantan wire is used for making standard resistance because it has:

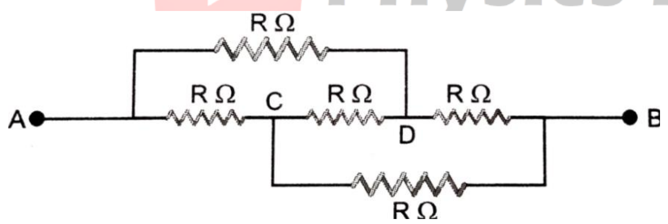
a. Low specific resistance
b. High specific resistance
c. Negligible temperature coefficient of resistance
d. High melting point
e. Has a much lower resistance than the copper wire

68. The equivalent resistance between the points A and B in the following figure is:



a. 10 Ohms
b. 20 Ohms
c. 40 Ohms
d. 50 Ohms

69. * Five equal resistors, each equal to R, are connected as shown in the following figure; then the equivalent resistance between the points A and B is:



a. R Ohms
b. R/5 Ohms
c. 5R Ohms
d. 2R/3 Ohms

ANSWER KEY # 01

1	A	31	D	61	A
2	B	32	C	62	C
3	D	33	B	63	A
4	C	34	B	64	A
5	D	35	D	65	D
6	A	36	A	66	B
7	A	37	C	67	C
8	B	38	C	68	A
9	D	39	B	69	A
10	D	40	B	70	-
11	B	41	E	71	-
12	B	42	C	72	-
13	A	43	B	73	-
14	A	44	A	74	-
15	A	45	B	75	-
16	A	46	A	76	-
17	A	47	C	77	-
18	D	48	A	78	-
19	D	49	A	79	-
20	B	50	B	80	-
21	A	51	D	81	-
22	C	52	D	82	-
23	A	53	A	83	-
24	B	54	D	84	-
25	B	55	B	85	-
26	C	56	B	86	-
27	A	57	D	87	-
28	D	58	B	88	-
29	B	59	B	89	-
30	C	60	C	90	-

CHAPTER 16: EM WAVES & ELECTRONICS

ELECTROMAGNETIC WAVES

Electromagnetic waves are the waves produced by the oscillations of electric and magnetic fields. Electric & Magnetic waves vibrate perpendicular to each other as well as normal to the direction of their propagation.

MODULATION:

- It is a technique by which some characteristics of the carrier wave are varied with time in accordance with the modulating signal.
- The higher frequency wave having constant amplification and a fixed frequency is called carrier wave whereas an audio signal is called modulating signal.

Mathematically,

$$V_C(t) = A \sin(2\pi f_c t + \phi)$$

Where;

- A - Amplitude of the carrier wave
- f_c - Frequency of the carrier wave
- ϕ - Phase angle

There are three types of modulation:

- Amplitude Modulation
- Frequency Modulation
- Phase Modulation

AMPLITUDE MODULATION [A.M.]

In Amplitude Modulation, the amplitude of the carrier wave is varied in accordance with modulating signal Voltage.

FREQUENCY MODULATION [F.M.]

- In frequency modulation, the amplitude of the modulated carrier wave is kept constant, but the frequency of it varies in proportional to the amplitude of the modulating signal.
- The frequency of FM transmitter without any modulating signal input is called centre frequency or resting frequency.
- The frequency of FM transmitter with modulating signal input is called frequency deviation and total deviation is called carrier swing.
- FM broadcast transmitters operate at frequencies of 88MHz to 108MHz.

PERCENTAGE OF MODULATION [P.M.]

It shows the extent to which the modulating signal modulates the carrier waves. If modulation is symmetrical, then percentage of modulation is

$$M = \frac{B}{A} \times 100$$

Where,

- B = Amplitude of modulating signal
- A = Amplitude of carrier waves

SIDEBANDS

A sideband is a band of frequencies higher or lower than the carrier frequency and carry the information i.e. intelligence signal.

DEMODULATION

The process by which the original modulating signal or intelligence is recovered in the radio receiver is called detection or demodulation.

Energy Band Theory:

- The fundamental electrical property of a solid is its response to an applied electrical field, i.e., its ability to conduct electric current. The electrical behaviors of various materials are diverse. Some are very good conductors, e.g., materials with conductivities of the order of $10^7\ (\Omega m)^{-1}$.
- At the other extreme, some solids, e.g., wood, diamond etc., have very low conductivities ranging between 10^{-10} and $10^{-20}\ (\Omega m)^{-1}$, these are called insulators.
- Solids with intermediate conductivities, generally from 10^{-6} to $10^{-4}\ (\Omega m)^{-1}$, are termed semiconductors, e.g., silicon, germanium etc.

Valence Band:

The electrons in the outermost shell of an atom are called valence electrons and the energy band occupying these electrons is known as valence band. It may be either completely filled or partially filled with electrons and can never be empty.

Conduction Band:

The band above the valence band is called conduction band. In conduction band electron moves freely and conduct electric current through solids. That is why the electrons occupying this band are known as conductive electrons or free electrons. Any electron leaving the valence band is accommodated by this band. It may be either or partially filled with electrons.

Forbidden Band:

The energy gap between the valence band and the conduction band is called forbidden band. These are normally completely filled and no electron of them takes part in the conduction process.

Types of Solids: On the basis of electrical conductivity, solids are classified into three types:

- Conductors
- Insulators
- Semi-conductors

(i) CONDUCTORS:

Since in conductors there are large number of free electrons ready for conduction of electric current. In terms of energy bands, it means that conductors are also those materials in which valence and conduction bands largely overlap each other as shown in figure.

There is no physical distinction between the two bands which ensures the availability of a large number of free electrons, which can easily move from valence to conduction band.

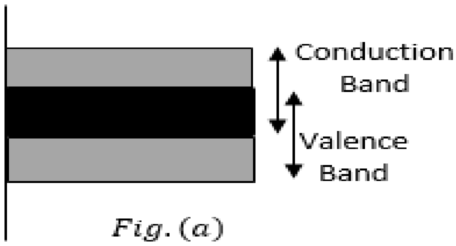


Fig. (*a*)

(ii) INSULATORS:

Insulators are those solids in which valence electrons are bound very tightly to their atoms and are not free. The forbidden energy gap between valence and conduction energy band is also wide. This shows that large amount of energy is required to jump valence electrons to conduction band. Therefore, conduction band remains empty for the case of insulators (i.e. there is no free electron available).

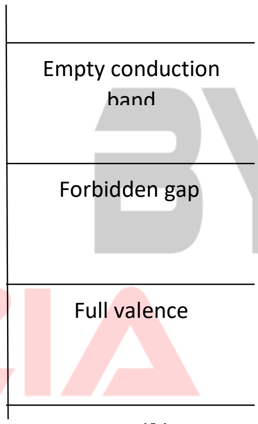


Fig. (*b*)

(iii) SEMI-CONDUCTORS:

There are certain elements whose conductivity lies in between those of insulators and conductors. These elements are called semi-conductors. The semi-conductors at room temperature have partially filled conduction and valence band, and very narrow forbidden energy gap between valence and conduction energy bands as shown in figure (c).

At 0K, there is no free electron in the conduction band and their valence band is completely filled. It means at 0K a semi-conductor behaves like insulator.

However, with increase in temperature, some electrons possess sufficient energy to jump across the small energy gap from valence to conduction band. This transfer some free electrons in the conduction bands and some vacancies of electrons in the valence band.

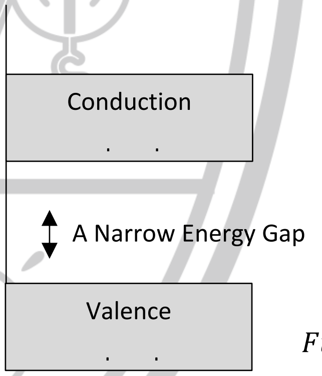


Fig. (*c*)

The vacancy of electron in the valence band is known as a hole. It behaves like a positive charge.

Note:

The most famous semi-conductors are germanium (Ge) and silicon (Si).

DOPING:

The mixture of impurity in pure semi-conductors is called doping. Here a very small quantity (1 x 10^6) of certain element of 3rd (Group # IIIA) or 5th (Group # VA) group is mixed in the pure semi-conductor. This is done during the formation of crystals of semi-conductor elements.

- The doped semi-conductors are called Extrinsic Semi-Conductors.
- A semi-conductor in its extremely pure form is known as Intrinsic Semi-Conductor.

Intrinsic semi-conductor elements have atoms with four valence electrons. In solid crystalline form, the atoms of these element arrange themselves in such a pattern that each atom has 4 equidistant neighbors. This pattern along with its valence electrons. Each atom with its four valence electrons, share an electron from its neighbors. Thus, the total number of electrons in its outermost orbit is eight which makes a stable configuration.

This sharing of electrons between two atoms creates covalent bonds. Due to these covalent bonds electrons are bound in their respectively shells.

Note:

All semi-conductor element belongs to the fourth group of the periodic table, and each atom of these elements has four valence electrons. There each can make four covalent bonds (with other four atoms). There are two types of extrinsic semi-conductors:

- P-type semi-conductor
- N-type semi-conductor

P-type Semi-Conductor:

- When an impurity from third group (or a trivalent element for e.g. boron, aluminum, gallium) is added into pure semi-conductor then this doped semi-conductor is called p-type semi-conductor.
- When an impurity from third group or a trivalent element e.g., aluminum, boron, gallium or indium etc., is added to a silicon crystal then its three electrons make covalent bonds with three surrounding electrons of silicon (Si) atom and one vacancy is left. The one missing electron in the covalent bond with the fourth neighboring Si atom, is called a "hole". The extrinsic semi-conductor thus found is called p-type semi-conductor.
- Here holes are its majority carriers and electrons are its minority carriers.
- As they accept electrons so they are also called "acceptor" & doping is termed as Acceptor Doping.

N-type Semi-Conductor:

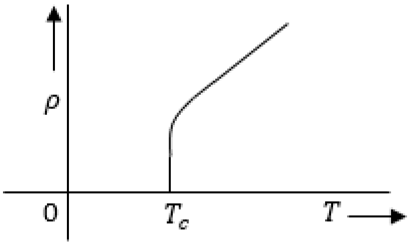
- When an impurity from fifth group (or a pentavalent element for e.g. arsenic, antimony, bismuth or phosphorus) is added into pure semi-conductor, then this doped semi-conductor is called n-type semi-conductor.
- When an impurity from fifth group or a pentavalent element like arsenic, antimony or phosphorus etc., is added to a silicon (Si) crystal then its four valence electrons make covalent bond with four surrounding electrons of Si, but one electron of pentavalent element is left unbounded. It is called a free electron. Such extrinsic semiconductors are called n-type.
- Here majority carriers are electrons and minority carriers are holes.
- As they donate electrons so they are also called "donor" & this doping is termed as Donor Doping.

Super Conductor:

"A conductor with almost zero resistance is called as super conductor". A super conductor loses its resistance at very low temperature and no energy is dissipated and the electric current once established through them continue to flow even if source of applied EMF is removed.

Critical Temperature:

The temperature at which the resistance or resistivity of a conductor becomes zero is called critical temperature (T_c), as shown in the resistivity-temperature graph.



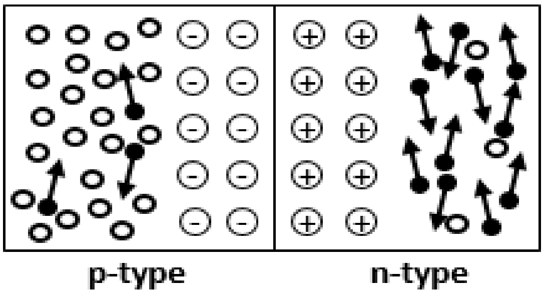
This shows that, at certain temperature the value of resistivity ρ falls to zero.

P-N Junction:

If a part of semiconductor element (germanium or silicon) is developed as p-type, while its remaining part is developed as n-type then plane of separation is called p-n junction.

Depletion Region:

Just after the development of p-n junction, some of the free electrons diffuse from n-type side into p-type side (Diffusion Current) and a layer of negative charge is developed in p-type side near the pn-junction.



As electrons are removed from n-region therefore a layer of positive charge is automatically developed in n-region near the junction. The region between these two layers is called depletion region.

Potential Barrier:

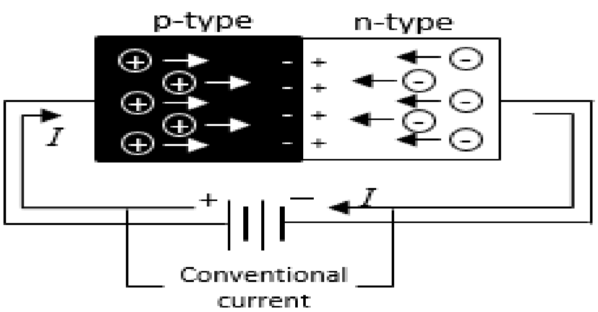
The depletion region is constituted of +ve and –ve ions, due to charge on these ins a potential difference develops across the depletion region, this potential difference is called potential barrier, which stops further diffusion of electrons into the p-region. The value of this potential difference is 0.7V in case of silicon and 0.3V in case of germanium.

Biased p-n Junction:

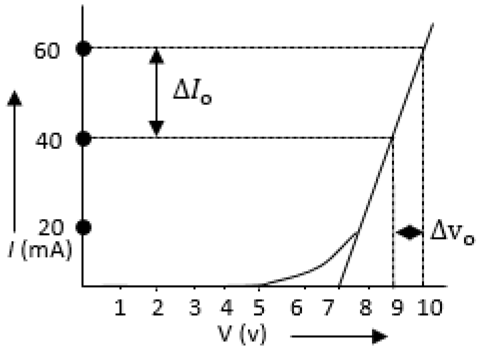
If a battery is connected across a pn-junction, then battery potential will bias the junction. There are the following two ways in which a p-n junction can be biased with a battery.

(i) Forward Biased p-n Junction:

When an external potential difference is applied across a p-n junction, such that p-type side is positive and n-type is negative (figure (a)). In this state the p-n junction is said to be forward biased.

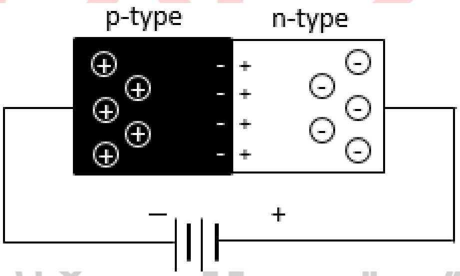


The value of current for different values of bias voltage is noted and a current-bias voltage graph is plotted. The shape of this graph is shown in figure.

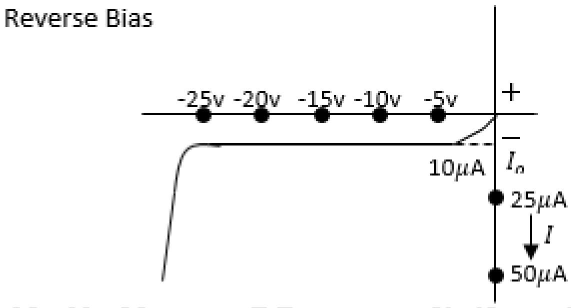


(ii) Reverse Biased p-n Junction:

When the external potential difference is applied across a p-n junction such that its positive terminal is connected to n-region and its negative terminal is connected to p-region, as shown in figure (a), the p-n junction is said to be reverse biased.



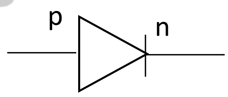
The graph shown in figure is called reversed characteristics curve for p-n junction.



Break Down Voltage:

When a p-m junction is connected in reverse biased current, with the increase of reverse voltage the kinetic energy of minority charge carriers increase, and as a result of which covalent bonds break. Due to which a large "electron-hole" pairs are created. This increases the value of reverse current till a point is reached when the junction breaks down and reverse current sharply. This corresponding reverse voltage is called "break-down voltage".

Symbolic Representation of p-n Junction:



p-n junction is also known as a semi-conductor diode whose symbolic representation is given as shown in figure.

The arrow head represents the p-region and known as anode.

The vertical line represents the n-region and is known as cathode. The current flows in the direction of arrow when the diode is forward biased.

Rectification:

The conversion of alternating current (AC) to direct current (DC) is known as rectification. A device or circuit used for rectification is called a Rectifier. Semi-conductor diodes are extensively used as rectifier.

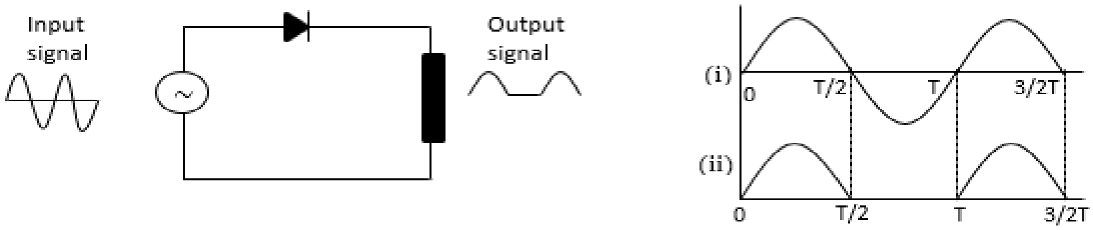
There are two very common types of rectification:

(i) Half wave rectification
(ii) Full wave rectification.

Half-Wave Rectification:

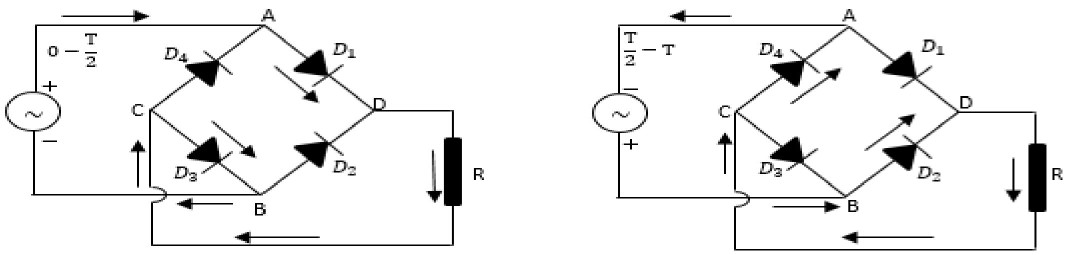
When direct current is obtained only for the positive half cycle of input alternating current, the rectification is called half-wave rectification.

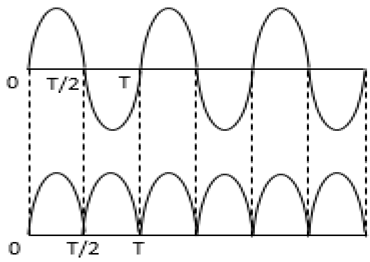
A half-wave rectification is shown in figure below.



Full-Wave Rectification:

When direct current is obtained from the both halves (positive and negative) of the input alternating current cycle, the rectification is called Full-wave rectification. We can use "bridge circuit for full wave rectification. This circuit consists of four diodes connected in a bridge type arrangement, as shown in figure.





Note:

The output voltage (DC) can be made smooth by use of filter circuit, which of a capacitor of suitable capacitance, which is connected in parallel with load resistance 'R'.

By doing so we can get approximately constant voltage.

Types of p-n Junction:

There are many types of p-n junction developed for special purposes other than rectification. Three most commonly used such diodes are,

(i) Light emitting diode
(ii) Photo diode
(iii) Photo voltaic cell (Solar Cell)

PHOTODIODES

- Devices which can convert light energy directly into electrical energy (when light is incident on such material, an electrical current is caused to flow) are called Photodiodes.
- A semiconductor photodiode is a **reverse biased** junction diode.
- Photodiodes are used in high speed reading of computer punched cards and tapes, light detection system, light operated switches, production line counting of objects etc.

LIGHT EMITTING DIODE (LED)

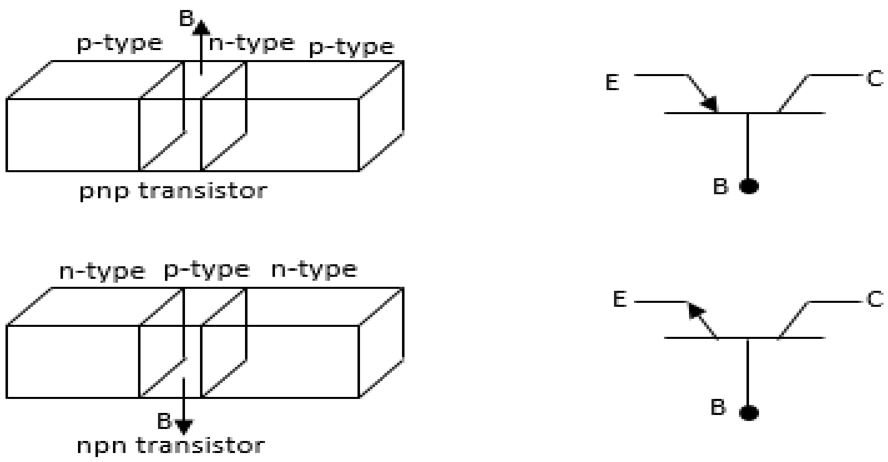
- Light Emitting Diode (LED), is a forward biased diode.
- It converts electrical energy to light energy.
- It is used in digital clocks, calculators and in battery operated devices.
- The process of giving off light by applying an electrical source of energy is called **Electroluminescence**.

SOLAR CELL

- A solar cell is a photo diode that is used to extract energy from sun light.
- Selenium and silicon are widely used materials in solar cells.
- It is used for converting solar light energy into electrical energy in space vehicles.

Transistors:

It is a semi-conductor device having two p-n junctions joined back-to-back, in which a thin layer of n-type material is sandwiched between two layers of p-type material, or a thin layer of p-type material is sandwiched between two layers of n-type material.



(E = emitter, C = collector, B = base)

Parts of Transistor:

The thick end regions of the transistors are called "emitter" and "collector", and the thin middle region (of the order of 10^{-6}m) is called base.

In the emitter and collector regions concentration of the impurity atom is much larger than in the base region, and the emitter has greater concentration of impurity as that of collector. The collector is comparatively larger than the emitter.

Operation of Transistor:

For normal operation of the transistor two batteries are connected in such a way that its emitter base junction is forward biased and its collector base junction is junction is reverse biased. The biasing arrangement for n-p-n transistor and p-n-p transistor are shown in figure 'a' an 'b' respectively.

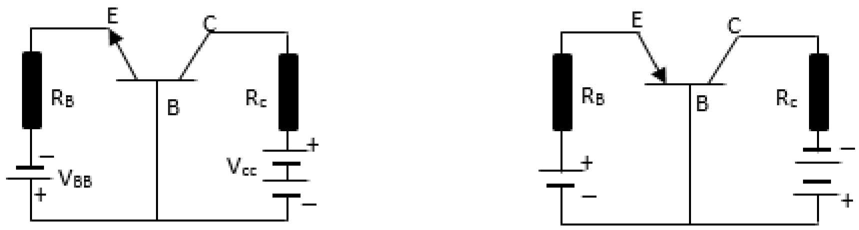


Fig. (a) *Fig. (b)*

Here V_{CC} is much greater than V_{BB}, and polarities of the biasing batteries V_{BB} and V_{CC} are opposite in the two types of the transistors.

<u>Note:</u>

In actual practice, the n-p-n transistor is generally used. So, we will discuss n-p-n transistor only.

<u>Current Flow in A n-p-n Transistor:</u>

Usually the collector base junction of transistor is reverse biased and emitter base junction is forward biased. Thus, the emitter base unction has low resistor and the collector base junction has high resistor.

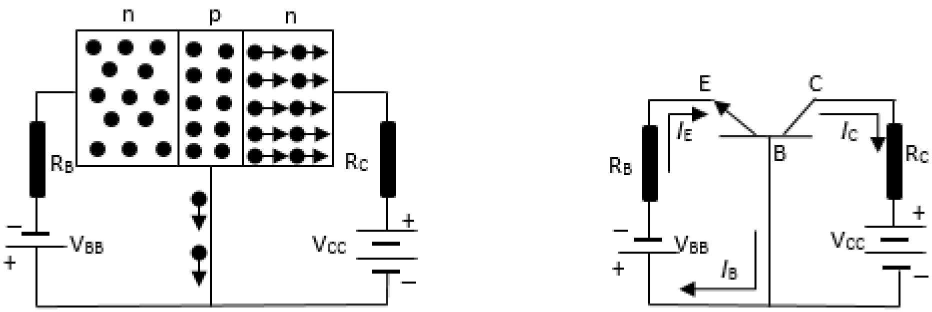


Fig. (a) *Fig. (b)*

Electrons in N-type emitter region cross into the base region owing to the forward bias. In the base region a few electrons may be neutralized by the holes, but as the base is narrow many electrons will diffuse across the base-collector junction.

As the base region is very narrow and has very small concentration of impurity with a few holes, so the collector current is very nearly equal to the emitter current. It means that a transistor transfers current from low resistance 'R_B' to high resistance 'R_C', which also acts as load.

Figure (b) shows, an electronic current 'I_E' flows from the emitter into the base.

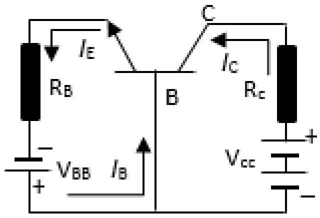


Fig. (c)

The direction of flow of conventional current is shown in figure (c).

The current 'I_E' is divided in two parts I_B and I_C.

Therefore, we can write.

$$I_E = I_C + I_B$$

As very few electrons flow out of the base, so I_B is very small as compared to I_C. It's also found that for a given transistor the ratio of collector current 'I_C' to base current is nearly constant.

i.e., $\beta = \frac{I_C}{I_B}$

The ratio 'β' is called current gain of transistor (Common Emitter Configuration) and its value is very large (of the order of hundreds).

Current gain in Common Base Configuration: $\alpha = \frac{I_C}{I_E}$

The static characteristics for transistor consist of two sets of curves

1. Input Characteristics

- It gives the relationship between input voltage and input current.
- The input signal is applied between base and emitter.
- To draw the input characteristics, the output voltage V_{CE} is held constant and for different values of input voltage V_{BE}, the base current I_B is recorded.
- I_B decreases with increase in V_{CE} for a given V_{BE}.

2. Output Characteristics

- It gives the relationship between output voltage and output current.
- The output signal is applied between collector and emitter.
- To draw the input characteristics, the base current I_B is held constant and for different values of input voltage V_{CE}, the collector current I_c is recorded.

TRANSISTOR AS AN AMPLIFIER

A device that converts a weak signal (current, voltage etc.) into a stronger signal is called Amplifier and this process is called Amplification.

In transistor, a small change in base current produces a large change in collector current. Thus, the transistor can be used as an amplifier to amplify current or voltage in electronic devices.

PRACTICE SHEET # 01

1.Which of the following are not electromagnetic waves
A) Light waves B) X-Rays
C) Heat waves D) Sound waves

2.Which of the following are electromagnetic waves
A) Light waves B) Sound waves
C) Water waves D) Waves along a stretched string

3.Electromagnetic waves always propagate in free space with the speed of
A) Electrons B) Sound
C) Light D) α-particle

4.Electromagnetic waves consists of
A) Electric and magnetic field moving parallel to each other
B) Electric and magnetic field moving at right angle to each other
C) Electric field moving with velocity of light
D) Magnetic field moving with velocity of light

5.Near absolute zero temperature extrinsic semi-conductor behave like
A) Conductor B) Metals
C) Insulator D) None of these

6.Germinium and silicon are the material which used
A) Conductor B) Semi-conductor
C) Insulator D) None of these

7.The outer most orbit of each atom in silicon contains
A) Four electron B) Eight electron
C) Two electron D) No electron

8.Which of the following is donor impurity
A) Arsenic B) Indium
C) Holes D) Carbon

9.The charge carries in P-type substance are
A) Protons B) Electron
C) Holes D) Negative ions

10.The charge carries N type material are
A) Electron B) Holes
C) Protons D) Positive ions

11.P-type material are obtained by adding germanium with
A) Tetravalent impurity atoms B) Trivalent impurity atoms
C) Pentavalent impurity atoms D) None of these

12.N-type material are obtained by doping intrinsic germanium with
A) Tetravalent impurity atoms B) Trivalent impurity atoms
C) Pentavalent impurity atoms D) None of these

13.Hole is equivalent to
A) A neutral particle B) Negative charge
C) A positive charge D) None of these

14.A semiconductor diode when forward biased offers
A) High resistance B) Infinite resistance
C) Low resistance D) None of these

15.A PN junction conducts current only when is
A) Reverse biased B) Neither reverse nor forward
C) Forward biased D) All of the above

16.Rectification is the process of converting
A) A.C into D.C B) D.C to A.C
C) Both A.C to D.C& D.C to A.C D) None of these
17.The device used for conversion of A.C into D.C is called
A) A detector B) An amplifier
C) An oscillator D) A rectifier
18.The specially designed semiconductor diodes used as fast counters in electronics circuits are
A) Solar cells B) Light emitting diodes
C) Photo diodes D) None of these
19.The specially designed semiconductor diodes used as indicator lamps in electronic circuits are
A) Light emitting diodes B) Photodiodes
C) Solar cells D) Photo voltaic cells
20.Solar cell (or photo voltaic cell) is a device which converts
A) Chemical energy into electrical energy
B) Light energy into electrical energy
C) Electrical energy into light energy
D) Chemical energy into light energy
21.With the rise of temperature, the conductivity of a semiconductor
A) Increase B) Decrease
C) Remain constant D) Some tine decrease some time increase
22.The band theory of solids successfully classifies the solids into
A) Semiconductor only B) Conductor only
C)Insulator only D) All of the above
23.The base of transistor should be of
A) High doping B) Low doping
C) Zero doping D) None of these
24.On doping the conductivity of a semi-conductor
A) Decrease B) Increase
C) Remain constant D) None of these
25.Electromagnetic waves are
A) Radio waves B) Sound waves
C) Water waves D) None of the above
26.Number of electron in the outer most shell of G_e and Si is
A) 2 B) 8
C) 6 D) 4
27.The trivalent impurities are called
A) Donor impurities B) Neutral impurities
C) Accepter impurities D) None of these
28.In a rectification circuit, a transistor is used
A) Amplifier B) Filter
C) Transistor D) Modulator
29.In a half-wave rectifier the diode conducts during
A) Both have input cycle
B) A portion of the positive half of the input cycle
C) A portion of the negative half of the input cycle
D) One half of the input cycle
30.The device used for conversion of AC into DC
A) An oscillator B) A detector

C) An amplifier D) A rectifier

31.In n-p-n transistor, p work as

A) Collector B) Emitter

C) Base D) Ant type of these

32.The solids of which the gap between the valance band and conduction band is small, are called

A) Insulator B) Semiconductor

C) Conductor D) P-type substance

33.If $\acute{\varepsilon}_0$ is the permittivity and μ_0 is the permeability of free space, then the velocity of electromagnetic waves in free space is given by

A) B)

C) D)

34.Which of the following is transported by electromagnetic waves?

A) Current B) Matter

C) Energy D) Charge

35.Which waves are emitted from antenna?

A) Stationary waves B) Longitudinal waves

C) Transverse waves D) Sound waves

ANSWER KEY # 01

1→D	8→A	15→B	22→D	29→D
2→A	9→C	16→A	23→B	30→D
3→C	10→A	17→D	24→B	31→C
4→B	11→B	18→C	25→A	32→B
5→C	12→B	19→A	26→B	33→D
6→B	13→B	20→B	27→B	34→C
7→A	14→C	21→A	28→B	35→C

PRACTICE SHEET # 02

1. **Electromagnetic waves are produced by:**
   a. Stationary electrons
   b. Electrons moving with uniform speed
   c. Electrons moving with uniform velocity
   d. Accelerated electrons

2. **Each electromagnetic wave is composed of:**
   a. Electric and magnetic fields vibrating parallel to each other
   b. Electric and magnetic fields vibrating perpendicular to each other
   c. Stationary electric and magnetic fields
   d. None of these

3. **An electromagnetic wave travels in a direction:**
   a. Perpendicular to electric as well as magnetic field vectors
   b. Parallel to electric as well as magnetic field vectors
   c. Parallel to electric but perpendicular to magnetic field vectors
   d. Perpendicular to electric but parallel to magnetic field vectors

4. **Speed of an electromagnetic wave in a medium depends upon**
   a. Magnetic properties but is independent of electric properties
   b. Electric properties but is independent of magnetic properties
   c. Electric as well as magnetic properties of the medium
   d. None of these

5. **If ϵ_0 is the permittivity and μ_0 is the permeability of free space, then the space of electromagnetic waves in vacuum is given by:**
   a. $C = \frac{1}{\epsilon_0\mu_0}$
   b. $C = \epsilon_0\mu_0$
   c. $C = \sqrt{\epsilon_0\mu_0}$
   d. $C = \frac{1}{\sqrt{\epsilon_0\mu_0}}$

6. **Speed of radio waves in vacuum is:**
   a. 3×10^6 m/s
   b. 3×10^8 m/s
   c. 3×10^8 m/s
   d. 3×10^{10} m/s

7. **Which one of the following waves do not travel at the same speed of light?**
   a. Sound waves
   b. Radio and T.V. waves
   c. Heat waves
   d. X-rays

8. **Which of the following electromagnetic waves has the highest frequency and shortest wavelength?**
   a. X-rays
   b. Ultraviolet waves
   c. Cosmic rays
   d. γ- rays

9. **Which of the following wave are not affected by electric and magnetic fields:**
   a. Cathode rays
   b. β – rays
   c. α- rays
   d. Electromagnetic waves

10. **The product of permittivity ϵ_0 and permeability μ_0 of free space is given by:**
    a. C^2
    b. $1/C^2$
    c. C
    d. 1/C

11. **Radio waves and visible light in vacuum have**
    a. Same wavelength but different velocities
    b. Same velocity but different wavelengths

c. Different velocities and wavelengths
d. Same velocity and wavelength

12. Electromagnetic radiation of frequency 3 x 10^5MHz lies in the:
a. Radio wave region
b. Visible region
c. Infrared region
d. Microwave region

13. An electromagnetic wave has wavelength 10cm. It is in the:
a. Visible region
b. Radio region
c. Ultraviolet region
d. X-Rays region

14. Electromagnetic wave:
a. Travel in free space at the speed of light
b. Are transverse
c. Are produced by an accelerating charge
d. All of the above

15. If E and B be the electric and magnetic field vectors of an electromagnetic wave, then the propagation of the wave is along the direction of:
a. E
b. B
c. E x B
d. B x E

16. Which one is the weakest type of bonding in solids?
a. Ionic
b. Covalent
c. Metallic
d. Vander Walls

17. A metallic bond differs from a covalent bond in that:
a. It is not directional
b. It is not saturated
c. The valence electrons are not attached to any particular atom
d. All of the above

18. The binding force in a metallic crystal are:
a. Electrostatic force of attraction
b. Vander wall forces of attraction
c. Magnetic forces
d. Covalent forces

19. With the rise in temperature, the specific resistance of a semi-conductor:
a. increases
b. remains unchanged
c. decreases
d. First decreases then increases

20. Bonding in a Germanium crystal is:
a. Metallic
b. Ionic
c. Covalent
d. Vander wall

21. A hole in a p-type semiconductor is:
a. An excess electron
b. A missing electron
c. A missing atom
d. A donor level

22. In an intrinsic semiconductor
a. Only electrons are responsible for the flow of current
b. Only holes are responsible for the flow of current
c. Both holes and electrons carry current and their number is same
d. Both holes and electrons carry current but electrons are the majority carriers

23. When the conductivity of a semi-conductor is only due to the breaking of the covalent bonds, the semiconductor is called:
a. Intrinsic b. Donor
c. Acceptor d. Extrinsic

24. If Germanium has to be doped with a donor impurity, the foreign atom should be:
a. Tetravalent b. Pentavalent
c. Trivalent d. none of these

25. The impurity atoms with which pure silicon should be doped to make a p-type semiconductor are those of:
a. Phosphorus b. Boron
c. Aluminum d. both b and c

26. To obtain a p-type semiconductor, we need to dope pure silicon with:
a. Aluminum b. Phosphorus
c. Oxygen d. Germanium

27. When Arsenic is added as an impurity to silicon, the resulting material is
a. n-type semiconductor b. n-type conductor
c. p-type semiconductor d. p-type conductor

28. A typical example of a semiconductor is:
a. Platinum b. Germanium
c. Quartz d. Mica

29. An n-type semiconductor is formed
a. From pure Germanium
b. From pure Silicon
c. When Germanium crystal is doped with an impurity containing five valence electrons
d. When Germanium crystal is doped with an impurity containing three valence electrons

30. Which of the following is not a property of covalent crystals?
a. High melting point b. High latent heat of fusion
c. Directional bond d. Good conductor

31. A hole in a semi-conductor:
a. is a positively charged vacancy b. has zero mass
c. has mass equal to proton d. has mass equal to positron

32. The forbidden gap in the energy bands of Germanium at room temperature is about:
a. 1.1 eV b. 0.1 eV
c. 0.67 eV d. 6.7 eV

33. Out of the following bonds the strongest is:
a. covalent b. ionic
c. Vander walls d. metallic

34. In a good conductor of electricity, the type of bonding that exists is:
a. Ionic b. Covalent
c. Vander walls d. Metallic

35. **Diamond is very hard because:**
a. it is a covalent bond
b. it has large cohesive energy
c. it has high melting point
d. it is insoluble in all solvents

36. **Semi-conductor junction diode has a property of:**
a. Free conduction
b. One-way conduction
c. Two-way conduction
d. Reverse conduction

37. **A device that converts A.C into D.C is called:**
a. Oscillator
b. Amplifier
c. Rectifier
d. Photo conductor

38. **A PN junction diode can be used as:**
a. Rectifier
b. Amplifier
c. Transistor
d. Oscillator

39. **When p-type material of a PN junction is connected with positive terminal and n-type with negative terminal of a battery it is said to be:**
a. Forward biased
b. Reverse biased
c. Zero biased
d. None of the above

40. **When p-type material of a PN junction is connected with negative terminal and n-type with positive terminal of a battery it is said to be:**
a. Forward biased
b. Reverse biased
c. Zero biased
d. None of these

41. **A PN junction conducts when it is:**
a. Froward biased
b. Reverse biased
c. Zero biased
d. None

42. **Process of conversion of AC into DC is called:**
a. Amplification
b. Photoconductor
c. Modification
d. Rectification

43. **A thin layer of a one type of semiconductor material (P-type or N-type) sandwiched between two thick layers of other type is called:**
a. Diode
b. Rectifier
c. Transistor
d. Modulator

44. **Usually a transistor is used as a:**
a. Rectifier
b. Amplifier
c. Modulator
d. Oscillator

45. **A single PN junction diode acts as:**
a. Rectifier
b. Amplifier
c. Half-wave rectifier
d. Full-wave rectifier

46. **Process of addition of group 5 impurity such as arsenic, antimony etc. in a Germanium or silicon crystal produces an excess electron for conduction, hence it is known as:**
a. Acceptor doping
b. Donor doping
c. Forward doping
d. Reverse doping

47. Process of addition of group 3 impurity such as gallium, indium etc. in a Germanium or silicon crystal produces shortage of electron that creates positively charged region is known as:

a. Acceptor doping
b. Donor doping
c. Forward doping
d. Reverse doping

48. For normal working of a transistor its emitter-base junction is:

a. Zero biased
b. Reverse biased
c. Forward biased
d. None

49. For normal working of a transistor its collector-base junction is:

a. Forward biased
b. Reverse biased
c. Zero biased
d. None

50. When a PN-junction is reverse biased, it offers:

a. Zero resistance
b. Maximum resistance
c. Minimum resistance
d. None

51. In a PN-junction, the barrier potential offers opposition to only:

a. Majority carries in both region
b. Minority carriers in both regions
c. Electrons in N region
d. Holes in P region

52. PN junction diode works as an insulator, if connected:

a. to A.C source
b. in forward bias
c. in reverse bias
d. either to AC source or in reverse bias

53. The resistance of a PN-junction in forward bias is:

a. infinite
b. zero
c. high
d. low

54. The reverse biasing in a diode junction:

a. increase the number of majority charge carriers
b. increase the number of minority charge carriers
c. increase the potential barrier
d. decreases the potential barrier

55. A diode as a rectifier converts:

a. AC into DC
b. DC into AC
c. Varying DC into constant DC
d. High voltage into low voltage and vice versa

ANSWER KEY # 02					
S.No.	Answer	S.No.	Answer	S.No.	Answer
1.	D	21.	A	41.	A
2.	B	22.	C	42.	D
3.	A	23.	A	43.	C
4.	C	24.	B	44.	B
5.	D	25.	D	45.	C
6.	B	26.	A	46.	B
7.	A	27.	A	47.	A
8.	C	28.	B	48.	C
9.	D	29.	C	49.	B
10.	B	30.	D	50.	B
11.	B	31.	A	51.	A
12.	D	32.	C	52.	C
13.	B	33.	B	53.	D
14.	D	34.	D	54.	C
15.	C	35.	B	55.	A
16.	D	36.	B		
17.	D	37.	C		
18.	A	38.	A		
19.	C	39.	A		
20.	C	40.	B		

CHAPTER 17: ADVENT OF MODERN PHYSICS

In the early part of the twentieth century, many experimental and theoretical problems remained unsolved. Attempts to explain the behavior of matter on the atomic level with the laws of classical physics were not successful. There was tremendous development in experimental and theoretical physics in the beginning of 20^{th} century. Phenomena such as black body radiation, photoelectric effect, emission of sharp spectral lines by atom in a gas discharge tube, and invariance of speed of light are explained by a revolutionary framework of explanation called "modern physics". The two main features of modern physics are:

(i) Theory of relativity
(ii) Quantum theory

The observations on abject moving very fast, approaching the speed of light, are explained by the special theory of relativity. And the behavior of electromagnetic radiation and particles on a very small scale are explained by the quantum theory.

THEORY OF RELATIVITY:

The theory of relativity is concerned with the relations between the observations of same phenomenon as observed by two different observers from two different frame of references.

Theory of relativity is of two types:

(i) General theory of relativity
(ii) Special theory of relativity

General Theory of Relativity:

The general theory of relativity is concerned with the relation between the observations of same phenomenon as observed by two different observers from two different "non-inertial" frames of references.

Special Theory of Relativity:

This principle was put forward by Albert Einstein, which is stated as

"All possible frames of reference moving at constant velocity relative to one another are equivalent for the statement and description of physical laws".

Based on the constancy of speed of light, Einstein re-stated the principle of relativity as follows.

"All inertial frames of reference are completely equivalent for all physical phenomena including mechanical as well as electromagnetic phenomena".

The special theory of relativity is concerned with the relation between the observations of same phenomenon as observed by two different observers from two different "inertial" frame of references.

Postulates of Special Theory of Relativity:

The special theory of relativity is based upon two postulates, which can be stated as follows:

Postulate 1:

The laws of physics are the same in all inertial frames.

Postulate 2:

The speed of light in free space has the same value for all observers. Its value is independent of motion of source or observer.

FRAME OF REFERENCE

A Frame of reference is the regular set of coordinates which is used to specify the relative position of a body in space.

Inertial frame of reference is a reference frame moving with constant velocity or at rest i.e. having no acceleration. In this frame, Newton laws are valid but are in valid for non-inertial frame.

A frame which is moving with a variable velocity or a frame which is accelerated is called a Non-inertial frame.

Results Obtained from Special Theory of Relativity:

It has been shows that when the relative motion of the frame becomes large enough to approach the velocity of light c, then the Galilean transformations are found to be noticeably wrong. For the correction of this state a factor $\sqrt{1-\frac{v^2}{c^2}}$ is introduced. This factor is called **Lorentz Factor.**

The following results are obtained from the special theory of relativity:

TIME DILATION:

The relation is:

$$t = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

Where

t_0 = Time interval between two events when the observer is stationary in an inertial frame with respect to frame of events.

t = Time interval when the observer is moving with respect to frame of events with velocity v, or if the frame of events is moving with respect to observer with a uniform velocity v.

c = Speed of light in free space.

Since $\sqrt{1-\frac{v^2}{c^2}} < 1$ we have $t > t_0$.

"According to time dilation relation, the time interval between two events dilates (appear to longer) due to relative motion of the observer and the frame reference of events. It becomes infinite when object moves with velocity of light."

Note:

Aging process of the human body is slowed by motion at very high speeds.

LENGTH CONTRACTION:

The relation is:

$$\ell = \ell_0\sqrt{1-\frac{v^2}{c^2}}$$

Where,

ℓ_0 = Length of an object (like a rod) or distance between two points, measured by an observer when it is at rest with respect to the observer.
ℓ = Length of the object observed by an observer relative to whom, object moves with velocity 'v'.
c = Speed of light in free space.

"According to this relation, the length of an object decreases with the increase of its velocity relative to the observer. It appears to be zero when object moves with velocity of light (i.e., v = c)."

Note:

The length contraction happens only along the direction of motion. No such contractions would be observed perpendicular to the direction of motion.

MASS VARIATION:

The relation is:

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Where,

m_0 = Mass of an object at rest in an inertial frame of rest mass.
m = Mass of the object moving with velocity 'v' relative to the observer.
C = Speed of light in free space.

"According to this relation, the mass of an object increases with the increase of its velocity and it becomes infinite when object moves with velocity of light."

MASS-ENERGY RADIATION (RELATIVISTIC MASS-ENERGY EQUIVALENCE):

The relation is:

$$E = mc^2$$

Where,

E = Energy of a body.
m = Mass of the body when it is moving with velocity v.
c = Speed of light in free space.

According to this relation mass can be converted into energy an energy into mass. When an object moves with velocity of light, whole of its mass is converted into an equivalent energy.

Note:

(1) The speed of a material object can never exceed the speed of light:
If a material object moves with speed of light (v = c) then its relativistic mass becomes infinite (i.e., $m \longrightarrow \infty$)
As we know,

$F = ma$

In this case

$F = (\infty)\, a = \infty$

So infinite mass means infinite inertia and it mean that, infinite force is required to accelerate a body with speed of light. Which is impossible.

(2) Relativistic variation of mass, length and time are not observed in daily life:

Because in everyday life, the speed of an object 'v' is very very small as compared to the speed of light 'c', even Earth's orbital speed is only $30kms^{-1}$, whereas the speed of light in free space is $300,000\ kms^{-1}$.

Therefore, in relations for time, length and mass derived from the special theory of relativity, the ratio v^2/c^2 is negligible.

Under such a case:

$$t = t_0, \ell = \ell_0 \text{ and } m = m_0$$

Thus, no change in time, length and mass are observed.

Hence relativistic effect can only be appreciable, if the speed of an object is very very large at least one tenth of the speed of light.

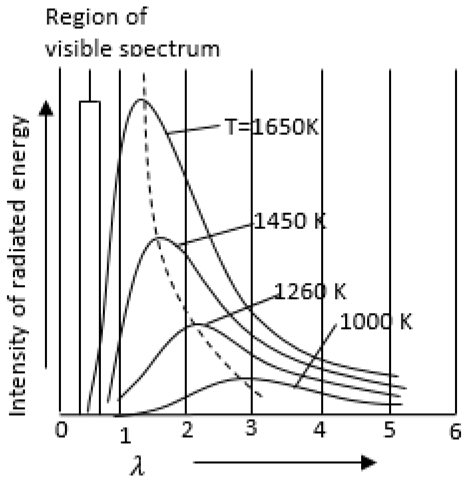
BLACK BODY RADIATION:

A black body is a body which absorbs all the radiation of energy wavelength falling upon it. At normal temperature it must appear black since it does not reflect light so it is called black body. A good absorber is a good emitter of radiation; therefore, we would expect a black body to be the best possible emitter at a given temperature. The radiation emitted by it is called black body radiation.

Energy Distribution Curves:

The amount of radiation emitted with different wavelengths is shown in the form of energy distribution curves for each temperature in the figure.

These curves reveal the following facts:



(1) At a given temperature, the energy is not uniformly distributed in the radiation spectrum of the body.

(2) The radiation intensity increases with increase in wavelengths and at a particular wavelength "λ_{max}", it has a maximum value. With further increase in wavelength, the intensity of radiation decreases.

(3) For all wavelengths, an increase in temperature causes an increase in energy emission.

(4) At a given temperature T, the emitted energy has a maximum value for a certain wavelength "λ_{max}" and the value of "λ_{max}" is inversely proportional to Kelvin's temperature of the black body, i.e.,

$$\lambda_{max} \propto \frac{1}{T}$$

$$\lambda_{max} = \text{Constant}\frac{1}{T}$$

$$\lambda_{max}T = \text{Constant}$$

The value of the constant is about 2.9×10^{-3}m K, it is known as Wien's constant. This equation means that as T increases, λ shifts to shorter wavelength (Wein's Law). We can say that A white hot furnace is hotter than one which is red hot. These equations failed to predict energy distribution in entire curve at all temperatures.

(5) The area under each curve represents the total energy E radiated (per second per unit surface area) of overall wavelength at a particular temperature. It is found that area is directly proportional to the fourth power of kelvin temperature T. Thus

$$E \propto T^4$$

Or

$$E = \sigma T^4$$

Where σ is called Stephen's Constant. Its value is 5.67×10^{-8} $Wm^{-2}K^{-4}$ and the above relation is known as Stefan-Boltzmann law. These equations failed to predict energy distribution in entire curve at all temperatures.

RAYLEIGH-JEAN LAW:

According to Rayleigh-Jean law: the energy associated with a particular wavelength is inversely proportional to the fourth power of wave length.

$$\mathbf{E = \frac{constant}{\lambda^4}}$$

This was found to be applicable for large values but not for wavelengths near or less than $\boldsymbol{\lambda_{max}}$ for which energy had infinite values. This is called ultraviolet catastrophe.

PLANCK'S LAW:

After the failure of Wien's and Rayleigh-Jeans laws which were based on classical physics to explain the distribution of energy in continuous spectrum from a black body, Max Planck introduced "quantum theory".

The Plank's theory of black body radiation explained completely the experimentally curve. This theory based on the following assumptions (postulates).

Postulate 1:

According to this postulate, the atoms that make up the walls of the cavity radiator, behave like tiny electromagnetic oscillators. These atomic oscillators can emit electromagnetic waves into the cavity and can absorb electromagnetic waves from it. Each oscillator generate radiations of same frequency as frequency of the oscillators is given by the following formula:

$$E = nhf$$

Where h = Planck's constant (6.63×10^{-34} J-s).

f = frequency of the oscillator

n = 1, 2, 3, ………… (quantum number)

Postulate 2:

This states that, the quantized energy state of an oscillator changes by absorbing or by emitting energy. This is possible only in the form of packets (photons) and this is not continuous absorption or continuous emission. Each quantum is associated with radiation of a single frequency. Each photon or packet has energy given by:

$$E = hf$$

$$E = \frac{hc}{\lambda}$$

Note:

- Max Planck received the Nobel Prize in physics in 1918 for his discovery of energy quanta.
- Planck's Constant & Angular Momentum have similar units.

The Photon:

The emission of energy from a matter is not continuous, it is emitted in the form of packets or tiny bundles of energy which are integral part of all electromagnetic radiation and that they could not be subdivided. These "tiny bundles of energy" are called photons.

CHARACTERISTICS

- A photon has no charge and no mass.
- It can interact with all charged particles as well as with some neutral ones.
- All electromagnetic radiations consist of photons.
- A photon has a stable configuration and does not decay into any other particle.
- Its lifetime is infinite so long it does not undergo interaction with other particles.
- The rest mass of photons is zero.

$$\mathbf{E = mc^2 = pc}$$

$$\mathbf{m = \frac{h\upsilon}{c^2}}$$

Momentum of Photon:

The momentum of photon is given by,

$$p = \frac{h}{\lambda}$$

Interaction of Electromagnetic Radiation with Matter:

Electromagnetic radiation or photons interact with matter in three distinct ways depending mainly on their energy. The three processes are:

(i) Photoelectric effect
(ii) Compton effect
(iii) Pair production

PHOTOELECTRIC EFFECT:

When light of suitable frequency falls upon a metal surface, electros are ejected from metal surface. Thus, phenomenon is called photoelectric effect. These emitted electrons are known as photoelectrons.

Experimental Facts Observed Practically:

There are following experimental facts which are observed practically.

(1) There is a particular minimum value of frequency of incident radiations for which no electron is emitted, even that radiation is of very high intensity and it is allowed to fall for

a large interval of time. This particular minimum frequency is called "threshold frequency" (f_0). Its value depends upon nature of the metal.

(2) Number of photo electron increases with the increase of intensity of incident light, when incident radiation has frequency greater than threshold frequency.

(3) The value of $(K.E.)_{max}$ of a photo electron is directly proportional to the frequency of incident radiation.

Explanation on the Basis of Electromagnetic Wave Theory:

According to classical theory of electromagnetic radiation the value of electric intensity increases due to increase of intensity of radiation. Hence due to increase in electric intensity, the $(K.E.)_{max}$ must also be increased, but this fact is not observed experimentally. Because an electron is of very smaller size so energy obtained by it from wave front incident upon it is very small and it requires to collect enough energy due to which it is emitted. But experimentally it is confirmed that photoelectric effect is a spontaneous process. Hence classical theory of electromagnetic radiation fails to explain photoelectric effect. The classical theory cannot also explain why a beam of light of frequency slightly less than the threshold frequency of f_0, however intense it may be, does not cause emission of electrons.

Explanation on the Basis of Quantum Theory:

Einstein's quantum theory explained the photo electric effect.

According to Einstein's quantum theory the incident electromagnetic radiations consist of photon. The energy of each photon is given by,

$$E = hf$$

When this photon falls on the electron inside the metal gives all of its energy to that electron i.e., the photon is absorbed completely. A part of this energy is used in making the electron free from metal surface. This is called work function and is denoted by 'ϕ'. The remaining energy is still carried by electron which comes out of the metal.

Hence by using law of conservation of energy we can write,

$$\begin{pmatrix}\text{Incident Photon}\\ \text{energy}\end{pmatrix} - \begin{pmatrix}\text{Work}\\ \text{function}\end{pmatrix} = \begin{pmatrix}\text{Max. K. E.. of}\\ \text{Photo electron}\end{pmatrix}$$

$$hf - \phi = \frac{1}{2}mv^2{}_{max}$$

Hence, we can also write Einstein's photoelectric equation as,

$$K.E._{max} = hf - hf_0$$

Note:

(i) All the emitted electrons do not possess the maximum K.E.., some electrons come straight out of the metal surface and some lose energy in atomic collisions before coming out. The equation $(K.E._{max} = hf - hf_0)$ holds good only for those electrons which comes out with full surplus energy.

(ii) Albert Einstein was awarded Nobel Prize in physics in 1921 for his explanation of photoelectric effect.

(iii) The phenomenon of photoelectric effect cannot has explained if we assume that light consists of waves and energy is uniformly distributed over its wave front. It can only be explained by assuming light consists of corpuscles of energy known as photon. Thus, it shows the corpuscular nature of light.

STOPPING POTENTIAL:

The minimum negative potential (voltage) required to stop photoelectrons is called Stopping potential (V_0).

THRESHOLD FREQUENCY:

The minimum frequency of incident light required to eject electrons (below which no electrons escape the metal surface) is called Threshold frequency (f_o or $ύ_o$).

WORK FUNCTION:

The minimum energy of incident light required to eject electrons from metal surface (i.e.to overcome the binding force of nucleus on electrons) is called Work function of the particular metal and is denoted by Ø which is a constant of the metal.

CUTT-OFF WAVELENGTH:

The maximum wavelength incident light above which emission of photoelectrons will stop is called Cut-off wavelength.

EXPERIMENTAL RESULTS:

1. **Photoelectric current Vs Accelerating Voltage Curves:**
   - The stopping potential is independent of the intensity of the source and kinetic energy of photoelectrons will be maximum for the condition.
2. **Curves for different Frequencies but same intensity**
   - Saturation current depends upon intensity and not on frequency.
   - When frequency is increased from υ_1 to υ_1, the stopping potential becomes more and more negative
3. **A graph between K.E $_{max}$ and frequency (f) of light**
   - There is a minimum frequency f_o called threshold frequency below which no electrons are emitted.
   - Slope of the line is h/c.

<u>COMPTON EFFECT:</u>

When x-rays photons are scattered by loosely bound electrons, then there is effect on the wavelength of these scattered x-rays. This phenomenon is called Compton Effect. In this effect the wavelength of scattered x-rays is greater than wavelength of incident x-rays.

A photon collides with an electron and both are scattered

In this collision, a part of incident photon energy and momentum is transferred to an electron. Applying energy and momentum conservation laws to the process, he derived an expression for the change in wavelength '$\Delta\lambda$' known as Compton Shift for scattering angle θ as:

$$\Delta\lambda = \frac{h}{m_o c}(1 - \cos\theta)$$

Where m_o = rest mass of the electron

$$\frac{h}{m_o c} = \frac{6.63\times10^{-34}\ \text{Js}}{(9.1\times10^{-31}\ \text{kg})(3\times10^{8}\ \text{ms}^{-1})}$$

$= 2.43\times10^{-12}$ m

The factor $\frac{h}{m_o c}$ has dimensions of length and is called Compton Wavelength.

Note:

(i) The change in wavelength "$\Delta\lambda$" depends only on the scattering angle 'θ'.

(ii) Compton carried out experiment to measure '$\Delta\lambda$' as a function of 'θ' for several different initial wavelengths and determined the change in wavelength $\Delta\lambda$. He found that the experimental value of $\Delta\lambda$ for a given angle θ was in excellent agreement with the theoretical predictions. The theory-experiment agreement confirmed that the photon is a particle like wave not only in the photoelectric effect but in the scattering process, as well.

(iii) Compton was awarded Nobel Prize in Physics in 1927 for discovery of Compton Effect.

Note:

Light and other electromagnetic radiation acts as waves when they move from place to place but behave as particles or photons when interacting with material substance.

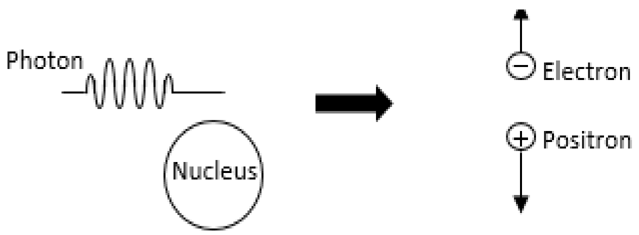
PAIR PRODUCTION:

When there is an interaction of very high energy photon (such as that of γ-rays) with matter, then this photon disintegrates into an electron-positron pair. This phenomenon is known as "pair production".

The positron is a positive electron; it is also known as antiparticle of electron or anti-electron.

Explanation:

As we know energy, momentum and charge are all conserved. In order to conserve the momentum and energy, the pair production occurs near a nucleus (in electric field in the vicinity of a heavy nucleus) which takes the recoil as shown in figure. This process is also called materialization of energy, because in this process, radiant energy is converted into matter accordance with Einstein's equation ($E = mc^2$), i.e., energy and mass are inconvertible.



Pair Production

For an electron or positron, the rest mass energy is $m_oc^2 = 0.511$ MeV, where m_o is the rest mass of an electron. In order to create an electron-positron pair an energy $2m_oc^2$ (=1.02MeV) is required. When photon of energy (hf) greater than $2\ m_oc^2$, the probability of pair production created, and this energy will be used up in the creation of the electron-positron pair. The surplus energy will be carried away by the two electrons as kinetic energy, i.e.,

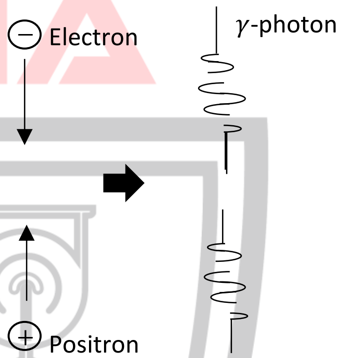
$$\text{Energy of photon} = \begin{bmatrix} \text{Energy required} \\ \text{for pair production} \end{bmatrix} + \begin{bmatrix} \text{K.E..of} \\ \text{the particle} \end{bmatrix}$$

$$hf = 2m_0c^2 + \text{K.E..}(e^-) + \text{K.E..}(e^+)$$

ANNIHILATION OF MATTER:

The reverse process of pair production is known as annihilation of matter. In this process, a positron combines with an electron and they annihilate each other and their mass appears as two gamma ray photons,

i.e., $e^- + e^+ \longrightarrow \gamma + \gamma$



Each photon has an energy equal to the rest mass of electrons ($m_oc^2 = 0.51$MeV). The two photons are produced travelling in opposite directions in order to conserve momentum as shown in figure. The charge and energy is also conserved.

These two phenomena (pair production and Annihilation of matter) tell that energy can be converted into matter and matter into energy, therefore they provide an experimental verification for Einstein's mass-energy relation ($E = mc^2$)

DE BROGLIE HYPOTHESIS:

Louis de Broglie proposed in 1924 that, all the moving particles (small particles like electrons, proton and neutrons) behave like waves, whose wavelength is given by:

$$\lambda = \frac{h}{mv}$$

Wave Nature of Macroscopic Particles is Negligible:

An object of large mass and ordinary speed has such a small wavelength that its wave effects such as interference and diffraction are negligible.

Note: From de Broglie equation,

$$\lambda = \frac{h}{mv}$$

Or

$$\lambda = \frac{h}{\sqrt{2mVe}}$$

THE DAVISSON AND GERMER EXPERIMENT

The theoretical prediction of DE Broglie's hypothesis was experimentally confirmed by the famous experiment conducted by Davisson and Germer in the year 1927.They calculated the wave length of electron the known accelerating potential 'V' by applying the relation for kinetic energy of the electron i.e. $\lambda = \frac{h}{\sqrt{2em_oV}}$

Davisson and Germer experiment has provided a direct evidence for DE Broglie's hypothesis that particles have wave like properties.

WAVE PARTICLE DUALITY:

Wave can behave like particles and particles can behave like waves. This is called Wave-Particle duality.

Uncertainty Principle:

Positron and momentum of a particle cannot both be measured simultaneously with perfect accuracy. This uncertainty is also associated with the measuring instrument. It is a consequence of the wave particle duality of matter and radiation. This was first proposed by Werner Heisenberg in 1927 and hence is called as Heisenberg Uncertainty Principle.

$$\Delta x \,.\, \Delta p \approx h$$

This is the mathematical form of uncertainty principle. This relation shows that if we make Δx small then the value of Δp becomes large to get their product of the order of a constant (Planck's constant h). This prove that it is impossible to make measurement of position and momentum simultaneously and accurately.

There is another form of uncertainty principle which relates the energy of a particle and the time at which it had the energy. We know that the energy is related to frequency by E = hf, therefore a small change

$$\Delta E \approx h\Delta f$$

Or $$\Delta E \approx h\frac{1}{\Delta t} \qquad \left(\because f = \frac{1}{t}\right)$$

Or $$\Delta E \,.\, \Delta t \approx h$$

Accurate forms of Uncertainty Principle:

According to Heisenberg's more careful calculations, he found that at the very best:

$$\Delta x \,.\, \Delta p \geq \hbar$$

$$\Delta E \,.\, \Delta t \geq \hbar$$

Where $\hbar = \frac{h}{2\pi} = 1.05 \times 10^{-34}$ Js

Note:

(i) Heisenberg Uncertainty Principle is completely negligible for measurements of position and momentum of macroscopic objects but is a predominant fact in the atomic domain.

(ii) Werner Karl Heisenberg received Nobel Prize for physics in 1932, for the development of quantum mechanics.

PRACTICE SHEET # 01

1. **Planck's work was connected with:**
   a. wave nature of matter
   b. photoelectric effect
   c. structure of atom
   d. quantum nature of radiation

2. **The photoelectric effect is the ejection of electrons from the surface of a metal when:**
   a. It is heated to a high temperature
   b. Electrons of suitable velocity strike it
   c. Radiation of suitable wavelength falls on it
   d. It is placed in a strong electric field

3. **Photoelectric effect can be explained only by assuming that electromagnetic radiation:**
   a. is a transverse wave
   b. is a longitudinal wave
   c. can be polarized
   d. consists of quanta

4. **Einstein's photoelectric equation is**

$$E_k = h\nu - \phi$$

   In this equation E_k refers to:
   a. Kinetic energy of all emitted electrons
   b. Mean kinetic energy of emitted electrons
   c. Maximum kinetic energy of emitted electrons
   d. Minimum kinetic energy of emitted electrons

5. **In order to increase the kinetic energy of ejected photoelectrons, there should be an increase in:**
   a. intensity of radiation
   b. wavelength of radiation
   c. frequency of radiation
   d. both wavelength and intensity of radiation

6. **A photon of frequency v is incident on a metal surface whose threshold frequency is v_o. The maximum kinetic energy of the emitted electron will be:**
   a. $h(v - v_o)$
   b. $h(v + v_o)$
   c. $\frac{1}{2}h(v - v_o)$
   d. $\frac{1}{2}h(v + v_o)$

7. **The threshold wavelength for a photoelectric surface is 6000Å and the wavelength of incident light is 5000Å. Then the maximum energy of emitted electrons would be:**
   a. 0.041 eV
   b. 0.41 eV
   c. 4.1 eV
   d. 41 eV

8. **The energy of a photon of wavelength λ is:**
   a. $hc\lambda$
   b. hc/λ
   c. λ/hc
   d. $h\lambda/c$

9. **A photon of energy 3.4 eV is incident on a metal having work function 2 eV. The maximum kinetic energy of photoelectrons is equal to:**
   a. 1.4 eV
   b. 1.7 eV
   c. 5.4 eV
   d. 6.8 eV

10. **The momentum of a photon of frequency v is:**
    a. hv/c^2
    b. hv/c
    c. hvc
    d. hvc^2

11. **The momentum of a photon of an electromagnetic radiation is 3.3×10^{-29} kg m/s. The frequency of the associated waves is ($h = 6.6\times10^{-34}$ Js, $c = 3\times10^{8}$ m/s)**
    a. 3.0×10^{3} Hz
    b. 6.0×10^{3} Hz
    c. 7.5×10^{12} Hz
    d. 1.5×10^{13} Hz

12. A photo-sensitive material would emit electrons if excited by photons beyond a threshold. To cross the threshold, you would increase:

a. then intensity of light
b. the wavelength of light
c. the frequency of light
d. the voltage applied to light source

13. If the wavelength of incident radiations in a photoelectric experiment is decreased, then:

a. the photoelectric current will decrease
b. the photoelectric current will increase
c. the stopping potential will decrease
d. the stopping potential will increase

14. The momentum of a photon of an electromagnetic radiation is 3.3×10^{-29} kg ms^{-1}. If h = 6.6×10^{-34} Js is and c = 3×10^{8} m/s, then the frequency of the radiation is:

a. 3×10^{-12} Hz
b. 3×10^{-13} Hz
c. 1.5×10^{13} Hz
d. 1.5×10^{-13} Hz

15. Compton effect is associated with:

a. gamma rays
b. X-rays
c. beta rays
d. positive rays

16. The de Broglie wavelength of particle of mass m moving with a kinetic energy E is:

a. $\sqrt{\frac{h}{2mE}}$
b. $\frac{h}{\sqrt{2mE}}$
c. $\frac{h}{2mE}$
d. $\frac{\sqrt{h}}{2mE}$

17. A particle of mass 10^{-31} kg is moving with speed of 10^{5} m/s. The de Broglie wavelength of the particle is:

a. 6.63×10^{-8} m
b. 6.63Å
c. 66.3 Å
d. 6.63×10^{-7} m

18. Absolute motion cannot be detected:

a. in its own frame of reference
b. in a different frame of reference
c. both in its own and different frame of reference
d. due to random errors

19. Which of the following is not an example of inertial frame?

a. a body placed on the surface of earth
b. a body placed in a car moving with uniform velocity
c. a body placed in a car moving with some acceleration
d. a rocket moving with uniform velocity

20. The special theory of relativity treats problems involving:

a. Inertial frame of references
b. Non-inertial frame of references
c. Both inertial and non-inertial frames of references
d. An accelerating from of reference

21. Which of the following is not a postulate of special theory of relativity?

a. Laws of physics are same in all inertial frames
b. Speed of light in free space has the different value for all observers
c. Speed of light in free space has the same value for all observers
d. All of these are postulate of special theory of relativity

22. A bar 1.0 m in length and located along x-axis moves with a speed of 0.75 c with respect to a stationary observer. The length of the bar as measured by the stationary observer is:

a. 1.66 m
b. 1.0 m
c. 0.66 m
d. 2.66 m

23. The mass 'm' of a body moving at 0.8 c (whose rest mass is m_o) becomes:

a. 2 m_o b. 1.67 m_o c. 0.67 m_o d. 2.67 m_o

24. At high temperature, the proportion of shorter wavelength radiation, emitted by the body:

a. decreases
b. first increases then decreases
c. increases
d. remains constant

25. The value of the Stephen's constant for black body radiations is given by:

a. $5.6\times10^{8}Wm^{-2}K^{-4}$ b. $5.67\times10^{-8}Wm^{-2}K^{-4}$ c. 2.9×10^{-3} mK d. 4×10^{4}WmK

26. With the help of 50 KV electron microscope, a resolution of:

a. 0.5 to 1 m is possible b. 1 m to 10 m is possible
c. 0.5 to 1 nm is possible d. 1 to 10 nm is possible

27. de-Broglie's hypothesis was experimentally verified by:

a. Maxwell b. Compton c. Einstein d. Davison and Germer

28. The uncertainty in the measurement of position and momentum of a particle is:

a. associated with the measuring instrument
b. consequences of wave particle duality of matter and radiation
c. due to random error
d. the Compton effect

29. In order to observe the position of an electron with less uncertainty and also for minimizing diffraction effect, we must use light of:

a. shorter wavelength b. longer wavelength
c. shorter frequency d. any wavelength

30. The life time of an electron in an excited state is about 10^{-8} sec. The uncertainty in energy during this time is:

a. 10.5×10^{-19} J b. 10.5×10^{-29} J c. 1.05×10^{-16} J d. 1.05×10^{-16} J

31. The length of a spaceship is measured to be exactly half its proper length. Find the velocity of the space ship:

a. c b. 0.56 c c. 0.752 c d. 0.866 c

32. If an electron moves with 0.8c its mass will be ______ times the rest mass:

a. $\frac{3}{5}$ m_o b. $\frac{5}{3}$ m_o c. $\frac{5}{6}$ m_o d. $\frac{4}{3}$ m_o

33. At what speed would the mass of the particle become double of its rest mass:

a. $\sqrt{3}$ c b. 0.93 c c. 0.866 c d. 0.98 c

34. An electron has mass $\frac{5}{3}$ m_o . The K.E. energy of the electron is:

a. $m_o c^2$ b. $\frac{1}{3}$ m_oc^2 c. $\frac{2}{3}$ m_oc^2 d. $\frac{3}{2}$ m_oc^2

35. Special theory of relativity deals with the events in the frames of reference which move with constant:
a. acceleration b. momentum c. space interval d. time interval

36. On the annihilation of a particle and its antiparticle its energy released is E. The mass of each particle will be:
a. E/c b. E/2c c. E/c^2 d. $E/2c^2$

37. Whose experimental work proved that the velocity of light is a universal and natural constant:
a. Lorentz b. Einstein c. Maxwell d. Michelson

38. Two photons approach each other. Their relative velocity will be:
a. slightly less than c b. c/2 c. c d. zero

39. A certain particle called μ-mesons has a life time 2×10^{-6} s. If it is traveling with a speed of 2.994×10^{8} m/s. Then its mean life time will be:
a. 0.317×10^{-6} s b. 3.17×10^{-4} s c. 31.7×10^{-6} s d. none of these

40. The mass of an object will be doubled at speed:
a. 2.6×10^{8} m/s b. 1.6×10^{8} m/s c. 2.6×10^{7} m/s d. 3.6×10^{7} m/s

41. If a material object moves with speed of light, its mass becomes:
a. Equal to its rest mass b. Four times of its rest mass
c. Double of its mass d. Infinite

42. 0.1 kg mass will be equivalent to the energy:
a. 5×10^{8} Joules b. 6×10^{16} Joules c. 9×10^{16} Joules d. 9×10^{15} Joules

43. When light falls on metal surface, photoelectrons are emitted. If the intensity of the light is increased, which of the following will increase:
a. The number of electrons emitted per second
b. The maximum K.E. of the emitted electrons
c. The minimum K.E. of the emitted electrons
d. The velocity of the emitted electrons

44. The amount of energy required to eject an electron from metal surface is called:
a. Threshold Frequency b. Work function
c. Pair production d. Compton effect

45. Einstein's photo-electric equation is given by:
a. $\frac{1}{2}mv^2_{max} = hf + \phi$ b. $\frac{1}{2}mv^2_{max} = hf - \phi$ c. $f = \frac{1}{2}mv^2_{max} + \phi$ d. $hf= \frac{1}{2}mv^2_{max} - \phi$

46. In Compton scattering, the change in the wavelength is given by:
a. $\Delta\lambda = \frac{h}{m_oc^2}(1 + \cos\theta)$
b. $\Delta\lambda = \frac{h}{m_oc^2}(1 - \cos\theta)$
c. $\Delta\lambda = \frac{hc}{m_o}(1 - \cos\theta)$
d. $\Delta\lambda = \frac{h}{m_oc}(1 - \cos\theta)$

47. **The momentum of the moving photon is:**
a. zero b. $P = h\lambda$ c. $P = h/\lambda$ d. $P = \lambda/h$ e. $P = 1/\lambda h$

48. **Disintegration of photon on striking a nucleus into an electron and position is known as:**
a. Compton Effect b. Photo-electric effect
c. Annihilation of matter d. Pair production

49. **The minimum energy required by a photon to create an electron-positron pair is:**
a. 3 MeV b. 4 MeV c. 1.02 MeV d. 0 MeV

50. **The rest mass energy of an electron is:**
a. 9.11×10^{-31} J b. 6.7 MeV c. 0.511 MeV d. 1.67×10^{-27} J

51. **The wavelength of de-Broglie is smaller is:**
a. Mass of the particle is large b. Mass of the particle is small
c. Velocity of the particle is small d. Both mass and velocity of the particle are small

52. **At low temperature, a body usually emits radiations of:**
a. Long wavelength b. Short wavelength
c. Moderate wavelength d. Infinite wavelength

53. **In the equation $\lambda_{max} \times T$ = Constant, the value of the constant is about:**
a. 2.5×10^{3} mk b. 3.5×10^{-3} mk c. 5.3×10^{-4} mk d. 2.9×10^{-3} mk

54. **The maximum energy of photo electrons is:**
a. $\frac{1}{2} mv^2_{max} = V_o c$ b. $\frac{1}{2} mv^2_{max} = V_o c^2$ c. $\frac{1}{2} mv^2_{max} = V_o^2 c$ d. $\frac{1}{2} mv^2_{max} = V_o/c$

55. **Interference and diffraction of light confirm its:**
a. Particle nature of light b. Dual nature of light
c. Wave nature of light d. Electromagnetic nature of light

56. **Planck's constant 'h' has the same unit as that of:**
a. Linear momentum b. Torque c. Angular momentum d. Power

57. **Absolute motion cannot be detected:**
a. In its own frame of reference
b. In a different frame of reference
c. Both in its own frame of reference and in a different frame of reference
d. None of them

58. **The length of rod at rest as measured by an observer moving parallel to it at relativistic speed v is given by:**
a. $l = l_o\sqrt{1 - v^2/c^2}$ b. $l = l_o\left(1 - \frac{v^2}{c^2}\right)$ c. $l = \frac{l_o}{\sqrt{1-\frac{v^2}{c^2}}}$ d. $l = l_o\left(1 + \frac{v^2}{c^2}\right)$

59. **The mass of an object will be doubled at a speed of:**
a. 2.6×10^{7} m/s b. 1.6×10^{8} m/s c. 2.6×10^{8} m/s d. 3.6×10^{7} m/s

60. **The relativistic energy E is equivalent to relativistic mass m is given by:**
a. $m = Ec^2$ b. $m = E/c^2$ c. $m = E/c$ d. $m = c^2/E$

61. **The SI unit of Planck's constant is:**
a. $J\text{-}s^{-1}$ b. $J\text{-}s^{-2}$ c. J-s d. $J\text{-}s^2$

62. **Photoelectric effect was discovered by:**
a. Einstein b. G.P Thomson c. Hallwachs d. Lenard

63. **If the energy of incident photon is greater than the rest mass energy of electric-positron pair, the surplus energy is shared by the pair as:**
a. Potential energy b. Thermal energy c. Electrical energy d. Kinetic energy

64. **Compton shift in wavelength is maximum when:**
a. scattering angle is 0° b. scattering angle is 90°
c. scattering angle is 180° d. none of them

65. **The correct relation for uncertainty principle is:**
a. $\Delta p \Delta t = h$ b. $\Delta x \Delta t = h$ c. $\Delta p \Delta x = h$ d. $\Delta p \Delta x = \frac{1}{h}$

66. **Planck's constant h has the same unit as that of:**
a. Torque b. Linear momentum c. Angular momentum d. No unit

67. **If a material object moves with speed of light, its mass becomes:**
a. Equal to its rest mass b. Four times of its rest mass
c. Double of its mass d. Infinite

68. **Rest mass energy of electron-positron pair is:**
a. 2 MeV b. 1.02 MeV c. 1 MeV d. 5 MeV

69. **The value of Stefan's constant 'σ' is given by:**
a. $5.67\times10^{8}\ wm^{-2}k^{-4}$ b. $5.67\times10^{-8}\ wm^{-2}k^{-4}$
c. $5.67\times10^{-18}\ wm^{-2}k^{-4}$ d. $5.67\times10^{-15}\ wm^{-2}k^{-4}$

70. **In the equation $\lambda_{max} \times T$ = constant, the value of the constant is about:**
a. 2.5×10^{3} mk b. 3.5×10^{-3} mk c. 5.3×10^{-4} mk d. 2.9×10^{-3} mk

71. **The stopping potential for the certain metal is 10 volts. Thus, work function for the cathode is:**
a. 10 J b. 1.6×10^{-18} J c. 1.6×10^{-19} J d. 1.6×10^{-20} J

ANSWER KEY # 01

1.	D	31.	D	61.	C
2.	C	32.	B	62.	C
3.	D	33.	C	63.	D
4.	C	34.	D	64.	C
5.	C	35.	B	65.	C
6.	A	36.	D	66.	C
7.	B	37.	D	67.	D
8.	B	38.	C	68.	B
9.	A	39.	C	69.	B
10.	B	40	A	70	D
11.	D	41.	D	71.	B
12.	C	42.	D	72.	
13.	D	43.	A	73.	
14.	C	44.	B	74.	
15.	B	45.	B	75.	
16.	B	46.	D	76.	
17.	A	47.	C	77.	
18.	B	48.	D	78.	
19.	C	49.	C	79.	
20.	A	50.	C	80.	
21.	B	51.	A	81.	
22.	C	52.	A	82.	
23.	B	53.	D	83.	
24.	C	54.	A	84.	
25.	B	55.	C	85.	
26.	C	56.	C	86.	
27.	D	57.	A	87.	
28.	B	58.	A	88.	
29.	A	59.	C	89.	
30.	C	60.	B	90.	

CHAPTER # 18: ATOMIC SPECTRA

SPECTROSCOPY:

The branch of physics that deals with the investigation of wavelengths and intensities of electromagnetic radiations emitted or absorbed by atoms is called Spectroscopy. It includes the study of spectra produced by atoms.

In general, there are three types of spectra:

(i) Continuous spectra e.g., black body radiation spectrum.
(ii) Band spectra e.g., molecular spectra.
(iii) Discrete of line spectra e.g., atomic spectra.

TYPES OF SPECTRA

1) LINE SPECTRUM OR ATOMIC SPECTRA:

- A line spectrum is obtained from atoms in gaseous state in the form of discrete lines.
- Line spectra are characteristic of the elements that emit the radiation.
- Line spectra are also called atomic spectra because the lines represent wavelengths radiated from atoms when electrons change from one energy level to another.

2) BAND SPECTRUM/MOLECULAR SPECTRA:

- Band spectra is the name given to groups of lines so closely spaced that each group appears to be a band.
- Band spectra, or molecular spectra, are produced by molecules radiating their rotational or vibrational energies, or both simultaneously.

3) CONTINUOUS SPECTRUM:

A continuous spectrum is mainly obtained from solids and liquids in which a continuous radiation of different wavelengths are emitted or absorbed.

TYPES OF ATOMIC SPECTRA

1. EMISSION LINE SPECTRUM

When an atomic gas or vapor is 'excited' its electrons jump back (after excitation) to the ground state by emitting radiation. Such a spectrum is called Emission line spectrum.

Emission 'SPECTRA' consist of bright lines on a dark background.

2. ABSORPTION LINE SPECTRUM

When a light containing different wavelengths is passed through a tube containing gaseous state of an element under investigation, some of the wavelengths, of incident light, are absorbed. The remaining part of the incident radiation is recorded to obtain ABSORPTION line spectrum.

The resulting absorption line spectrum consists of a bright background crossed by dark lines corresponding to the missing wavelengths.

Bohr's Model of the Hydrogen Atom:

In order to explain the empirical results obtained by Rydberg to explain hydrogen spectrum, Neil Bohr, in 1913, formulated a model of hydrogen atom. This theory is the mixture of classical physics and Planck's quantum theory.

This theory has following postulates:

Postulate 1:

An electron revolves in circular orbit around the nucleus of hydrogen atom, then no energy is being absorbed or emitted. The emission or absorption of energy is possible only when the electron jumps from one orbit to the other.

Postulate 2:

An electron revolves in circular orbit around the nucleus of hydrogen atom is fixed orbits satisfying the following condition:

$$\text{Angular momentum of electron} = \frac{nh}{2\pi}$$

Or
$$mvr = \frac{nh}{2\pi}$$

Where (n = 1, 2, 3, ...) and it is called the principal quantum numbers.

m = mass of the orbiting electron.

v = velocity of the orbiting electron

h = Planck's constant

r = Radius of the orbit

This is called quantization condition because orbit is allotted to the electron according to this condition.

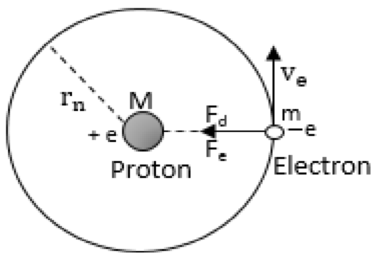
Postulate 3:

Whenever an electron makes a transition, that is jumps from high energy state E_n to a lower energy state E_p, a photon of energy 'hf' is emitted. The amount of energy emitted is equal to difference of energies corresponding to these two orbits,

i.e., $hf = E_n - E_p$

where ($f = c/\lambda$) is the frequency of the radiation emitted.

Radii of Quantized Orbits:



$$r_n = \frac{n^2h^2}{4\pi^2Kme^2}$$

If we put ħ = h/2π (ħ is Dirac Constant having value of 1.05 * 10^-4 Js;

The radius of Bohr's orbit is given as

$$\mathbf{r = 4\pi\varepsilon_o \frac{n^2\hbar^2}{me^2} = (0.53 \times 10^{-10} m)n^2}$$

It is general formula for the radius of n^{th} orbit in hydrogen atom.

For n = 1, we get

$$r_1 = \frac{h^2}{4\pi^2 K m e^2}$$

This agrees with the experimentally measured values and is called the first Bohr's orbit radius of the hydrogen atom.

Thus according to Bohr's Theory, the radii of different stationary orbits of the electrons in the hydrogen atom are given by,

$$r_n = r_1, 4r_1, 9r_1, 16r_1, \ldots\ldots$$

Speed of Electron:

The speed of the electron in n^{th} orbit is given by the following relation,

$$v_n = \frac{nh}{2\pi m r_n}$$

Putting value of r_n we get:

$$v_n = \frac{nh}{2\pi m\left(\frac{n^2h^2}{4\pi^2 K m e^2}\right)}$$

Or
$$v_n = \frac{2\pi K e^2}{nh}$$

It is mathematical formula to calculate the speed of electron in n^{th} orbit.

Energy of Electron in Quantized Orbits:

Total energy = E_n = (K.E..) + (P.E)

$$E_n = -\frac{2\pi^2 K^2 m e^4}{n^2 h^2}$$

It is the expression of the total energy of an electron in n^{th} orbit of hydrogen atom. Its value increases with the increase of value of 'n'.

The negative sign shows that there is a deficiency of energy due to which the electron cannot leave the field of nucleus by itself.

The lowest energy state corresponding to n = 1, is called the ground state or normal state.

It is written as:

$$E_o = -\frac{2\pi^2 k^2 m e^4}{h^2} = -13.6\text{eV}$$

The energy of n^{th} orbit is given as:

$$E_n = -\frac{13.6}{n^2}\text{eV} \quad \text{where n=1,2,3...}$$

Thus for n = 1, 2, 3, ... we get the allowed energy levels of a hydrogen atom to be,

$$E_n = -E_o, \frac{-E_o}{4}, \frac{-E_o}{9}, \frac{-E_o}{16}, \ldots\ldots$$

When the electron is in the first Bohr orbit, it is said to be in the ground state. When it is in higher orbit, it is said to be in the excited state.

Note:

(i) Ionization Energy:

The energy required to completely remove an electron from an atom is called ionization energy. The ionization energy to the electron may be provided by collision with an external electron.

Thus ground state energy,

$\left(E_o = \frac{2\pi^2 K^2 m e^4}{h^2} = -13.6eV\right)$ is the required energy to completely remove an electron from the first Bohr orbit. This is called as ionization energy.

(ii) Ionization Potential:

As the ionization energy to the electron is provided by collision with an external electron, the minimum potential through which this external electron should be accelerated, so that it can supply the requisite ionization energy is known as ionization potential.

(iii) Excitation Energy:

The energy required to excite (lift the electron from its ground state to higher energy orbit) a hydrogen atom is called its excitation energy. This energy is usually given to the atom by making collision of it with, accelerated electron from outside the atom.

(iv) Excitation Potential:

The electric potential required to accelerate an electron to such an energy that it can excite the atom by colliding it, is called excitation potential of hydrogen atom.

(v) Discrete Stationary States of the Atom:

An electron is bound to the nucleus in an atom, can move around the nucleus in certain circular orbits without radiating. These orbits are called the discrete stationary states of the atom.

De-Broglie's Hypothesis:

This states that the electron revolving in an orbit behave like waves, whose wave length is given by $\lambda = \frac{h}{mv}$.

This hypothesis was stated in support of Bohr's postulate, i.e.; the angular momentum of electron is given by, $(mvr_n = nh/2\pi)$

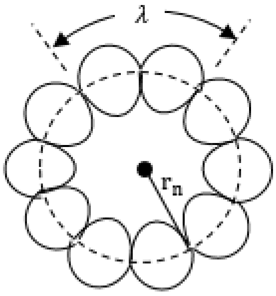


Fig. (a)

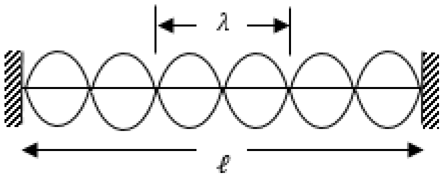


Fig. (b)

Explanation:

In the figure (a), we have n^{th} orbit of hydrogen atom in which electron is revolving. The circumference of this orbit is given by:

Circumference = $2\pi r_n$

The whole circumference is filled with standing de-Broglie waves, which can be calculated as follow:

Consider a string of length 'ℓ' as shown in figure (b). If tjis is put into stationary vibrations, we must have,

$$\ell = n\lambda$$

Where n is an integer. Suppose that the string is bent into circle of radius 'r_n' as demonstrated in figure (a) we get,

$$\ell = 2\pi r_n = n\lambda$$

or $$\lambda = \frac{2\pi r_n}{n} \qquad .....(i)$$

But from de-Broglie hypothesis

$$\lambda = \frac{h}{p} = \frac{h}{mv} \qquad .....(ii)$$

Comparing eq. (i) and (ii) we get,

$$\frac{h}{mv} = \backslash f(2\pi r_n, n)$$

Or $$mvr_n = \frac{nh}{2\pi}$$

Hence de-Broglie's Hypothesis has theoretical support as explained above.

Note:

The electron revolving in an orbit behave like waves. These waves are called particle waves.

As orbit of the electron is a closed path, so the wave in this closed path, so the wave in this closed path is in shape of stationary wave (having nodes and antinodes).

Hydrogen Emission Spectrum:

The various different wavelengths of electromagnetic radiations are emitted from hydrogen atom, the collection of all these different wave length is called "emission spectrum".

This spectrum consists consist of different series:

(i) Lyman series
(ii) Balmer series
(iii) Paschen series
(iv) Bracket series
(v) Pfund series

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

Where R_H is the Rydberg constant given by:

$R_H = \frac{E_o}{hc} = 1.0974 \times 10^7 m^{-1}$

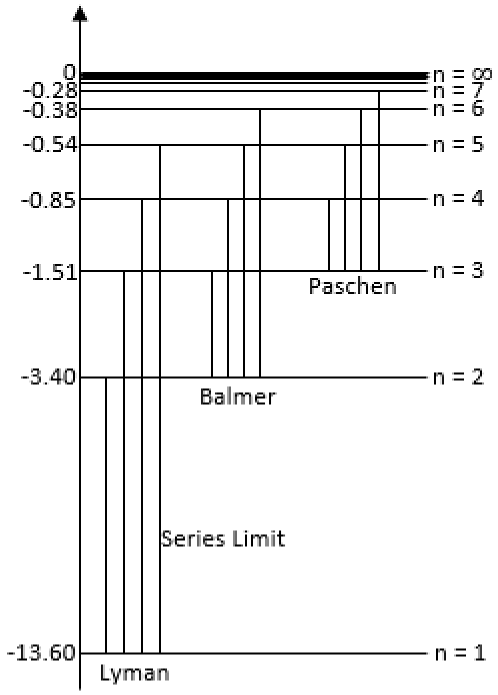
If we put "p = 1", n = 2, 3, 4, 5, ..., then we get a series of different values 'λ' called Lyman series.

If we put "p = 2", n = 3, 4, 5, 6, . . . , than we get a series of different values of 'λ' called Balmer series.

If we put "p = 3", n = 4, 5, 6, 7, ... , than we get a series of different values of 'λ' called Paschen series.

Similarly, we can find other series.

The expected jumping of electrons inside hydrogen atom are shown by the help of following diagram, known as energy level diagram. The vertical lines represent the electron jump and the horizontal lines represent the energy of electron in different orbits.



ENERGY LEVEL DIAGRAM FOR THE HYDROGEN ATOM

X-RAYS

When high energy electrons strike a metal surface, high-frequency radiations of extremely large penetrating power are emitted, known as X-rays.

Inner Shell Transitions and Characteristic X-Rays:

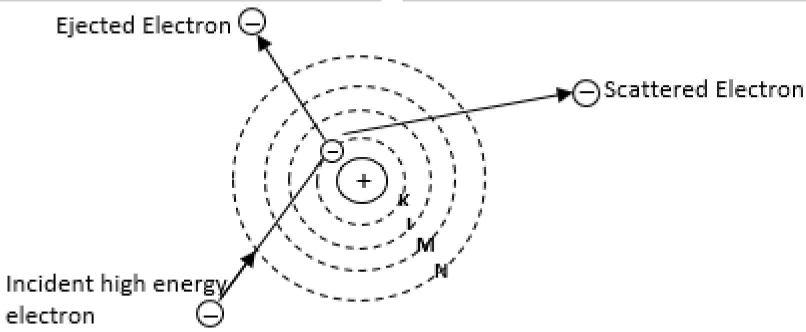
The jumping of electron from one orbit to the other, when energy is absorbed or emitted by it, is called Transition of Electron.

When the transition is from higher to lower orbit then emission of radiation takes place (spectral lines). The emitted radiations are visible spectrum if the transition is between two orbits with less energy difference. These radiations may lie in infrared, or visible spectrum or in ultraviolet region.

But if the transition of electron takes place between two orbits of large value of energy difference, then radiations of high frequency are emitted.

These high energy photons are called X-rays. Their frequency is much greater than the frequency of ordinary light.

These X-rays consist of series of specific wavelengths or frequencies and hence are called characteristic X-rays. The characteristic X-rays are used for the study of atomic structure and periodic table of electrons. The wavelengths of sharp peaks are CHARACTERTISTICS of the target material and independent of the applied voltage.



The Continuous X-Ray Spectrum:

The continuous spectrum is due to an effect known as bremsstrahlung or breaking radiation. When the fast moving electrons bombard the target, X-rays the first collision with the target atoms. This gives the most energetic X-rays or X-rays of maximum frequency f_{max}. In the case when the electrons lose all their energy in the first collision, the entire kinetic energy appears as a photon of energy (hf_{max}), i.e.,

K.E. = hf_{max}

Other electrons do not lose all their energy in the first collision. They may suffer a number of collisions before coming to rest. This will give rise to photons of smaller energy or X-rays of smaller frequency. Thus, the continuous spectrum is obtained sue to deceleration of imparting electrons.

Properties of X-rays:

1. X-rays travel in straight lines with speed of light.
2. These are not deflected by electric or magnetic fields.
3. X-rays are highly penetrating and their power of penetration depends upon the density of the material on which they fall. The denser the substance, the smaller the penetration.
4. Like light, they are electromagnetic waves of very short wavelength and show reflection, refraction, interference, diffraction and polarization under suitable arrangements.
5. X-rays effect a photographic plate.

6. X-rays ionize a gas and also eject electrons from certain metals on which they fall (photo electric effect).
7. X-rays can produce fluorescence.

Laser:

Laser is the acronym for light amplification by simulated emission of Radiation. Laser light is unidirectional coherent beam (all in phase with one another) of visible light. It is also monochromatic (having single wavelength and frequency).

Three kinds of transitions involving radiation are:

1. **Induced Absorption:**

An atom can be raised to the excited state by absorbing a photon.

2. **Spontaneous Emission**

An atom in an excited state can drop to ground state by emitting a photon. The emitted radiation is incoherent.

3. **Induced Emission:**

An atom in an excited state can absorb a photon of energy $h\upsilon$ that causes the atom to drop to ground state by emitting a second photon. The radiation is exactly in phase with the incident one hence coherent.

Population Inversion:

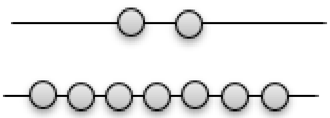
The situation in which number of excited atoms exceeds the number of atoms in ground state.

Stimulated Emission:

It is emission of photons due to down transition of electrons in excited state.

Note:

E_1
(Larger energy)
E_2
(Smaller energy)

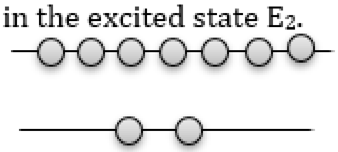


(a) Normal Population

A normal population of atomic energy state, with more atomic in the lower energy state E_1 than in the excited state E_2.

E_1

E_2



(b) Population inversion

A population inversion, in which the higher energy state has a greater population than the lower energy state.

Note:

A **metastable state** is an excited state in which an excited electron is usually stable and the electron takes relatively longer time to fall spontaneously to a lower state. The transition from or to this state are difficult as compared to other excited states. Electron can stay 10^{-8} sec in an ordinary excited state. META STABLE STATE is a state which has longer life time i.e. 10^{-3} sec.

Optical Pumping

The process in which electron are raised from ground state to an excited state by providing light is called OPTICAL PUMPING.

RUBY LASER

A ruby laser is a cylindrical rod with parallel, optically flat reflecting ends, one of which is partly reflecting. It produces an intense coherent monochromatic red beam of light.

Ruby is a crystal of Al_2O_3 in which some of the Al^{+3} are replaced by Cr^{+3} ions.

APPLICATIONS OF LASER:

- Three dimensional images of objects obtained by using lasers in a process called Holography.
- As surgical tool for "welding" detached retina.
- To perform precision surveying and length measurement.
- As a potential energy source or inducing nuclear fusion reactions.
- For telephone communications along optical fibers.
- For precision cutting of metals and other materials.

Helium-Neon Laser:

It is a most common type of lasers used in physics laboratories. Its discharge tube of the assembly contains 85% helium and 15% neon gas. The neon is lasing or active medium in this tube.

Note:

Laser can be made from solids and liquids as well as gases. Helium-Neon laser is a most common type of gas laser.

PRACTICE SHEET # 01

1.The spectral line of hydrogen atom in the visible region were studied by:
A) Lyman B) Balmer
C) Paschen D) Brackett

2. The series spectral lines in the ultraviolet region of the hydrogen spectrum are called:
A) Balmer series B) Brackett series
C) Paschen series D) Lyman series

3. Rutherford concluded that the nucleus which is the central part of the atom is:
A) Positively charged B) Negatively charged
C) Electrically neutral D) None of these

4. Electron in the hydrogen atom jump from any higher orbit to 1st orbit. The set of lines emitted is called:
A) Lyman B) Blamer
C) Paschen D) Brackett

5. The Balmer series is obtained when an electron in hydrogen atom jumps from higher orbit to an orbit where n is equal to:
A) 1 B) 2
C) 3 D) 4

6. When an electron is excited from lower to a higher orbit, it will:
A) Emit energy B) Absorb energy
C) Absorb as well as emit energy D) None of these

7. If an electron in an atom makes a transition from higher to a lower orbit, it will :
A) Emit energy B) Absorb energy
C) Neither emit nor absorb energy. D) Absorb as well as emit energy

8. The radius of the 2nd orbit in hydrogen atom is:
A) Greater than the 1st orbit B) Equal to the 1st orbit
C) Less than the 1st orbit. D) None of these.

9. Which of the following transitions in hydrogen atom emits the photon of high frequency:
A) n = 1 to n = 2 B) n = 2 to n = 1
C) n = 2 to n = 6 D) n = 6 to n = 2

10. Paschen series is obtained when the transition of the electron is terminated on:
A) 3rd orbit B) 2nd orbit
C) 1st orbit D) 4th orbit

11. Radiation with wavelength longer then red light is called:
A) Ultraviolet radiation B) Gamma radiation
C) Infra-red radiation D) visible rays.

12. Radiation with wavelength shorter than violet light is called:
A) Infra-red radiation B) X-rays
C) Radar waves D) Ultraviolet radiation

13. The ground state energy for the hydrogen atom:
A)-10.6 eV B) -13.6 eV
C) -3.4 eV D) -6.8 eV

14. The radius (in m) of the 1st Bohr orbit in hydrogen is:
A) 9.11×10^{-31} B) 8.85×10^{-12}
C) 1.6×10^{-19} D) 0.53×10^{-10}

15. When an electron jumps from higher orbit to lower orbit it emits photon of energy equal to.
A) Difference of the energies in the two orbits.
B) Sum of the energies in the two orbits.

C) The energy of the higher orbit
D) None of these

16. The total energy of electron in an atom:
A) Vibrational energy + Rotational energy. B) Vibrational energy + K.E
C) P.E + K.E D) Rotational energy + K.E

17. K_β characteristics X-rays are produced due to transition of electron:
A) Form L- shell to K-shell B) From M-shell to L-shell
C) From M-shell to K-shell D) From N-shell to K-shell

18.The transition of inner shell electron in heavy atoms give rise to the emission of:
A) Gamma rays B) X-rays
C) Beta rays D) None of these

19.The energy required to move an electron from ground state to higher energy state is called:
A) Excitation potential B) Ionization energy
C) Electron affinity D) Electro positivity

20. The energy in electron volt needed to remove the most loosely bounded electron from the natural atom is:
A) Excitation potential B) Ionization energy
C) Threshold energy D) Potential energy

21. Which of the following is not the spectral series of atom hydrogen:
A) Paschen series B) Lyman series
C) Balmer series D) None of these

22. The penetrating power of X-rays is increased by:
A) Decreasing their intensity B) Increasing their intensity
C) Increasing their velocity D) None of these.

23. X-rays are not affected by:
A) Electronic field B) Magnetic field
C) Both A & B D) None of these

24. X-rays travel with the speed of
A) beta rays B) alpha rays
C) cathode rays D) light

25. X-rays are:
A) Longitudinal waves B) Matter waves
C) Electromagnetic waves D) None of these

26. X-rays are:
A) high energy electrons B) high energy photons
C) high energy protons D) of unknown nature

27. X-rays are similar in nature to:
A) Gamma rays B) Alpha rays
C) Cathode rays D) Beta rays

28. X-rays exhibits the phenomenon of:
A) Diffraction B) Interference
C) Polarization D) All of the above

29. Meta stable states have life time of the order of:
A) 10^{-8} sec B) 10^{-6} sec
C) 10^{-3}sec D) 10^{-10} sec

30. A LASER provides:
A) An intense beam of photons B) A coherent beam of photons
C) A mono chromatic beam of photons D) All of the above

31. The value of Rydberg's constant is:

A) 1.0975×10^{5} / m
B) 1.0975×10^{7} /m
C) 1.0974×10^{-7} / m
D) 1.0974×10^{-17} /m

ANSWER KEY # 01

1→B	8→A	15→A	22→C	29→C
2→B	9→B	16→C	23→C	30→D
3→A	10→A	17→C	24→D	31→B
4→A	11→C	18→B	25→C	
5→B	12→D	19→A	26→B	
6→B	13→B	20→B	27→A	
7→A	14→D	21→D	28→A	

PRACTICE SHEET # 02

1. **The relation between energy (E) and momentum (p) for a proton is:**
   a. $E^2 = p^2c^2$
   c. $E^2 = p^2/c^2$
   b. $E^2 = pc^2$
   d. $E^2 = p^2c$

2. **The value of Rydberg's constant 'R_H' is:**
   a. 1.0974×10^{-9} m^{-1}
   c. 1.0974×10^{9} m^{-1}
   b. 1.0974×10^{7} m^{-1}
   d. 1.0974×10^{-7} m^{-1}

3. **According to Bohr's atomic model, the energy is radiated in the form of a photon by an atom, whenever:**
   a. One of its electrons jumps from a higher energy orbit to lower energy orbit
   b. One of its electrons speed up in its orbit
   c. One of its electrons speed down in its orbit
   d. One of its electrons jumps from a lower energy to a higher energy orbit

4. **The total energy of the electron in an atom is the sum of:**
   a. rotational & translational kinetic energy
   b. potential and kinetic energy
   c. elastic and magnetic energy
   d. electric and solar energy

5. **The speed of the electron in the first Bohr orbit is:**
   a. 2.19×10^{6} m/s
   c. 1.29×10^{8} m/s
   b. 2.19×10^{8}m^{2}s^{-1}
   d. 0.19×10^{6} m/s

6. **X-rays are used to take x-rays picture of human body to locate fractures etc., because:**
   a. Their power of penetration is inversely proportional to the density of the target material
   b. They are highly penetrating
   c. They are not highly penetrating
   d. They are neutral

7. **The electron to be confined within a nucleus of radius 10^{-14} m, which is uncertainty in its position, the uncertainty in momentum is:**
   a. 6.63×10^{-20} kgm^{-1}s^{-1}
   b. 0.24×10^{-19} kgms^{-1}
   c. 6.63×10^{-20} kgms^{-1}
   d. 1.4×10^{-19} kgs^{-1}

8. **Generation laser is due to de-excitation of an atom by:**
   a. Incident electron with the emission of secondary electron
   b. Incident photon with the emission of secondary photon
   c. Incident proton with the emission of secondary proton
   d. Incident neutron with the emission of secondary neutron

9. **The incident photon absorbed by an atom in the ground state E_1, thereby leaving the atom in the excited state E_2 is called:**
   a. induced emission
   b. spontaneous emission
   c. induced absorption
   d. spontaneous absorption

10. **The light amplifying gas used in solid lasers is:**
    a. carbon dioxide gas
    b. Helium-Neon gas
    c. Argon ion gas
    d. All of these

11. An electron is moving round the nucleus of a hydrogen atom in a circular orbit of radius r. The coulomb force F between the two is:
    a. $\frac{-Ke^2\vec{r}}{r^3}$ b. $\frac{Ke^2\vec{r}}{r^2}$ c. $\frac{-Ke^2\vec{r}}{r^2}$ d. $\frac{Ke^2\vec{r}}{r^3}$

12. The ratio of speed of an electron in ground state in Bohr's orbit of hydrogen atom to velocity of light in air is:
    a. $\frac{e^2}{2\epsilon_o hc}$ b. $\frac{2e^2\epsilon_o}{hc}$ c. $\frac{e^2}{\epsilon_o hc}$ d. $\frac{2\epsilon_o hc}{e^2}$

13. The radius of first orbit of hydrogen is 0.53Å. The radius of fourth orbit is:
    a. 8.48Å b. 2.12Å c. 4.24Å d. 0.193Å

14. The amount of energy required to transfer electron from first orbit hydrogen to third orbit is:
    a. 13.6 eV b. 3.4 eV c. 12.09 eV d. 1.511 eV

15. The energy necessary to remove the electron from n = 10 the state in hydrogen atom will be:
    a. 0.136 eV b. 0.0136 eV c. 1.36 eV d. 13.6 eV

16. The value of Rydberg's constant is:
    a. 1.1×10^7 m^{-1} b. 11×10^7 per cm c. 9.1×10^7 per meter d. 1.1×10^8 m^{-1}

17. The energy of a hydrogen atom in its ground state is −13.6 eV. The energy of the level corresponding to n = 5 is:
    a. −0.85 eV c. −2.72 eV
    b. −5.40 eV d. −0.54 eV

18. When the hydrogen atom gets to its lowest excited level, its radius is ––– Bohr radius:
    a. four times b. half c. same d. twice

19. The ratio of the angular momentum of the orbital electron in the first orbit to that in the second orbit is:
    a. 0.5 b. 2 c. 1 d. none of them

20. The value of Rydberg constant is:
    a. 1.0974×10^{-7} m^{-1} c. 1.0974×10^7 m^{-1}
    b. 1.0974×10^7 m^{-1} d. 10.0974×10^7 m^{-1}

21. The velocity of moving electron in nth orbit is given by the relation:
    a. $v_n = nh/2\pi mr_n$ c. $v_n = nh/\pi mr_n$
    b. $v_n = nh/\pi mr_n$ d. $v_n = n\,2\pi mr_n/h$

22. The radius of the first Bohr orbit in hydrogen atom is:
    a. 8.85×10^{-12} cm b. 0.53×10^{-19} cm c. 9.11×10^{-33} cm d. 1.6×10^{-13} cm

23. The energy of the 4th orbit in hydrogen atom be:
    a. −2.51 eV b. – 3.50eV c. – 1360eV d. – 0.85eV

24. In hydrogen spectrum, which one of the following series lies in the ultraviolet region:
    a. Balmer series b. Pfund series

c. Bracket series
d. Lymann series

25. Energy required by an atom to move from ground state to highest energy state is called:
a. Ionization energy
b. Excitation energy
c. Excitation potential
d. Ionization potential

26. The reverse process of photo-electric effect is called:
a. Pair production
b. Compton effect
c. Annihilation of matter
d. Production of X-rays

27. Operation of a laser depends upon:
a. the existence of atoms in excited state
b. the existence of atoms in meta stable state
c. the existence of atoms in ground state
d. spontaneous emission of radiation

28. X-rays photons cannot produce pair production because:
a. Their rest mass is zero
b. They are electromagnetic waves
c. Their energy is less than the rest mass energy of the pair, $2m_oc^2 = 1.02$ MeV
d. They are chargeless

29. Lyman series in mathematical form can be written as:
a. $\frac{1}{\lambda} = \frac{1}{R_H}\left[\frac{1}{1^2} - \frac{1}{n^2}\right]$
c. $\frac{1}{\lambda} = R_H\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$
b. $\frac{1}{\lambda} = R_H\left[\frac{1}{1^2} - \frac{1}{n^2}\right]$
d. $\frac{1}{\lambda} = R_H\left[\frac{1}{3^2} - \frac{1}{n^2}\right]$

30. Second postulate of Bohr's atomic model is given by:
a. $2\pi r = \frac{nh}{m}$
b. $mvr = \frac{nh}{2\pi}$
c. $\frac{mvr}{r} = \frac{2\pi}{nh}$
d. $mvr = \frac{h}{2\pi}$

31. The potential required to remove an electron from the atom is called:
a. Excitation potential
b. Ionization potential
c. Critical potential
d. Absolute potential

32. SI unit of Rydberg constant is:
a. m^{-2}
b. m-s
c. m^{-1}
d. ms^{-1}

33. One widely used system is computerized axil topography is called:
a. Computer
b. X-ray source
c. Bremsstrahlung
d. CAT- scanner

34. The radius of hydrogen atom is about:
a. 5×10^{-11} m
b. 1×10^{-11} m
c. 5×10^{11} m
d. 5×10^{-11} cm

35. LASER means:
a. Light amplification by simple energy radiation
b. Light amplification by stimulated emission of radiation
c. Light amplification by slow energy radiation
d. Light amplification by special energy radiation

36. Helium-Neon Laser discharge tube contains neon:

a. 25% b. 40% c. 15% d. 82%

37. If an electron in an atom jumps down from outer to inner orbit, it will:

a. Emit energy b. Absorb energy
c. neither emit nor absorb energy d. both emit and absorb energy

38. The numerical value of ground state energy is maximum for:

a. 1st orbit b. 3rd orbit c. 2nd orbit d. 4th orbit

39. The electrical P.E. of an electron in an orbit around the nucleus is:

a. $\frac{ke^2}{{r_n}^2}$ b. $-\frac{ke^2}{r_n}$ c. $\frac{ke}{{r_n}^2}$ d. $-\frac{ke^2}{{r_n}^2}$

40. The orbital speed of the electron in the nth orbit is:

a. $V_n = \frac{nh}{2\pi m r_n}$ b. $V_n = \frac{2\pi m r_n}{nh}$ c. $V_n = \frac{nh}{\pi m r_n}$ d. $V_n = 23 m/s$

41. Bohr's atomic model:

a. Assumes that electrons have wave properties
b. Assumes only certain values of angular momenta to be possible for orbital electrons
c. Has an origin from the theory of relativity
d. Assumes that an electron in an atom can never radiate.

42. If the electron in a hydrogen atom jumps from the third orbit to the second orbit, the emitted radiation has wavelength (R is the Rydberg's constant)

a. $\frac{36}{5R}$ b. $\frac{5R}{36}$ c. $\frac{6}{5R}$ d. $\frac{5R}{6}$

43. In which region of the electromagnetic spectrum does the Lyman series of hydrogen atom lie?

a. Infrared b. Visible c. Ultraviolet d. X-ray

44. According to Bohr's theory, a line in the Balmer series arises when the electron jumps from any of the higher orbits to the orbit with quantum number:

a. 1 b. 2 c. 3 d. 4

45. The ratio of the longer and shortest wavelength of the Lyman series is approximately:

a. 4/3 b. 9/4 c. 9/5 d. 16/7

46. With increasing quantum number, the energy difference between adjacent levels in atoms:

a. Decreases
b. Increases
c. Remains constant
d. Decrease for low Z and increases for high Z atoms

47. The Rydberg constant R = $1.09 \times 10^7 m^{-1}$. The wavelength of the first line of the Balmer series is:

a. 6563Å b. 6563 nm c. 6563 micro meter d. 6563 fermi

48. If the radius of the first orbit of hydrogen atom is 5.29×10^{-11} m, the radius of the second orbit will be:
a. 21.16×10^{-11}m b. 15.87×10^{-11} m c. 10.58×10^{-11} m d. 2.64×10^{-11}m

49. A Balmer line is emitted when the electron in a hydrogen atom jumps from:
a. a higher orbit of the first orbit
b. a higher orbit to the second orbit
c. the first orbit to the higher orbit
d. the second orbit to the higher orbit

50. For the hydrogen atom the transition n = 2 → n = 3 represents:
a. an emission line of the Paschen series
b. an absorption line of the Paschen series
c. an emission line of the Balmer series
d. an absorption line of the Balmer series

51. The wavelength of X-rays is of the order of:
a. centimeter b. micron c. angetron d. metre

52. The shortest wavelength of X-rays emitted from an X-ray tube depends on the:
a. current in the tube
b. voltage applied to the tube
c. nature of the gas in the tube
d. atomic number of the target material

53. The largest distance between the inter-atomic places of a crystal is 10Å. The upper limit for the wavelength of X-rays which can be studied with this crystal is:
a. 1Å b. 5Å c. 10Å d. 20Å

54. The size of an atom is of the order of:
a. 1Å b. 1 fm c. 1 nm d. 1 micron

55. An electron is moving with a velocity of 6.6×10^{5} m/s. Its de Broglie wavelength is:
a. 1.1×10^{-9} m b. 1×10^{-5} m c. 1×10^{-7} m d. 1×10^{-10} m

56. The velocity of an electron in the ground state of a hydrogen atom in m/s is:
a. 2×10^{5} b. 2×10^{6} c. 2×10^{7} d. 2×10^{8}

57. Energy required to remove an electron from the n = 10 state of hydrogen atom is:
a. 13.6 eV b. 1.36 eV c. 0.136 eV d. 0.0136 eV

58. In the Bohr model of the hydrogen atom, the lowest orbit responds to:
a. infinite energy b. maximum energy c. minimum energy d. zero energy

59. When hydrogen atom goes from the ground to the first excited level, its radius:
a. remains same
b. becomes half
c. becomes double
d. becomes 4 times

60. Which of the following phenomenon confirms the waves nature of electrons in the Davisson Germer experiment?
a. Refraction of electrons
b. Transmission of electrons
c. Diffraction of electrons
d. Dispersion of electrons

61. **If the ionization energy of hydrogen atom is 13.6 eV, the ionization potential will be:**
a. 13.6 V b. 136.0 V c. 3.4 V d. none of them

62. **The SI unit of Rydberg's constant is:**
a. m/s b. m^{-1} c. m^{-2} d. m-sec

63. **The first excitation energy of H-atom will be:**
a. 10.2 eV b. 3.4 eV c. 137.0 eV d. 9.4 eV

64. **X-rays are similar in nature to:**
a. Cathode rays b. Positive rays c. Alpha rays d. γ - rays

65. **The duration of a laser pulse is 10^{-8} sec. The uncertainty in its energy will be:**
a. 6.625×10^{-26} J c. 61.050×10^{-26} J
b. 6.625×10^{-28} J d. 10.5000×10^{-26}J

66. **A laser produces:**
a. An incoherent beam of light
b. A coherent beam of light
c. An intense directional coherent beam of light
d. An intense uni-directional coherent monochromatic beam of light

67. **The energy of the 4th orbit in hydrogen atom is:**
a. – 2.51eV c. – 13.60eV
b. – 3.50eV d. – 0.85eV

68. **Balmer series lies in:**
a. Ultraviolet region b. Infrared region
c. Visible region d. Par ultraviolet region

69. **The value of first Bohr's orbit radius is:**
a. 0.053 nm b. 0.53Å c. 0.53 nm d. Both (a) & (b)

70. **The residing time of atoms in meta stable state in case of laser action is:**
a. 10^{-4} s b. 10^{-5} s c. 10^{-8} s d. 10^{-3} s

71. **SI unit of Rydberg constant is:**
a. m^{-2} b. m-s c. m^{-1} d. m/s

72. **A radio transistor operates at a frequency of 880 KHz and a power of 10KW. The number of photons emitted per second is:**
a. 0.075×10^{-34} b. 1.71×10^{31} c. 13.27×10^{34} d. 1327×10^{34}

73. **A stream of photons is impinging normally on a completely absorbing screen in vacuum. If irradiance (energy/area × time) is I, then pressure on the screen is:**
a. $\frac{I}{C}$ b. $\frac{C}{I}$ c. CI d. zero

74. An electron of mass m when accelerated through a potential difference V has de-Broglie wavelength λ, The de Broglie wavelength associated with a proton of mass M accelerated through the same potential difference will be:

a. $\lambda\frac{m}{M}$ b. $\lambda\sqrt{\frac{m}{M}}$ c. $\lambda\frac{M}{m}$ d. $\lambda\sqrt{\frac{M}{m}}$

75. An electron and a photon possess the same de-Broglie wavelength. If E_e and E_{ph} are respectively the energies of electron and photon v and c are their respectively velocities, then $\frac{E_e}{E_{ph}}$ =

a. $\frac{v}{c}$ b. $\frac{v}{2c}$ c. $\frac{v}{3c}$ d. $\frac{v}{4c}$

ANSWER KEY # 02

1.	A	31.	B	61.	A
2.	B	32.	C	62.	B
3.	A	33.	D	63.	A
4.	B	34.	A	64.	D
5.	A	35.	B	65.	A
6.	A	36.	C	66.	D
7.	C	37.	A	67.	D
8.	B	38.	A	68.	C
9.	C	39.	B	69.	D
10.	D	40	A	70	D
11.	A	41.	B	71.	C
12.	A	42.	A	72.	B
13.	A	43.	C	73.	A
14.	C	44.	B	74.	B
15.	A	45.	A	75.	B
16.	A	46.	A	76.	
17.	D	47.	A	77.	
18.	A	48.	A	78.	
19.	A	49.	B	79.	
20.	B	50.	D	80.	
21.	A	51.	C	81.	
22.	B	52.	B	82.	
23.	D	53.	D	83.	
24.	D	54.	A	84.	
25.	B	55.	A	85.	
26.	D	56.	B	86.	
27.	B	57.	C	87.	
28.	C	58.	C	88.	
29.	B	59.	D	89.	
30.	B	60.	C	90.	

CHAPTER 19: NUCLEAR PHYSICS

ATOMIC NUCLEUS:

- The central part of an atom is called Nucleus (having diameter of about 10^{-15} m). Its size is approximately $1/10^5$ times the size of an atom. It contains whole of positive charge of atom and about "99.9" percent of its mass is concentrated in the nucleus.
- A nucleus consists of two types of particles called proton and neutron. Being the constituents of a nucleus, they are commonly known as nucleons.
- A proton is a positively charged particle with a mass 1.67×10^{-27} Kg and a positive charge of 1.6×10^{-19} coulomb. The charge on a proton is equal in magnitude to that of the electron but opposite to it in sign. The existence of proton was experimentally verified in 1920 by Rutherford.
- The neutrons are neutral particles as they have no charge. The mass of a neutron is nearly equal to the mass of a proton. The existence of a neutron was predicted by Rutherford but it was discovered by Chadwick in 1932.

Mass Number (A):

"The mass number of an element is the sum of the number of protons and neutrons in the nucleus of an atom of that element."

The mass number is usually denoted by "A".

Charge Number or Atomic Number (Z):

"The atomic number of an element is equal to the number of protons (or electrons) in an atom of that element."

It is also called the charge number.

- The atomic number of an element determines the nature of that element and usually denoted by 'Z'.
- If an element has mass number 'A' and charge number 'Z', then the number of neutrons in the nuclei of that element is

$$N = A - Z$$

Unified Atomic Mass Unit (u):

- The unified atomic mass unit is one-twelfth of the mass of carbon atom.
- Formerly unified atomic mass unit was called atomic mass unit (amu). It is numerically equal to the mass of a proton i.e., 1u

Or $1\text{amu} = 1.66\times10^{-24}$ gm

Or $1\text{u} = 1.66\times10^{-27}$ gm

- The mass of a proton in terms of unified atomic mass is 1.007825u and that of neutron is 1.008665u, while that of an electron is 0.00055u.

Isotopes:

"Isotopes are the nuclei of an element which have the same atomic number (Z) but different numbers (A)."

They have the identical chemical properties.

Note:

(i) The chemical properties of all the isotopes of a given element are same, but the physical properties may be different. The chemical properties are independent of the different number of neutrons inside the nucleus of an atom, and depend only on the number of electrons revolving round the nucleus.

(ii) It is not possible to separate the isotopes of an element by chemical methods. Physical methods are found to be successful for this purpose.

(iii) The isotopes of some other elements are:

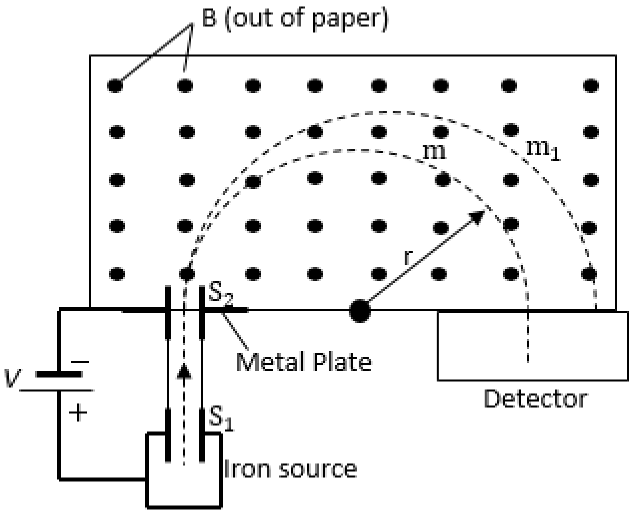
Carbon: ${}_6C^{12}$, ${}_6C^{13}$, ${}_6C^{14}$ having 6, 7 & 8 neutrons.

Uranium: ${}_{92}U^{234}$, ${}_{92}U^{235}$, ${}_{92}U^{238}$ having 142, 143 and 146 neutrons.

Mass Spectrograph:

It is the device, with the help of which the isotopes of any element can be separated from one another and their masses can also be determined quite accurately.

A simple mass spectrograph is shown in figure (a).



In the mass spectrograph, positive particles are passed through an electric field and a magnetic field, which sorts out the particles according to their masses, velocities and charges. Lighter particles are deflected more than heavy ones.

Mass Defect:

- The mass of a nucleus is always less than the total mass of its constituent nucleons.
- This difference of mass between the sum of the masses of the nucleons and the mass of the nucleus is called mass defects of that atom.

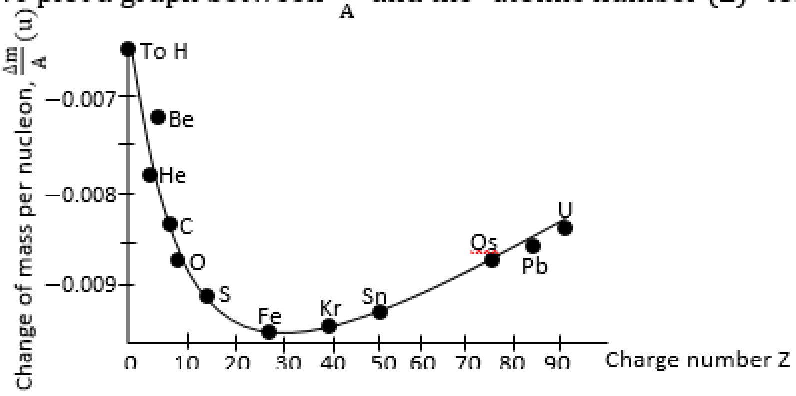
i.e., Mass defect = Mass of nucleons – Mass of nucleus

Or $\Delta m = [Zm_o + (A - Z)m_o] - M$

The mass defect per nucleon for nucleus (or atom) is known as packing fraction. It is given by the relation,

$$\boxed{\frac{\Delta m}{A} = \frac{M - (Zm_o + Nm_o)}{A}}$$

Equation(i) shows that $\left(\frac{\Delta m}{A}\right)$ is negative, because 'M' is always less than the combined mass of the nucleons. If we plot a graph between $\frac{\Delta m}{A}$ and the "atomic number (Z)" for different nuclei as shown in figure.



We can see that the packing fraction or mass defect per nucleon, is smaller for the nuclei in the middle of the periodic table (S, Fe, Kr etc.) as compared to that for the lighter nuclei of the atoms at the beginning (H, Be, He, etc.) and for the heavier nuclei of the atoms at the end (Os, Pb, U) of the periodic table.

Binding Energy:

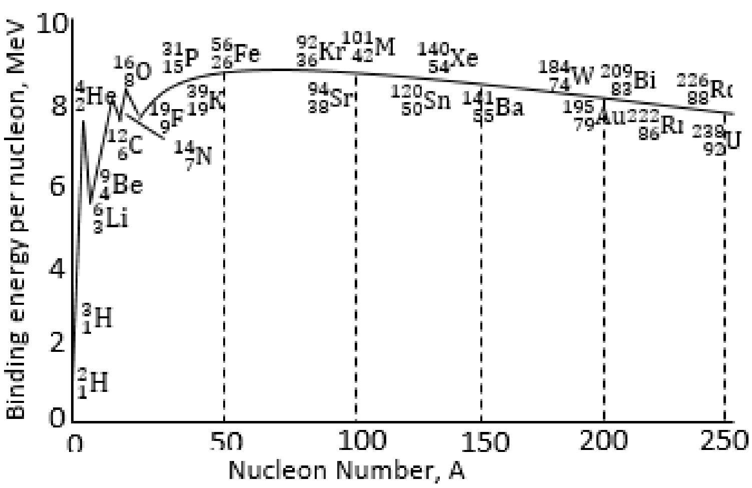
- The binding energy is the amount of energy required to break a nucleus apart into separated nucleons.
- Using Einstein's mass-energy relation, the binding energy of a nucleus is given by:

$$\text{B. E.} = (Zm_p + Nm_n - M)c^2$$

- And the binding energy per nucleon of a nucleus (Binding fraction) is given by:

$$\text{B. E. per nucleon} = \frac{(Zm_p + Nm_n - M)c^2}{A}$$

If we plot a graph between the "binding energy per nucleon" and the "atomic mass number (A)" as shown in figure.



We see that, the curve rises sharply at the beginning, reaches the maximum at around A = 50 (corresponding to the iron nuclei) and then decline gradually. It means that the binding energy per nucleon is smaller for lighter (H, He, Li, Be etc.) and heavier (Ra, U etc.) nuclei. While nuclei with intermediate mass number have the greatest binding energy per nucleon.

A useful measure of the stability of a nucleus is its binding energy per nucleon, since this represents the average energy which needs to be supplied to remove a nucleon. Thus, of all the elements "iron" is the most stable element, because its binding energy per nucleon is maximum. On the other hand, elements near the two extremes of the mass range are least stable.

This fact suggests that if heavy nuclei can somehow be split up into intermediate mass number nuclei or if lighter nuclei combine to produce comparatively heavier nuclei, energy will be released.

Note:

(i) If B.E. > 0, the nucleus is stable and energy must be supplied from outside to split it into its constituents. And if B.E. < 0, the nucleus is unstable and it will disintegrate by itself.

(ii) The mass defect per nucleon or packing fraction is '−ve' because mass is converting into energy, so that we have lesser mass and greater energy and therefore binding fraction is taken as positive.

Note:

Some atomic masses are given in the table as follows:

Particle	Mass (u)
e	0.00055
n	1.008665
^{1}H	1.007276
^{2}H	2.014102
^{3}He	3.01605
^{3}He	3.01603
^{4}He	4.002603
^{7}Li	7.016004
^{10}Be	10.013534
^{14}N	14.0031
^{17}O	16.9991

PACKING FRACTION:

The Binding Energy per nucleon is called PACKING FRACTION.

Radioactivity:

- In 1896, Henri Becquerel first observed the phenomena of radioactivity.
- J.J Thomson discovered electron.
- James Chadwick discovered neutron.
- The process of spontaneous self-disintegration of some of the heavy element is called radioactivity. And the elements exhibiting this activity are known as radioactive elements.
- It is a self-disrupting activity exhibited by some naturally occurring elements.
- All the elements having atomic number greater than 83 are radioactive (Strictly speaking this is not the condition of radioactivity).

The radiations emitted by radioactive substance are of three types:

(i) α-rays (ii) β-rays (iii) γ-rays

Units:

The unit of radioactivity is "curie", its symbol is "Ci".

One Curie = 3.7×10^{10} disintegrations per second

Nuclear Transmutation OR Radioactive Decay:

A radioactive element can decay by:

(i) Alpha decay
(ii) Beta decay
(iii) Gamma decay

α-Decay:

When a radioactive element emits α-particle, then its nature is changed a new element is formed whose atomic number (Z) is decreased by two than the atomic number of the nucleus decreased by 4. We can represent an alpha decay symbolically as follow:

$$^{A}_{Z}X \longrightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He$$

Example:

$$^{226}_{88}Ra \longrightarrow {}^{222}_{86}Rn + {}^{4}_{2}He$$

Note that the sum of the mass numbers and the charge numbers on both sides of the equation are equal.

β-Decay:

- **β -ve Decay (Electron):**

When a β- particle is emitted out of any nucleus, then its mass number (A) does not undergo any change but its charge number increases by one. The emission of a β- particle from any element 'X' is represented by the following equation

$$^{A}_{Z}X \longrightarrow {}_{Z+1}^{A}Y + {}^{0}_{-1}e$$

Here 'X' and 'Y' are parent and daughter elements respectively and "${}^{0}_{-1}e$" is β- particle.

Example:

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

With the emission of a β- particle, one of the neutrons in the nucleus is converted into a proton as given by the equation.

$$^{1}_{0}n \longrightarrow {}^{1}_{1}p + {}^{0}_{-1}e$$

Hence atomic number of daughter element is increased by one and a new element is formed.

- **β +ve Decay (Positron):**

When a β+ particle is emitted out of any nucleus, then its mass number (A) does not undergo any change but its charge number decreases by one. The emission of a β+ particle from any element 'X' is represented by the following equation

$$ {}^{A}_{Z}X \longrightarrow {}_{Z-1}^{\ \ A}Y + {}_{+1}^{\ \ 0}e $$

Here 'X' and 'Y' are parent and daughter elements respectively and "${}_{+1}^{\ \ 0}e$" is β+ particle.

With the emission of a β+ particle, one of the protons in the nucleus is converted into a neutron as given by the equation.

$$ {}^{1}_{1}p \longrightarrow {}^{1}_{0}n + {}_{+1}^{\ \ 0}e $$

Hence atomic number of daughter element is decreased by one and a new element is formed.

γ-Decay:

When γ-radiations are emitted out of nucleus then neither the charge number (Z) nor the mass number (A) of the nucleus under goes any change. It is due to the fact that a γ-radiation is simply a photon that has neither any charge nor any mass. Therefore, the nature of element remains unchanged. This nuclear reaction is written as:

$$ {}^{A}_{Z}X^{*} \longrightarrow {}^{A}_{Z}X + \gamma\text{-radiation} $$

Here ${}^{A}_{Z}X^{*}$ represents an excited nucleus, while ${}^{A}_{Z}X$ shows ground state of the nucleus.

<u>Note:</u>

The γ-radiations are emitted when an excited nucleus comes back to its normal state. These radiations are electrically neutral and consist of electromagnetic photons.

<u>Properties of α, β and γ Rays:</u>

α-Rays:

(i) These rays are made of positively charged particles.
(ii) Each α-particle has a charge +2e.
(iii) By measuring e/m, it is found that the α-rays consist of helium nuclei, ${}^{4}_{2}He$.
(iv) Their power of penetration through layers of matter is small.
(v) They can ionize the gases, when they pass through them.
(vi) When an α-particle is emitted from a radioactive substance, the charge number (Z) and mass number (A) both changes. Since α-particle has a charge '+2e' and a mass number '4'. This can be represented by the following equation:

$$ {}^{A}_{Z}X \longrightarrow {}^{A-4}_{Z-2}Y + \alpha\text{-particle} $$

Or
$$ {}^{A}_{Z}X \longrightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He $$

In other words, with the emission of α-particle, the element moves back two places in the periodic table.

(vii) The alpha rays are ejected with a speed of one tenth to one hundredth of the velocity of light c.

β-Rays:

(i) These rays are made of negatively charged particles.
(ii) Each β-particle has a charge '−1e'.

(iii) These are simply electrons in nature emitted by the nuclei.

(iv) They have medium power of penetration through material layer.

(v) They can ionize the gases, but their ionizing power is less than that of α-rays.

(vi) When a β-particle is emitted from a radioactive substance, the charge number (Z) changes but there is no change in the mass number (A). With the emission of β-particle, one of the neutrons in the nucleus is converted into proton as given by the equation:

$$^{1}_{0}N \longrightarrow {}^{1}_{1}p + {}^{0}_{-1}e$$

Or

$$^{1}_{0}N \longrightarrow {}^{1}_{1}p + {}^{0}_{-1}\beta$$

Thus, emission of β-particle can be represented by the following equation:

$$^{A}_{Z}X \longrightarrow {}_{Z+1}{}^{A}Y + \beta\text{-particle}$$

In other words, with the emission of β-particle, the daughter element (Y) is ahead of parent element (X) by one place in the periodic table.

(vii) The beta particles travel often with as higher velocity as about one fifth of the velocity of light.

γ-Decay:

(i) These rays are not deflected by electric or magnetic fields, so they consist of chargeless particles.

(ii) These are electromagnetic radiation in nature as the X-rays (photons) and have very small wavelength.

(iii) They have high penetration power.

(iv) Their ionizing power is very small.

(v) When a nucleus emits a γ-rays, neither it's charge number 'Z' nor its mass number 'A' changes.

The emission of γ-rays, from a nucleus can be represented by the equation.

$$^{A}_{Z}X^{*} \longrightarrow {}^{A}_{Z}X + \gamma\text{-rays}$$

Where $^{A}_{Z}X^{*}$, represents an excited nucleus, and $^{A}_{Z}X$ the nucleus in the ground state.

NUCLEAR CHANGES AND THE CONSERVATION LAWS

All types of radioactive decays obey some simple and basic rules which are based on conservation laws are as follows:

1. Conservation of Nucleon Number A.
2. Conservation of Charge Number Z.
3. Conservation of Energy.
4. Conservation of Linear Momentum.
5. Conservation of Angular momentum (including spin)

THE LAW OF RADIOACTIVE DECAY

The rate of decay in a radioactive process is experimentally found to be directly proportional to the number of parent nuclides present in the unstable nuclides of a given species.

$$\Delta N = -\lambda N \Delta t$$

Where, λ is the constant called the disintegration or the decay constant.

The negative sign indicates the decrease in the number of nuclides N with time.

ΔN is the number of disintegrations in time interval Δt.

The decay constant is a characteristic of the substance that decays and is absolutely independent of all external conditions such as temperature, pressure.

- If λ is large, more nuclei will be decaying in the same time interval i.e. the element decays rapidly.
- If λ is small, the element will decay slowly.

ACTIVITY:

The number of disintegrations per second is called Activity. Activity is denoted by A.

It is always taken as a positive number.

$$A = \lambda N$$

The unit of λ is **CURIE (Ci).**

Ci = 3.70×10^{10} disintegration /sec.

Its S.I unit is **BECQUREL.**

1 Bq= 1 disintegration /sec.

On solving the above equation is by integrating it and after applying boundary conditions, we get

$$N = N_o e^{-\lambda t}$$

This equation gives a mathematical form of law of Radioactive Decay, where

N_o = Initial number of nuclei.

N = Number of nuclei present at time 't'.

<u>Half Life:</u>

The time required to decay half of the atoms of radioactive element is called its Half Life.

Example:

Let we take 100,000 atoms of a radioactive element. After one half-life period, 50,000 atoms will decay into daughter element. If the half-life of the element is 1 week, then at the end of two weeks only 25,000 atoms will be left and the end of three weeks only 12,500 atoms will be left and so on. Hence this decay process continues, until the last atom to decay process continues, until the last atom to decay which required infinite time which is not possible.

Hence "total life" cannot be used to distinguished the various radioactive elements therefore we use "half-life".

<u>Measurement of Half-Life:</u>

Method I:

We can conclude from this example that if we have N_o number of any radioactive element then after a period of n half-lives the number of atoms left behind is $\left(\frac{1}{2}\right)^n N_o$.

Method II:

The half-life of a radioactive element can also be determined by using the relation

$$\lambda T_{1/2} = 0.693$$

Where 'λ' is the decay constant of the given element. The decay constant 'λ' can be determined experimentally and by substituting its value in above equation the half-life of the substance can be calculated.

Note:

Different radioactive materials have different half-lives. For example the half-life of uranium -238 is 4.5×10^9 years, while the half-life of radium -226 is 1620 years. The half-life of some radioactive elements is very small, for example the half-life of radon gas is 3.8 days and that of uranium -239 is 23.5 minutes.

Q-VALUE OF REACTION

All the radioactive decays or nuclear reactions involves the release of some energy which is commonly denoted by the symbol Q, and in the general terminology of Nuclear physics it is referred to as the Q-value of the reaction.

- If Q is positive, energy is released and the reaction is exothermic.
- if Q is negative, energy is absorbed and the reaction is endothermic.

Rutherford Nuclear Reactions:

In 1918, Rutherford performed an experiment on the nuclear reaction. He bombarded α-particles on nitrogen. He observed that as a result of this reaction, oxygen is obtained and a proton is emitted.

i.e., $^{14}_{7}N + ^{4}_{2}He \longrightarrow ^{17}_{8}O + ^{1}_{1}H$

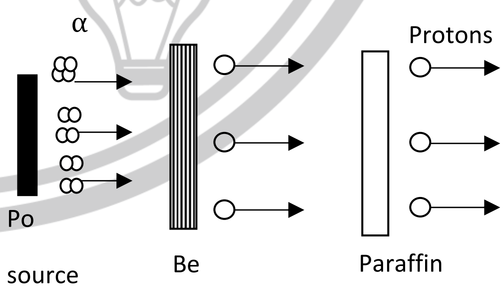
This reaction indicates that when α-particle enters the nucleus of nitrogen then an excitation is produced in it. And as a result of it $^{17}_{8}O$ and a proton are produced.

Conditions for Nuclear Reactions:

(i) Conservation of Mass
(ii) Conservation of Energy

Discovery of Neutron:

In 1932, James Chadwick discovered neutron. The arrangement of Chadwick's experiment for the discovery of neutron is shown in figure.



When $^{9}_{4}Be$ was bombarded with α-particles emitting out of $^{210}_{84}Po$, then as a result of a nuclear reaction $^{12}_{6}C$ and a neutron were obtained. This reaction is shown below with an equation.

$$^{9}_{4}Be + ^{4}_{2}He \longrightarrow ^{12}_{6}C + ^{1}_{0}n$$

As neutron carries no charge, therefore it presented a great amount of difficulty for its identification. Anyhow when neutron was passed through a block of paraffin, fast moving protons were ejected out and these were easily identified.

1. Protons-Induced Reactions

When proton is absorbed in the target material, the reaction is said to be Proton Induced Reaction.

Example: If lithium absorbs a proton, two alpha particles are found to be produced in the reaction

$$_{3}Li^{7} + {}_{1}H^{1} \rightarrow {}_{2}He^{4} + {}_{2}He^{4}$$

2. Deuteron - Induced Reactions

When deuteron is absorbed in the target material, the reaction is said to be Deuteron Induced Reaction.

Example: High energy deuterons may be absorbed by $_{3}Li^{6}$ to produce two alpha particles i.e.

$$_{3}Li^{6} + {}_{1}H^{2} \rightarrow {}_{2}He^{4} + {}_{2}He^{4}$$

3. Gamma-Induced Reactions

High energy gamma rays also have been found to induce nuclear reactions by a process which is usually known as photo disintegration.

$$_{13}Al^{27} + {}_{1}H^{2} + \gamma(50MeV) \rightarrow {}_{11}Na^{25} + 2\ {}_{1}H^{1}$$

Nuclear Fission:

The process of breaking up of the nucleus of a heavy atom into two nuclei nearly of the same size with the emission of energy is known as nuclear fission.

Explanation:

Otto Hahn and Fritz Strassman of Germany observed that when slow moving neutrons are bombarded on $^{235}_{92}U$, then as a result of the nuclear reaction $^{141}_{56}Ba$, $^{92}_{36}Kr$ and an average of three neutrons are obtained. It may be remembered that the mass of both krypton and barium is less than that of the mass of uranium.

The nuclear fission differs from the other nuclear reactions in two respects.

(i) As a result of the breakage of the uranium nucleus two nuclei of equal size are obtained. The decreases in mass is appreciable, whereas in the other nuclear reactions the difference between the masses of the reactants and the products was not large.

(ii) A very large amount of energy is given out in this reaction.
Fission reaction of $^{235}_{92}U$ can be represented by the equation,

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n + Q$$

Here Q is the energy given out in this reaction. By comparing the total energy on the left side of the equation with total energy on the right side, we find that in the fission of one uranium nucleus about 200MeV energy is given out. It may be note that there is no difference between the sum of the mass and the charge numbers on both sides of the equation.

Note:

The fission process of uranium does not always produce the same fragments (Ba, Kr). Two possible fission reactions of uranium are given below as an example:

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{132}_{50}Sn + {}^{101}_{42}Mn + 3{}^{1}_{0}n + Q$$

$$^{235}_{32}U + {}^{1}_{0}n \longrightarrow {}^{140}_{54}Xe + {}^{94}_{38}Sr + 2{}^{1}_{0}n + Q$$

Hence in the uranium fission reaction several products may be produced. All of these products (fragments) are radioactive.

Note:

Fission reaction is not confined to uranium alone; it is possible in many other heavy elements. However, it has been observed that fission takes place very easily with the slow neutrons in uranium −235 and plutonium −239, and mostly these two are used for fission purposes.

Fission Chain Reaction:

When a ${}^{235}_{92}U$ nucleus splits up into two fragments in the process of nuclear fission, about three neutrons are released per fission. These neutrons are very fast but they are slowed down due to successive collisions. They can start nuclear fission in three more ${}^{235}_{32}U$ nuclei with the release of nine neutrons. These nine neutrons can be used to start fission in nine more ${}^{235}_{92}U$ nuclei with the production of twenty seven neutrons and so on. In this way, the fission reaction started with a single neutron in uranium can proceed further by under suitable conditions. Such a self-sustaining fission reaction is called fission chain reaction.

Note: (Critical Mass & Critical Volume)

Such a mass of uranium in which one neutron, out of all the neutrons produced in one fission reaction, produces further fission is called critical mass. The volume of this mass of uranium is called critical volume.

Note:

If the mass of uranium is much greater than the critical mass, then the chain reaction proceeds at a rapid speed and a huge explosion is produced. Atom bomb works on this principle.

If the mass or uranium is less than the critical mass, the chain reaction does not proceed. If the mass or uranium is equal to the critical mass, the chain reaction proceeds at its initial speed and in this way we get a source of energy. Energy in an atomic reactor, is obtained according to this principle.

NUCLEAR REACTOR

A system used to obtain a controlled amount of heat from nuclear fission reaction is called a Nuclear Reactor.

CONSTRUCTION:

1. Nuclear Fuel

A material consisting of the fissionable (or fissile) isotope is called the reactor fuel. The fuels that may be used in a reactor are **Uranium U^{235}.**

2. Moderators

In the nuclear fission process at least one or more energetic neutrons are produced per fission. To reduce the energy of neutrons some suitable materials are required which are known as Moderators.

The good moderating materials possess usually low mass number and large slowing down power.

Ordinary water (light water) is an attractive moderator material.

Some Good Moderators are:

- Graphite
- Liquid nitrogen
- Beryllium
- Heavy Water

The process of slowing down fast-moving neutrons is called **Moderation.**

3. Coolants

To remove the huge amount of heat energy in nuclear reactor, coolants are used. The materials commonly used as coolants are:

- Light water
- Heavy water

Liquid metals (such as Sodium OR Sodium-Potassium alloy OR Mercury)

4. Control Materials

In order to control the nuclear fission in a reactor suitable neutron absorbing materials are required to be placed in the core region.

CADMIUM or BORON rods are usually used to absorb neutrons and control the rate of reaction.

5. Shielding

Radiation from the reactor are shielded by thick concrete and steel walls, as to keep the workers and staff safe from them.

A shielding material used for such protection is called the biological shielding because its purpose is to protect health.

BREEDER REACTOR:

Breeder reactor is used to convert unusable most abundant isotope into fissionable isotope with a long half-life.

In fast breeder reactor more, fissionable material is produced than consumed, by the capture of fast neutrons from fertile material. Sodium in the form of solid at room temperature is widely used as coolant and reactors are called Liquid Metal Breeder Reactors.

There is no need of moderator.

Fusion Reaction:

A nuclear reaction in which two light nuclei merge to form a heavy nucleus with release of energy is called fusion reaction.

Explanation:

The process of "fusion" is the reverse of "fission". As the binding energy per nucleon of a heavy nucleus is much more than the binding energy per nucleon for the two combining light nuclei. Therefore, during a fusion reaction some mass is lost and its equivalent energy is given out. In a fusion reaction more energy per nucleon can be obtained as compared to the fission reaction. However, it is very difficult to produce fusion reaction because when two positively charged nuclei are brought nearer and nearer to fuse, the electrostatic force of repulsion $\left(F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}\right)$ between them increases with decrease in distance r. This repulsive force becomes infinitely large, when the nuclei are near to fuse. Hence the nuclei must have very large kinetic energies to collide against such a high repulsive force.

Thus a very large amount of energy is required to produce fusion reaction. On the contrary no difficulty is faced to start the fission reaction because neutron has no charge on it and it has to face no repulsive force while reaching the nucleus.

Example:

Let me now take the example of a fusion reaction when two deuterons are merged to form a helium nucleus, 24 MeV energy is released during this process i.e.,

$$^{2}_{1}\text{H} + ^{2}_{1}\text{H} \longrightarrow ^{4}_{2}\text{He} + 24\text{MeV}$$

But there is a very little chance of the formation of $^{4}_{2}$He nucleus by the merger of two deuterons. The probability of occurring such a reaction is great where one proton or one neutron is produced as given below:

$$^{2}_{1}\text{H} + ^{2}_{1}\text{H} \longrightarrow ^{3}_{2}\text{He} + ^{1}_{1}\text{H} + 4.0\text{MeV}$$

$$^{2}_{1}\text{H} + ^{2}_{1}\text{H} \longrightarrow ^{3}_{2}\text{He} + ^{1}_{0}\text{n} + 3.3\text{MeV}$$

In both of these fusion reactions about 1.0MeV energy per nucleon is produced which is equal to the energy produced during fission.

Another fusion reaction of $^{2}_{1}$H and $^{3}_{1}$H is written as:

$$^{2}_{1}\text{H} + ^{3}_{1}\text{H} \longrightarrow ^{3}_{2}\text{He} + ^{1}_{0}\text{n} + 17.6\text{ MeV}$$

CARBON CYCLE AND SOLAR ENERGY

In 1938 it was suggested that the energy obtained from the SUN and STARS is due to the fusion process, called thermonuclear reaction, in which hydrogen nuclei fuse to form Helium Nuclei. This process goes through $_6C^{12}$, hence is Called CARBON CYCLE.

1. $^{12}_{6}C + ^{1}_{1}H \longrightarrow ^{13}_{7}N + \gamma \longrightarrow ^{13}_{6}C + ^{0}_{+1}e(positron) + \upsilon$
2. $^{13}_{6}C + ^{1}_{1}H \longrightarrow ^{14}_{7}N + \gamma$
3. $^{14}_{7}N + ^{1}_{1}H \longrightarrow ^{15}_{8}O \longrightarrow ^{15}_{7}N + ^{0}_{+1}e + \upsilon$
4. $^{15}_{7}N + ^{1}_{1}H \longrightarrow ^{12}_{6}C + ^{4}_{2}He$

On adding the above equations, we get

$$4(^{1}_{1}H) \longrightarrow ^{4}_{2}He + 2(^{0}_{+1}e) + 2\upsilon$$

$_6C^{12}$ acts as a nuclear catalyst.

In the above reactions, the total energy in one fusion process is 28Mev, and there in the sun are taking place such an infinite fusion reaction. So, enormous energy is released.

PROTON- PROTON CYCLE

Recently the following proton-proton cycle has been suggested as source of sun's and stars energy in which 4 proton ($_1H^1$) fuse to form one Helium nucleus.

i. $^1_1H + ^1_1H \longrightarrow ^2_1H + ^0_{+1}e + \upsilon$ Neutrino (Twice) 0.42Mev

ii. $^1_1H + ^2_1H \longrightarrow ^3_2He + \gamma - rays$ (Twice) 5.49Mev

iii. $^1_1H + ^3_2He \longrightarrow ^4_2He + \beta^+ + \upsilon$ (Twice) 20.47Mev

In this cycle two protons ($_1H^1$) at as nuclear catalyst.

In the fusion of four protons in the above cycle about 25MeV of energy is released

Methods for Producing Fusion Reaction:

(i) One method to produce fusion reaction is that the two nuclei must be given so much K.E. that they could merge together after overcoming the electrostatic force of repulsion between them. For thus we have to give these nuclei a very large velocity with the help of an accelerator. This method is used in the research study of nuclear. This method is used in the research study of nuclear fusion of $^2_1$H and $^3_1$H. But this method of nuclear fusion for getting energy cannot be used on a large scale.

(ii) There is another method to produce fusion reaction. In this method speed f nucleus is increased by increasing temperature. The temperature required for this purpose is about "10 million degrees Celsius". At such extraordinary temperature, the nuclear reaction is called "thermo nuclear reaction".
Ordinarily such a high temperature cannot be achieved. However, during the explosion of atom bomb this temperature can be had for very short time. At this temperature fusion of $^2_1$H and $^3_1$H becomes possible. It is does not hydrogen bomb.

<u>Nuclear Reaction in the Sun:</u>

The sun is composed primarily of hydrogen, a little amount of helium and a slight amount of other heavy elements. A large amount of energy keeps issuing out of it continuously at all times. The temperature of its core is about 20 million degrees Celsius and its surface temperature is about 5 million degrees Celsius. Its energy is due to fusion reaction called p-p reaction.

During this process two hydrogen nuclei or two protons fuse to form deuteron. This reaction is written as:

$$^1_1\text{H} + ^1_1\text{H} \longrightarrow ^2_1\text{H} + ^0_+\text{e} + \text{Energy}$$

With the fusion reaction of deuteron with proton, $^3_2$He and isotopes of helium is formed i.e.,

$$^2_1\text{H} + ^1_1\text{H} \longrightarrow ^3_2\text{He} + \gamma\text{-radiation} + \text{Energy}$$

In the last stage the two nuclei of $^3_2$He react in the following manner.

$$^3_2\text{He} + ^3_2\text{He} \longrightarrow ^4_2\text{He} + ^1_1\text{H} + ^1_1\text{H} + \text{Energy}$$

In this reaction six protons take part to give one helium nucleus and two protons. The result of different stages of this reaction is that, four protons have formed one helium nucleus.

It has been estimated that in this fusion reaction (p-p chain reaction) about 25.7MeV energy is given out i.e., 6.4MeV per nucleon energy is obtained which is much greater than the energy given out per nucleon (1MeV) during a fission reaction.

Units of Radioactivity:

The SI unit of radioactivity is Becquerel (Bq)

- 1 Bq. = One disintegration per second

A large unit of radioactivity is curie (Ci)

- 1 Ci = 3.7×10^{10} atoms decaying per second.

Basic Forces of Nature:

There are four forces of nature that act on the particles of matter:

(i) Gravitational force
(ii) Electromagnetic force
(iii) Weak nuclear force
(iv) Strong nuclear force

(i) Gravitational Force:

The gravitational force is the oldest known force. The region around the earth in which its attraction is experienced is called gravitational field. The force of attraction is called gravitational force. It always acts vertically downward towards center of earth. Compared to the other forces of nature it is the weakest force of all. Gravitational force is a long range force. It gives rise to the ocean tides and keeps the planets moving in their orbits around the sun.

(ii) Electromagnetic Force:

The electric and magnetic forces are unified to get an electromagnetic force by Faraday and Maxwell. They prove that a current is induced in a coil whenever a magnetic flux passing through the coil is changed. The electromagnetic force was the second force known. It is long-range force and causes all chemical reactions. The electromagnetic force holds atoms, molecule, solids, and liquids together. This force acting on a microscopic level is responsible for a variety of apparently different macroscopic forces such as friction, cohesion and adhesion. Like gravitational force it is also a long-range force.

(iii) Weak Number Force:

The weak nuclear force is short range force. It is responsible for spontaneous breakdown of nucleus due to radioactive process. It is kind of repulsive force of very short range (10^{-17}m).

(iv) Strong Nuclear Force:

The strong nuclear force is short range, like the weak nuclear force. It is responsible for holding the nucleus together. It is the strongest of all the forces. The strong nuclear force is effective only within sub-nuclear distances and therefore confines the neutrons and protons within the nucleus.

Note:

(i) In 1979, the physics Nobel prize was awarded to Glashow, Weinberg and a Pakistani scientist for the unification of electromagnetic and weak forces.
(ii) It is further expected that a strong nuclear force will eventually untie with electroweak force to make up a single entity resulting in the grand unified electr0nuclear force.

Building Blocks of Matter:

The elementary particles are the basic building blocks of matter. The subatomic particles are divided into three groups.

(1) Photons (2) Leptons (3) Hadrons

All photons and leptons are elementary particles. Hadrons are not elementary particles but as composed of elementary called quarks.

Scientists now believe that all matter belongs to either the quark group of the lepton group.

Hadrons:

Hadrons are particles that experience the strong nuclear force. Protons, neutrons and mesons are hadrons. The particles equal in mass or greater than protons are called baryons and those lighter than protons are called mesons.

Leptons:

Leptons are particles that do not experience strong nuclear force. Electron, muons and neutrinos are leptons.

Quarks:

According the quark theory initiated by M.Gell-Mann and G.Zweig, the quarks are proposed as the basic building blocks of the mesons and baryons.

A pair of quark and antiquark makes a meson and 3 quarks make a baryon. It is proposed that there are six quarks.

(i) up (ii) down (iii) straight

(iv) charm (v) bottom (vi) top

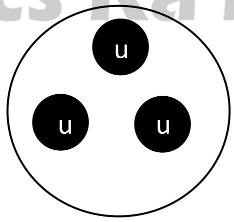
The charges on these quarks are fractional as shown in table.

Quarks and Antiquarks

Name	Symbol	Charge
Up	u	$+\frac{2}{3}e$
Down	d	$-\frac{1}{3}e$
Strange	s	$-\frac{1}{3}e$
Charm	c	$+\frac{2}{3}e$
Top	t	$+\frac{1}{3}e$
Bottom	b	$-\frac{2}{3}e$

A proton is assumed to be made up of two "up" quarks and one "down" quark as shown in figure (a).

Proton:

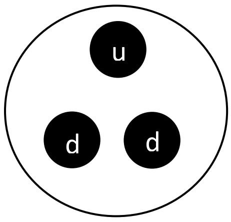


Charge

2/3 + 2/3 – 1/3 =1

The neutron is assumed to be made of one “up quark and two “down” quark as shown in figure.

Neutron:



Charge

2/3 – 1/3 – 1/3 = 0

PRACTICE SHEET # 01

1. Compared to the parent nucleus, the daughter of a β^- decay has
A. the same mass number but a greater atomic number
B. the same mass number but a smaller atomic number
C. a smaller mass number but the same atomic number
D. a greater mass number but the same atomic number
E. None of the above

2. The reaction $_{85}At^{218} \rightarrow {}_{83}Bi^{214}$ is an example of what type of radioactive decay?
A. alpha
B. β^-
C. β^+
D. electron capture
E. gamma

3. Tungsten-176 has a half-life of 2.5 hours. After how many hours will the disintegration rate of a tungsten-176 sample drop to $\frac{1}{10}$ its initial value?
A. 5
B. 8.3
C. 10
D. 12.5
E. 25

4. What's the missing particle in the following nuclear reaction?
$_{29}Cu^{63} + {}_{1}H^{2} \rightarrow {}_{30}Zn^{64}$ + (?)
A. Proton
B. Neutron
C. Electron
D. Positron
E. Deuteron

5. What's the missing particle in the following nuclear reaction?
$_{78}Pt^{197} + {}_{0}n^{1} \rightarrow {}_{78}Pt^{198}$ + (?)
A. Proton
B. Neutron
C. Electron
D. Positron
E. Gamma

6. **$_{1}H^{2} + {}_{1}H^{2} \rightarrow {}_{2}He^{3} + X$**
Identify the particle X resulting from the nuclear reaction shown above.
A. Positron
B. Electron
C. Proton
D. Neutron
E. Alpha particle

7. Lead-199 has a half-life of 1.5 hours. If a researcher begins with 2 grams of lead-199, how much will remain after 6 hours?
A. 0.125 grams
B. 0.25 grams
C. 0.375 grams
D. 0.5 grams
E. 0.625 grams

8. Which type of decay would cause the number of neutrons in the nucleus to decrease by 1?
A. Alpha decay
B. β^- decay
C. β^+ decay
D. Electron capture
E. Gamma decay

9. In which type of decay is the identity of the nucleus unchanged?
A. Alpha decay
B. β^- decay
C. β^+ decay
D. Electron capture
E. Gamma decay

10. Which type of decay ejects the heaviest particle?
A. Alpha decay
B. β^- decay
C. β^+ decay
D. Electron capture
E. Gamma decay

11. Which type of decay would cause the atomic number of the nucleus to increase?
A. Alpha decay
B. β^- decay

C. β^+ decay
D. Electron capture
E. Gamma decay

12. Positrons are created in a process known as
A. Pair production
B. Nuclear fission
C. Nuclear fusion
D. Annihilation of matter

13. Isobars have
A. Same atomic number but different mass number
B. Same mass number but different atomic number
C. Both mass number and atomic number different
D. None of these

14. Nuclei which have same number of protons but different number of neutrons are known as
A. Isotopes
B. Isomers
C. Isobars
D. None of these

15. Atoms of an element having the same atomic number but different mass called
A. Isobars
B. Isotopes
C. Isomers
D. Isotones

16. Radioactivity was discovered by
A. Rutherford
B.-Madam curie
C. Einstein
D. H. Bacquerel

17. Alpha particle is similar to
A. Helium atom
B. Helium neutron
C. Helium nucleus
D. None of these

18. ß-particle is similar to
A. Proton
B. Electron
C. Neutron
D. α-particle

19. The unit of radioactivity is
A. Joule
B. Kilogram
C. Curie
D. Newton

20. The rate of decay (disintegration per unit time) of a radioactive element
A. is constant
B. Decreases exponentially with time
C. Decreases linearly with time
D. Varies 'inversely as time

21. The half-life of a radioactive material depends upon
A. Temperature
B. Magnetic force
C. nature of material
D. Pressure

22. The sum of masses of constituent protons and neutrons is:
A. Less than the mass of nucleus
B. Greater than the mass of nucleus
C. Equal to the mass of nucleus
D. None of these

23. Gamma rays are
A. Helium nuclei
B. Electrons
C. Photons
D. Protons

24. Radioactive elements emit α, β and γ rays

A. When the elements are heated
B. When they interact with the other particles
C. Spontaneously
D. when they are exposed to

25. Fission chain reaction is controlled by introducing

A. Cadmium rods
B. Iron rods
C. Graphite rods
D. Copper rods

26. The process in which a heavy nucleus is broken into two Intermediate nuclei with the release of energy is called

A. Chemical reaction
B. Fusion reaction
C. Fission
D. None of these

27. This one is used as a fuel for conventional nuclear reactor

A. ${}_{92}U^{235}$
B. ${}_{94}Pu^{239}$
C. ${}_{90}Th^{227}$
D. None of these

28. One atomic mass unit (amu) is equal to

A. 931MeV
B. 120 MeV
C. 746 MeV
D. None of these

29. The radioactive decay law is:

A. $N_0/N\ e^{\lambda * t}$
B. $N=N_0\ e^{-\lambda * t}$
C. $N/N_0\ e^{\lambda * t}$
D. $N_0=\Delta N\ e^{\lambda * t}$

30. The atomic bomb is an example

A. Controlled nuclear fusion
B. Controlled nuclear fission
C. Uncontrolled nuclear fission
D. Uncontrolled nuclear fusion

31. Moderators are used in nuclear reactors to

A. Accelerate the neutrons
B. Slow down the neutrons
C. Absorb the fast neutrons
D. Bring the neutrons to stop

32. Which of the following is used as a moderator in a nuclear reactor

A. Uranium
B. Graphite
C. Aluminum
D. Calcium

33. When two or more nuclei combine together to form heavier nuclei with release of energy, the process is called

A. Nuclear fusion
B. Nuclear fission
C. Nuclear disintegration
D. Chemical reaction

34. Controlled fission chain reaction is maintained in

A. Galaxies
B. The sun
C. Cyclotron
D. Nuclear reactors

35. The source of energy in the sun and stars is mainly due to

A. Chemical reaction
B. Nuclear fusion
C. Nuclear fission
D. None of these

36. The deviation of alpha particles by thin metal foils through angles that range from 100 to 180° can be explained by

A. Scattering from Free electrons.
B. Scattering from bound electrons

C. Diffuse reflections from the metals surface.
D. Scattering from small but heavy regions of positive charge

37. Which one of the following statements is true of α particle?
A. They cause ionization of air
B. They are used to detect flaws in metal castings
C. They cannot be deflected by electric fields
D. They cannot be deflected by magnetic fields

38. Which one of the following statements is true for X-rays?
A. They cannot cause ionization of air
B. They are deflected by magnetic field
C. They are deflected by electric field
D. They are used to detect flaws in metal castings

39. The ratio N/No is defined as the:
A. Activity constant
B. Relative activity
C. Ratio of production
D. Disintegration constant

40. The half-life of radium is 1600 yrs. After 6400 yrs. the sample of the remaining radium would be its:
A. 1/8
B. 1/4
C. 1/16
D. 1/18

41. Fission of nuclei is possible because the binding energy per nucleon in them
A. Decreases with mass number at high mass numbers
B. Increases with mass number at high mass numbers
C. Decrease with mass number at low mass numbers
D. Increases with mass number at low mass numbers

42. The nuclear forces are:
A. Long range forces
B. Short range forces
C. Both long and short-range forces
D. None of these

43. For an exothermic reaction the Q value is:
A. Positive
B. Negative
C. Infinite
D. Zero

44. Binding energy of a nucleus is:
A. The amount of energy required to split a nucleus into its constituent nucleons:
B. The energy released when nucleons of a given nucleus are fused together
C. According to Einstein's special theory of relativity it is the energy which corresponding to mass defect of the nucleus
D. All of these

45. The spontaneous disintegration of the nucleus of atom is called as:
A. Pair production
B. Ionization
C. Excitation
D. Radioactivity

46. In a nuclear reactor, cadmium rods are used to:
A. Produce neutrons
B. Absorb neutrons
C. Slow down neutrons
D. Speed up neutrons

47. α-particles come out with an energy of:
A. 6.04×10^{14} MeV
B. 7.7 MeV
C. 2.04 MeV
D. 2.42×10^{-6} MeV

48. The ratio of mass of electron to proton is:
A. 1800
B. 1836
C. 1834
D. 444

49. ß particle have been identified as electron, their energy:
A. Is less as compared to the ordinary electrons
B. is greater as compared to the ordinary electrons
C. is same as compared to the ordinary electrons
D. Is zero

50. The energy equivalent to the mass reduced in the formation of a nucleus is called:
A. Nuclear energy
B. Potential energy
C. Fusion energy
D. Binding energy

51. The decay constant is absolutely independent of:
A. Mass number, charge number of radioactive substances
B. Density of nucleons in parent of radioactive substance
C. Temperature and pressure
D. Volume and charge of radioactive element

52. A naturally occurring disintegration involving the emission of high energy electrons is called
A. alpha decay
B. Beta decay
C. gamma decay
D. sigma decay

53. An alpha particle is emitted from $_{88}Ra^{226}$. What is the mass and atomic number of the daughter nucleus?

	Mass number	Atomic number
A.	224	84
B.	220	80
C.	222	86
D.	226	87

ANSWER KEY # 01

1.	A	11.	B	21.	C	31.	B	41.	A	51.	C
2.	A	12.	A	22.	B	32.	B	42.	B	52.	C
3.	B	13.	B	23.	C	33.	A	43.	B	53.	C
4.	B	14.	A	24.	C	34.	D	44.	D		
5.	E	15.	B	25.	A	35.	B	45.	D		
6.	D	16.	D	26.	C	36.	D	46.	B		
7.	A	17.	C	27.	C	37.	A	47.	C		
8.	C	18.	B	28.	A	38.	D	48.	B		
9.	E	19.	C	29.	B	39.	B	49.	B		
10.	A	20.	B	30.	C	40.		50.	D		

PRACTICE SHEET # 02

1. **Which of the following is a fusion reaction?**
   a. ${}^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{2}_{1}He$
   b. ${}^{1}_{0}n + {}^{14}_{7}N \rightarrow {}^{14}_{6}C + {}^{1}_{1}H$
   c. ${}^{1}_{0}n + {}^{238}_{92}U \rightarrow {}^{239}_{93}Np + \beta^{-} + \gamma$
   d. ${}^{3}_{1}H \rightarrow {}^{3}_{2}He + \beta^{-} + \gamma$

2. **If the total binding energies of ${}^{2}_{1}H$, ${}^{4}_{2}He$, ${}^{56}_{26}Fe$ and ${}^{235}_{92}U$ nuclei are 2.22, 28.3, 492 and 1786 MeV respectively, identify the most stable nucleus out of the following:**
   a. ${}^{56}_{26}Fe$
   b. ${}^{2}_{1}H$
   c. ${}^{235}_{92}U$
   d. ${}^{4}_{2}He$

3. **Heavy water is used as a moderator in a nuclear reactor. The function of the moderator is:**
   a. To control the energy released in the reactor
   b. To absorb neutrons and stop the chain reaction
   c. To cool the reactor
   d. To slow down the neutron to thermal energies

4. **The mass of neutron is nearly same as that of:**
   a. a proton
   b. a meson
   c. an epsilon
   d. an electron

5. **Mass defect of an atom refers to:**
   a. Inaccurate measurement of mass of nucleons
   b. Mass annihilated to produce energy to bind the nucleus
   c. Packing fraction
   d. Difference in the number of neutrons and protons in the nucleus

6. **Curie is a unit of:**
   a. energy of gamma rays
   b. half-life
   c. intensity of gamma rays
   d. radioactivity

7. **During a nuclear fusion reaction:**
   a. A heavy nucleus breaks into two fragments by itself
   b. A light nucleus bombarded by thermal neutrons breaks up
   c. A heavy nucleus bombarded by thermal neutrons breaks up
   d. Two light nuclei combine to give a heavier nucleus and possibly other products

8. **The control rod in a nuclear reactor is made of:**
   a. uranium
   b. cadmium
   c. graphite
   d. plutonium

9. **When an electron-positron pair annihilates, the energy released is (electron mass = 9×10^{-31} kg, c = 3×10^{8} m/s)**
   a. 1.6×10^{-13} J
   b. 3.2×10^{-13} J
   c. 0.8×10^{-13} J
   d. 4.0×10^{-13} J

10. **The half-life (T) and the disintegration constant (λ) of a radioactive substance are related as:**
   a. $\lambda T = 1$
   b. $\lambda T = 0.693$
   c. $\frac{T}{\lambda} = 0.693$
   d. $\frac{\lambda}{T} = 0.693$

11. In a nuclear reaction $^{238}_{92}U \rightarrow ^{A}_{Z}Th + ^{4}_{2}He$, the value of A and Z are:
a. A = 234, Z = 94 b. A = 238, Z = 94 c. A = 234, Z = 90 d. A = 238, Z = 90

12. The rest mass energy of an electron is:
a. 511 keV b. 510 MeV c. 931 keV d. 931 MeV

13. α −particle is bombarded on $^{14}_{7}N$ as a result $^{17}_{8}O$ is formed. The particle emitted is:
a. neutron b. proton c. electron d. positron

14. The um maintains in shinning because of:
a. burning of carbon b. the fission of helium
c. fusion of hydrogen nuclei d. chemical reaction

15. An electric field can deflect:
a. gamma rays b. α particles c. X-rays d. neutrons

16. A radioactive element $_ZX^A$ emits an α particle and changes to:
a. $_{Z+2}^{A}Y$ b. $_{Z-2}^{A}Y$ c. $^{A-4}_{Z}Y$ d. $^{A-4}_{Z-2}Y$

17. When the mass equal to 1 amu is converted completely onto energy produced is:
a. 1.5×10^{-18} J b. 1.5×10^{-10} J c. 1.5×10^{-14} J d. 1.5×10^{-12} J

18. γ ray is emitted when:
a. an atom de-excites b. a nucleus de-excites c. α emission occur d. none of these

19. In the nuclear reaction given by:

$$_2He^2 + {}_7N^{14} \rightarrow {}_8X^{17} + {}_1H^1$$

The nuclear X is:
a. oxygen of mass 17 b. nitrogen of mass 16
c. oxygen of mass 16 d. nitrogen of mass 17

20. 1 amu is equal to:
a. 1.66×10^{-24} kg c. 1.66×10^{-34} kg
b. 1.66×10^{-19} kg d. 1.66×10^{-27} kg

21. A mass spectrograph sorts out:
a. Molecules b. Atoms c. Elements d. Isotopes

22. The amount of energy required to break the nucleus is called:
a. Nuclear energy b. Kinetic energy c. Potential energy d. Binding

23. The reciprocal of decay constant (λ) of a radioactive element is:
a. Half-life b. Mean life c. Total life d. Curie

24. Which of the reaction equations shows the emission of alpha particles?
a. $_ZX^A \rightarrow {}_{Z+1}X^A + ^{4}_{2}He$ b. $_ZX^A \rightarrow {}_{Z-2}X^{A-4} + ^{4}_{2}He$
c. $_ZX^A \rightarrow {}_{Z-1}X^{A-4} + ^{4}_{2}He$ d. $_ZX^A \rightarrow {}_{Z-2}X^{A-1} + ^{4}_{2}He$

25. **The radioactive decay obeys the law:**
a. $N_o = N(1 + e^{\lambda t})$ b. $N = N_o e^{\lambda t}$ c. $N = N_o e^{-\lambda t}$ d. $N = Ne^{\lambda t}$

26. **The fission reaction is given by the following equation:**
a. ${}_1H^2 + {}_1H^2 \rightarrow 2He^4 + Q$
b. ${}_5H^{12} + {}_1D^2 \rightarrow {}_5B^{12} + {}_1H^1$
c. ${}_7N^{14} + {}_0n^1 \rightarrow {}_6C^{12} + {}_1H^2$
d. ${}_{92}U^{235} + {}_0n^1 \rightarrow {}_{56}Ba^{144} + {}_{56}Kr^{92} + 3{}_0n^1$

27. **β particle has penetration power:**
a. 100 times more than that of an α particle
b. 100 times less than that off an α particle
c. 1000 times less than that of an α particle
d. 10 times more than that of α particle

28. **Wilson cloud chamber is an instrument used for:**
a. accelerating +vely charged particles
b. accelerating –vely charged particles
c. making the path of ionizing particle visible
d. all of them

29. **α-radiations are used for the treatment of skin of patient due to:**
a. Highly ionizing power
b. Low penetration power
c. Positively charged particles
d. Helium nuclei

30. **Mass defect is given by Δm which is equal to:**
a. $zm_p - (A - Z)m_n - m_{nucleus}$
b. $zm_p + (A - Z)m_n - m_{nucleus}$
c. $zm_p + (A + Z)m_n - m_{nucleus}$
d. $zm_p + (A - Z)m_n + m_{nucleus}$

31. **The mass of a neutron is unified mass scale is:**
a. 0.00090 u b. 1.00040 u c. 1.00898 u d. 1.007275 u

32. **Decay constant for any element can be calculated by the relation:**
a. $\lambda = \Delta N/\Delta t$ b. $\lambda = \Delta t/\Delta N$ c. $\lambda = \Delta N/\Delta t/N$ d. $\lambda = \Delta N/N/\Delta t$

33. **The charge on β particle is:**
a. +e b. –e c. +2e d. –2e

34. **One joule of energy absorbed per kilogram of body is:**
a. Rem b. Roentgens c. Grey d. Bacquerel

35. **In fission reaction, heavy water is used as:**
a. Heat exchanger
b. Coolant
c. Moderator
d. Control of number of neutrons

36. **Which one of the following statements is correct?**
a. The strong nuclear force is responsible for stability of nucleus
b. The weak nuclear force is responsible for decay of nucleus and fusion process
c. The electromagnetic force is responsible for holding matter together
d. All of them

37. **The diameter of an atom is approximately:**
a. 10^{-12} m b. 10^{-11} m c. 10^{-10} m d. 10^{-15} m

38. **The lightest particle of matter which can physically exist is called:**
a. Photon b. Neutron c. Electron d. Proton

39. **One amu is equal to:**
a. 931.0 MeV b. 9.31 MeV c. 93.1 MeV d. 0.931 MeV

40. **Which of the following is not emitted by radioactive elements?**
a. α rays b. β rays c. γ rays d. Neutrons

41. **The nucleus of an atom consists of:**
a. Electrons and protons b. Electrons, protons and neutrons
c. Electrons and neutrons d. neutrons and protons

42. **The number of electrons in an atom of atomic number Z and mass number A is:**
a. Z b. A c. A – Z d. (A – Z)/2

43. **In stable nuclei, the number of neutrons (N) is related to the number of protons (Z) is:**
a. $N < Z$ b. $N = Z$ c. $N > Z$ d. $N \geq Z$

44. **One atomic mass unit is equal to:**
a. mass of one atom of hydrogen b. mass of one atom of $_6C^{12}$
c. 1/12th of the mass of one atom of $_6C^{12}$ d. 10^{-27} Kg

45. **The energy equivalent to one atomic mass unit is:**
a. 1.6×10^{-19} J b. 6.02×10^{23} J c. 937 MeV d. 9.31 MeV

46. **The average binding energy of a nucleon inside an atomic nucleus is about:**
a. 8 eV b. 8 MeV c. 8 J d. 8 ergs

47. **Which of the three basic forces gravitational, electrostatic and nuclear is/are able to provide an attraction between two neutrons?**
a. Electrostatic and nuclear b. Gravitational and nuclear
c. Electrostatic and gravitational d. Only nuclear

48. **An atomic nucleus has mass:**
a. Less than the total mass of their constituent protons and neutrons
b. Equal to the total mass of their constituent protons and neutrons
c. More than the total mass of their constituent protons and neutrons
d. Sometimes more and sometimes less than the total mass of their constituent protons and neutrons

49. **The nuclear force:**
a. obeys inverse square law of distance b. is a long-range force
c. is a short-range force d. is equal in strength to the electromagnetic force

50. **If M is the mass of nucleus and A is its mass number, then (M – A)/M is called its:**
a. binding energy b. Fermi energy c. mass defect d. packing fraction

51. **Radioactivity was discovered by:**
a. J.J. Thomson b. W. Roentgen c. H. Becquerel d. M. Curie

52. **A nuclide of mass number A and atomic number Z emits a β-particle. The mass number and atomic number of the resulting nuclide are, respectively;**
a. A, Z b. A + 1, Z c. A, Z + 1 d. A – A, Z – 2

53. **Out of the following, the one which can pass through 20 cm thickness of steel is:**
a. α – rays b. β – rays c. γ – rays d. ultraviolet rays

54. **γ – rays are deflected by:**
a. An electric field but not by a magnetic field
b. A magnetic field but not by an electric field
c. Both electric and magnetic field
d. Neither an electric nor a magnetic field

55. **The nucleus $^{115}_{48}Cd$, after two successive β^-, decays will give:**
a. $^{115}_{50}Sn$ b. $^{113}_{50}Sn$ c. $^{114}_{49}In$ d. $^{115}_{46}Pd$

56. **The end product of the decay of $^{232}_{90}Th$ is $^{208}_{82}Pb$. The number of alpha and beta particles emitted are, respectively:**
a. 3, 3 b. 6, 4 c. 6, 0 d. 4, 6

57. **The half-life of radium is 1600 years. The fraction of a sample of radium that would remain undecayed after 6400 years is:**
a. 1/2 b. 1/4 c. 1/8 d. 1/16

58. **The percentage of the original quantity of a radioactive material left after five half-lives is approximately:**
a. 1% b. 3% c. 5% d. 20%

59. **α, β and γ radiations come out of a radioactive substance:**
a. spontaneously b. when it is put in a reactor
c. when it is heated d. under pressure

60. **Which of the following statements is correct?**
a. Two isobars always have the same mass number
b. Two isotopes always have the same mass number
c. Two isotones always have the same mass number
d. Two isobars always have the same atomic number

61. **The half-life of a radioactive element is:**
a. $T = \frac{6.93}{\lambda}$ b. $T = 1.43\lambda$ c. $T = 0.693\lambda$ d. $T = \frac{0.693}{\lambda}$

62. **γ rays are similar to:**
a. Cathode rays b. Positive rays c. X-rays d. α rays

63. **Electrons:**
a. Can exist inside the nucleus b. Cannot exist inside the nucleus
c. Can exist both inside and outside the nucleus d. None of the above

64. **The atomic bomb is an example of:**
a. Controlled nuclear fission b. Controlled nuclear fusion

c. Uncontrolled nuclear fission
d. Uncontrolled nuclear fusion

65. Mass defect per nucleon is called:
a. Binding energy of nucleus
b. Packing fraction
c. Average energy of nucleus
d. Binding fraction

66. γ-rays can cause photoelectric effect emission when their energy is:
a. less than 0.1 MeV
b. greater than 0.1 MeV
c. Equal to 0.1 MeV
d. less than 0.1 eV

67. The sum of the masses of constituent nucleons as compared to the mass of the resultant nucleus is:
a. Smaller
b. Greater
c. The same
d. Sometimes smaller sometimes greater

68. 1 amu is equal to:
a. 1.66×10^{-24} kg
b. 1.66×10^{-19} kg
c. 1.66×10^{-34} kg
d. 1.66×10^{-27} kg

69. β particle ionizes an atom:
a. Due to electrostatic force of attraction
b. Due to electrostatic force of repulsion
c. Due to direct collision
d. Due to gravitational force

70. β particle has penetration power:
a. 100 times more than that of an α particle
b. 100 times less than that of an α particle
c. 1000 times less than that of an α particle
d. 10 times more than that of an α particle

ANSWER KEY # 02

1.	A	31.	C	61.	D
2.	A	32.	D	62.	C
3.	D	33.	B	63.	B
4.	A	34.	C	64.	C
5.	B	35.	C	65.	B
6.	D	36.	D	66.	A
7.	D	37.	C	67.	B
8.	B	38.	C	68.	D
9.	A	39.	A	69.	B
10.	B	40	D	70	A
11.	C	41.	D	71.	
12.	A	42.	A	72.	
13.	B	43.	D	73.	
14.	C	44.	C	74.	
15.	B	45.	C	75.	
16.	D	46.	B	76.	
17.	B	47.	B	77.	
18.	B	48.	A	78.	
19.	A	49.	C	79.	
20.	D	50.	D	80.	
21.	D	51.	C	81.	
22.	D	52.	C	82.	
23.	B	53.	C	83.	
24.	B	54.	D	84.	
25.	C	55.	A	85.	
26.	D	56.	B	86.	
27.	A	57.	D	87.	
28.	C	58.	B	88.	
29.	B	59.	A	89.	
30.	B	60.	A	90.	

CHAPTER 20: NUCLEAR RADIATIONS

Interaction of Radiation with Matter:

Interaction of α-particles with Matter:

An α-particle travels a well-defined distance in a medium before coming to rest. This distance is called the range of the particle. The range depends on the,

i. Charge, mass and energy of the particle and
ii. The density of the medium and ionization potentials of the atoms of the medium

As the particle passes through a solid, liquid or gas, it loses energy due to excitation and ionization of atoms and molecules in the matter. The ionization may be due to direct elastic collisions or through electrostatic attraction. Ionization is the main interaction with matter to detect the particle or to measure its energy.

Since α-particle is about "7000" times more massive than an electron, so it does not suffer any appreciable deflection from its straight path, provided it does not approach too closely to the nucleus of the atom. Thus α-particle continues producing intense ionization along its straight path till it loses all its energy and comes almost to rest. It then, captures two electrons from the medium and becomes a neutral helium atom.

Interaction of β-prticles with Matter:

β-particles also lose energy by producing ionization. However, its ionizing ability is about 100 times less than that of α-particles. As a result, its range is about 100 times more than α-particles. β-particles are more easily deflected by collisions than heavy α-particles. Thus, the path of β-particles is measured by the effective depth of penetration into the medium not by the length of erratic path. The denser the material through which the particle moves, the shorter its range will be.

α and β-particles both radiate energy as X-ray photons when they are slowed by the electric field of the charged particles in a solid material.

Interaction of γ-rays with Matter:

γ-rays are electromagnetic radiations of very short wavelength. Photons of γ-rays, being uncharged, cause very little ionization. Photons are removed from a beam by either scattering or absorption in the medium. They interact with matter in three distinct ways, depending mainly on their energy.

At low energies (less than about 0.5MeV), the dominant process that removes photons from a beam is the photoelectric effect.

At intermediate energies, the dominant process is Compton scattering.

At higher energies (more than 1.02MeV), the dominant process is pair production.

In air γ-rays intensity falls off as the inverse square of the distance from the source, in much the same manner as light from a lamp. In solids, the intensity decreases exponentially with increasing depth of penetration into the material. The intensity 'I_o' of a beam after passing through a distance 'X' in the medium is reduced to intensity 'I' given by the relation, ($\gamma = I_0 e^{-\mu x}$).

Where 'μ' is the linear absorption coefficient of the medium. This coefficient depends upon the energy of the photon and properties of the medium.

Interaction of Neutron with Matter:

Neutrons, being neutral particles, are extremely penetrating particles. To be stopped or slowed, a neutron must undergo a direct collision with a nucleus or some other particle that has a mass comparable to that of the neutron. Materials such as water or plastic, which contain more low-mass nuclei per unit volume, are used to stop neutrons. Neutrons produce a little indirect ionization when they interact with materials containing hydrogen atoms and knock out protons.

Radiation Detectors:

Nuclear radiations cannot be detected by our senses, we use some detectors for this purpose. Most detectors of radiations make use of the fact that ionization is produced along the path of the particle.

Some of the detectors are Wilson cloud chamber, Geiger counter, and solid state detectors.

Principle of Wilson Cloud Chamber, Geiger-Muller Counter and solid state detector:

(i) Wilson cloud chamber is based on the principle that super saturated vapours condense more readily on ions or dust particles to form trails of clouds.
(ii) Heiger-Muller counter is based upon the phenomenon of production of ions by the incident radiations.
(iii) Solid state detector is based on the principle that, when radiation is allowed to enter the depletion region electron-hole pairs are formed.

The summary of the nature of α, β and γ radiations

Characteristics	α-particles	β-particles	γ-particles
1. Nature	Helium nuclei of charge 2e	Electrons or positrons from the nucleus of charge $\pm$ e	E.M waves from excited nuclei with no charge
2. Typical sources	Radon -222	Strontium -92	Cobalt -60
3. Ionization (Ion Pairs mm^{-1}, in air)	About 10^4	About 10^2	About 1
4. Range in air	Several centimeters	Several metres	Obeys inverse square law
5. Absorbed by	A paper	$1-5$ mm of Al sheet	$1-10$ cm of lead sheet
6. Energy spectrum	Emitted with the same energy	Variable energy	Variable energy
7. Speed	-10^7 m/s	-1×10^8 m/s	-3×10^8 m/s

ALPHA PARTICLE

- It shoots out from the nucleus with a high velocity (0.1 x 10^8 m/s).
- It possesses very high energy (7.7 MeV).
- Due to its large size, more charge and high energy it can make very large number of collisions with the atoms and ionize them as it passes through them, before it stops.
- If an α particle passes close to an atom, the strong electrostatic attraction between it and an electron tears the electron off from the atom and ionizes it.
- An α particle loses about 35eV energy in each collision.
- The range of α particle is small. Metal sheets form good shields for α particle.
- Alpha particles produce fluorescence on striking certain substances such as zinc sulphide and barium platinocyanide.

- The number of ions produced by an α particle or its range in air is a measure of its energy.

PROTONS

- A proton is also a positively charged particle with properties similar to the particle. Its mass is one-fourth and charge is one half of that of an α particle.
- It is smaller in size and carries less energy at the same velocity.
- It suffers fewer collisions with the atoms of the medium as compared with the α particle and penetrates the medium to a greater distance (about 5 to 10 times) before stopping.
- Its ionizing power is also much less, about one-fifth that of the α particle.

BETA PARTICLES

- A β particle also ionizes the atoms of the medium along its path but this ionization is much less than that produces by an α particle or a proton.
- It can ionize an atom by strong electrostatic repulsion when it passes close to its electron.
- The range of β particle in a medium is very large, nearly 100 times that of an α particle of the same energy. The ionization produced by it is less than one-hundredth of that by the α particle.
- Alpha particles are stopped by an ordinary paper, but the β particle may pass through a thick book. A small thickness of a heavy metal rich in electrons is enough to stop the β particle e.g. 5×10^{-3} m of aluminum.
- Fluorescence is also produced when p-particles strike calcium tungstate and barium Platinocyanide.

GAMMA RAYS

- Gamma rays are very high energy electromagnetic radiations of extremely short wavelength emitted from the nuclei of radioactive atoms originating from the high energy transitions of the nucleus in the nuclei.
- They are accompanied with the emission of α or β particle.
- They carry no charge and have no rest mass but possess very high energy of the order of several MeV.
- They penetrate far greater distance in material media as compared to α or β particle.
- Very energetic γ-rays are capable of penetrating several centimetres of concrete.
- γ rays are also capable of ionizing even far more strongly the atoms of the medium they pass through.

γ rays (Photons) can produce ionization in three ways:

i. It may lose all its energy in a single encounter with the electron of an atom **(Photoelectric effect).**
ii. It may lose only a part of its energy in an encounter **(Compton Effect).**
iii. Very few of very high energy, gamma-rays photons may impinge directly on heavy nuclei, be stopped ad annihilated giving rise to electron-positron pairs **(Materialization of energy).**

Most of the photons are absorbed by electrons and substance rich in electrons, e.g. lead will stop most of the γ ray photons and serve as a good shield against γ rays.

NEUTRONS

- A neutron is essentially emitted from the nucleus of an atom. It is so called because it is electrically neutral and carries no charge. Its mass is very nearly equal to that of a proton.
- It can neither experience nor exert any electrostatic force of attraction or repulsion.
- Therefore, it can interact with an electron or the nucleus of an atom only by direct impact.
- When it hits an electron, it knocks it out from the atom (ionization) with practically no change in its own energy or direction of motion.
- When it hits a nucleus, appreciable changes in its energy and direction of motion are likely. A neutron is a highly penetrating but very slightly ionizing particle.

WILSON CLOUD CHAMBER

"Wilson cloud chamber is a device for making visible the paths of ionizing particles."

It helps to examine the mechanism of ionization of various ionizing radiations.

RESULTS:

- **Alpha Particles:** Particles produce straight, short and thick tracts which look like continuous streaks.
- **Beta Particles:** Particles produce twisted, longer and thinner tracks.
- **Gamma Particles:** Particles produce beaded, thin and irregular lines.

GEIGER COUNTER

- Geiger counter is a portable device which is widely used for the detection of ionizing particles or radiations.
- The sealed tube usually contains a special mixture (air, argon, alcohol, etc.) at a low pressure of 50 to 100 millimetres of mercury.
- A potential difference of the order of one thousand volts is applied.
- A series resistor R is about 10^9 ohms.
- In the case of ionizing radiations, the number of counts registered by the counter measures the intensity or ionizing power of the incident radiation.

SOLID-STATE DETECTOR

- These devices basically make use of the solid-state semiconductor diodes i.e. the p-n junction.
- If an energetic ionizing particle (or radiation) passes through the p-n junction region, a reverse current pulse passes through the diode due to the ionization of the atoms of the region.
- This device works at low potential differences up to 9 volts. It can detect particles having energy only a few electron volts.

RADIATION DAMAGES

Radiation can cause:

- Leukemia
- Radiation sickness
- Skin cancer
- Gene mutations

BIOLOGICAL AND MEDICAL USES OF RADIATION

These are fall into two categories:

i. They are uses as tracers
ii. They are used as therapeutic agents in medicine and as sterilizing agents

RADIOACTIVE TRACERS

${}_{53}I^{131}$ – For thyroid gland

${}_{20}Ca^{45}$ – For bone

${}_{11}Na^{23}$ – For the rate of flow of blood

${}_{6}C^{14}$ – Photosynthesis in leaf

COSMIC RAYS

- Radiation of high penetrating power falling on earth from outer space are called Cosmic Rays.
- It mostly of protons, having high energies extending up to 10^{18} eV. He (15%) , C, N, O (less than 1%) is also present.
- They are accelerated to high energies by interstellar magnetic fields.
- Sun contributes to low energy (less than 1 GeV) cosmic rays.

USES OF RADIATIONS

- Polymerization
- Sterilization and Food Preservation
- Gauging and Control
- Radiography

RADIATION METHODS IN ARCHAEOLOGY

- The radioisotope of ${}_{6}C^{14}$ are produced by cosmic rays neutrons.
- The half-life of ${}_{6}C^{14}$ is about 5730 years.
- Method of finding the age of a specimen by the ${}_{6}C^{14}$ method is called Radio-Carbon dating.
- The ratio of ${}_{6}C^{14}$ to ${}_{6}C^{12}$ atoms in plants was found to be 1.5 x 10^{-12} before the use of nuclear weapons.

ACTIVATION ANALYSIS

The detection and estimation of an element in a mixture is sometimes nearly impossible, if it is present in very minute traces or if its chemical properties are very similar to those of the other elements in the mixture. An effective technique is developed for these purposes is known as **Activation Analysis**.

PRACTICE SHEET # 01

1. ß-particles are
A. Positive
B. Negative
C. Positive or Negative
D. None of these

2. Wilson cloud chamber is an instrument used for
A. Accelerating negatively charged
B. Accelerating positively charged particles
C. Making the path of ionizing particle visible
D. All of the above

3. Which of the following is not a radiation detector?
A. Wilson cloud chamber
B. Geiger counter
C. Cyclotron
D. Solid state detector

4. The range of alpha particle in air is less because
A. It does interact with matter
B. It produces intense ionization
C. It is reflected soon
D. None of these

5. Alpha particles are highly ionized because of their:
A. Greater mass
B. Greater charge and low speeds
C. Greater density
D. Greater energy

6. Which of the following is uses to shield gamma radiation for safely purpose:
A. Lead
B. Wood
C. Aluminum
D. Air

7. Which of the following produces more ionization passing through a gas?
A. Alpha particles
B. ß-particles
C. Gamma particles
D. Electrons

8. The thin wire in the center of the GM (Geiger Muller) tube is:
A. Positively charged
B. Negatively charged
C. Without charge
D. None

9. Which of the following materials is used for shielding y-radiations?
A. Woody
B. Lead
C. Air
D. All of the above

10. Which of the following is electromagnetic in nature
A. α-rays
B. ß-rays
C. Gamma rays
D. Cathode rays

11. Capture of a neutron by a nucleus produces
A. Radio isotope
B. Proton
C. Helium
D. Deuteron

12. In pair-production gamma-ray photon is converted into
A. An electron
B. A proton
C. A positron
D. A pair of electron and positron

13. The penetrating power of β-particles is
A. Less than a-particles
B. Greater than a-particles
C. Equal to a particles
D. None of these

14. The penetrating power of y-rays is

A. Greater than α-rays
B. Smaller than α-rays and ß-rays
C. Equal to α-rays and ß-rays
D. None of these

15. Gamma-rays are

A. Electromagnetic waves
B. High energy photons
C. Having high penetrating power
D. All of the above

16. The penetration power of β-particles is greater than a-particles due to

A. Smaller ionization power
B. Greater ionization power
C. Equal ionization power
D. None of these

17. The rest mass of a Gamma radiation is:

A. 9.1×10^{-31}
B. Zero
C. 1.67×10^{-2} kg
D. Infinity

18. The ionization produces by beta particles are compared to alpha particle is:

A. Very large
B. Large
C. Small
D. None

19. Which of the following can be used for fast counting and operating at a low voltage

A. Wilson could chamber
B. Geiger counter
C. Scintillation counter
D. Solid Stale detector

20. Geiger counter is not suitable for

A. Slow counting
B. Fast counting
C. Slow and fast counting
D. None of these

21. A solid state detector basically consist of

A. Silicon crystal
B. PN-junction diode
C. Transistor
D. Germanium crystal

22. β-particles have erratic path due to their:

A. Repulsion
B. High speed
C. Frequent deflections
D. None of these

23. When the alpha particle passes through a gas, it produces:

A. Photoelectric effect
B. Ionization
C. X-rays
D. None

24. Gamma rays lose energy as they penetrate materials by the process of:

A. Compton effect
B. Photoelectric effect
C. Pair-production
D. All

25. Which of the following are not electromagnetic waves:

A. Light rays
B. X-rays
C. Gamma rays
D. Beta rays

26. Which of the following is the most useful tracer?

A. lodine -131
B. Cobalt -60
C. Carbon -14
D. Strontium-90

27. The track of the alpha particles in Wilson cloud chamber is:
A. Irregular and thin
B. Discontinuous and Dense
C. Dense, Straight and continuous
D. Done

28. Which of the following particles is more massive:
A. Electron
B. Beta particle
C. Alpha particle
D. It depends on the speed

29. The rate of flow of blood in the body can be traced by using this radio isotope:
A. $_{20}Ca^{45}$
B. $_{11}Na^{24}$
C. $_{1}H^{3}$
D. $_{6}c^{12}$

30. The solid state detector is a p-n junction which is given:
A. Forward bias
B. Reverse bias
C. A & B
D. None

31. Wilson cloud chamber is an instrument used for:
A. Accelerating negatively charged particles
B. Accelerating positively charged particles
C. Making the path of ionizing particle visible
D. All of the above

32. The method of finding the age of specimen by C^{14} is called
A. radio therapy
B. radiology
C. radio carbon dating
D. none

33. The charge on α- particle is:
A. +e
B. +2e
C. -2e
D. +4e

34. Alpha particles consist of:
A. Hydrogen nuclei
B. Boron nuclei
C. Helium nuclei
D. Chlorine nuclei

35. The sterilization of surgical instrument, medical supplies and bandages can be done exposing them to a beam of:
A. α-rays
B. ß-rays
C. y-rays
D. Both B and C

36. A Geiger Muller counter contains:
A. Argon and alcohol
B. Alcohol only
C. Super cool water vapors
D. Ions

37. In G.M tube ionization is produced when incident radiation collides with:
A. Central thin wire
B. Meal thin wire
C. Inert gas molecules
D. None

38. The device particularly useful for detecting low energy particles is called:
A. Wilson cloud chamber
B. Geiger counter
C. Solid state detector
D. Sir Bilal's counter

39. Which of the following is a radiation detector?
A. Wilson cloud chamber
B. Mercury thermometer
C. Cyclotron
D. Cyclotron

40. The capture of a neutron by a heavy nucleus cause:

A. Fusion B. Fission
C. Erosion D. None

ANSWER KEY # 01

1.	B	11.	A	21.	B	31.	C
2.	C	12.	D	22.	B	32.	C
3.	C	13.	B	23.	B	33.	B
4.	B	14.	A	24.	D	34.	C
5.	B	15.	D	25.	D	35.	C
6.	A	16.	A	26.	A	36.	A
7.	A	17.	B	27.	C	37.	C
8.	A	18.	C	28.	C	38	B
9.	B	19.	D	29.	B	39	A
10.	C	20.	B	30.	B	40.	B