# 2089

# BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING

# OCTOBER 2024 ANSWER KEY

## PART- A

**Answer any fifteen questions. All question carries equal marks (15 x 2 = 30 Marks)**

**1. State Coulomb's law. [2 Marks]**

**First Law**

Like charges repel each other whereas unlike charges attract each other.

**Second Law**

The force exerted between two-point charges is directly proportional to the product of their strengths and inversely proportional to the square of the distance between them.

**2. Name any two electrical quantities. [2 Marks]**

Charge (Q), Current (I), Electro Motive Force (EMF), Electric Potential (V)

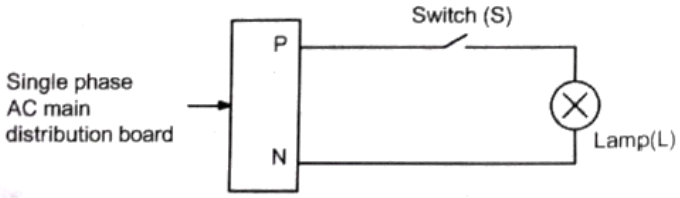
**3. Define voltage. [2 Marks]**

Voltage is defined as the electric potential difference per unit charge between two points in an electric field.

**4. List any two uses of electricity in health care. [2 Marks]**

- Surgical operations.
- Doctors need a powerful light during an operation on a patient.
- Diagnosis equipment's such as scan, X-rays and computers.
- Ventilations and oxygen supply for the patients.
- Centralized Monitoring system.
- Continuous electricity is needed in anesthesia machine.

**5. Draw the simple lamp circuit. [2 Marks]**




**6. List any two energy sources. [2 Marks]**

Fuel (Thermal), Water Power, Nuclear power, Solar power, Wind power, Tidal power

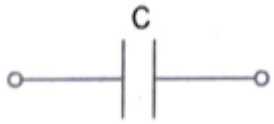
**7. Give the applications of solar panels. [2 Marks]**

- Powering homes and buildings.
- Lighting up remote areas.
- Solar panels can power the water irrigation pumps.
- Used for electric vehicle charging.
- Street lighting.
- Solar energy helps in turning the salty water into fresh water.
- Heating and cooling.

**8. What are the types of electric vehicles? [2 Marks]**

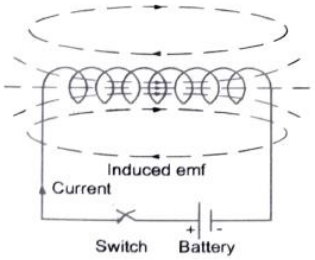
- Battery Electric Vehicle (BEV)
- Plug in Hydrid Electric Vehicle (PHEV)
- Hybrid Electric Vehicle (HEV)
- Fuel Cell Electric Vehicle (FCEV)

**9. Draw the symbol of capacitor and give its unit. [2 Marks]**




The unit of capacitance is Farad

**10. Define self-inductance. [2 Marks]**




Self-induction is an induction generated in a coil by the current flows through the coil.

**11. Write the working principle of resistor. [2 Marks]**

Resistors are used to resist the flow of current. When resistor is placed in a circuit, it reduces the flow of current passes through it. The part of current energy dissipate current in the form of heat in resistor, thus decreases the total current.

**12. What are the uses of inductor? [2 Marks]**

- Used in tuning circuits for selecting the desired frequency
- Used in proximity sensors
- Used in induction motors
- Used in transformers
- Used in fillers
- Used in chokes
- Used in relays
- Used in oscillator tank circuits
- Used in timer circuits

**13. What is meant by fermi level? [2 Marks]**

The highest energy level that an electron can occupy at absolute zero temperature is known as Fermi level. The fermi level lies between valence band and conduction band because at absolute zero ternperature the electrons are all in the lower energy state.

**14. What are intrinsic semiconductors? [2 Marks]**

A pure form of semiconductor is called intrinsic semiconductor.

**15. What is diffusion current? [2 Marks]**

Diffusion current is the movement of charge carriers, such as electrons and holes, in a semiconductor due to a concentration gradient.

This occurs when there is a difference in the concentration of charge carriers in different regions, causing them to move from areas of high concentration to areas of low concentration

**16. Write any two applications of diode. [2 Marks]**

- Rectifiers in power supplies
- Switches in digital logic circuits.
- Clamping networks used as DC restorer in TV receivers and voltage multipliers.
- Clipping circuits used as wave shaping circuits in computers, radars, radio and TV receivers.
- Demodulation circuits.

**17. What are the types of PCB? [2 Marks]**

- Single sided PCB
- Double sided PCB
- Multilayer PCB
- Rigid PCB
- Flexible PCB
- Rigid- Flexible PCB

**18. What is lightning arrester? [2 Marks]**

A lightning arrester or surge diverter is a protective device which diverts the high voltage lighting surge to ground and protects equipment. One end of lightning arrester is connected to the terminal of the equipment to be protected and the other end is effectively grounded.

**19. Write any two soldering tools. [2 Marks]**

- Soldering iron
- Solder
- Solder flux
- Solder flux pen
- Magnifying glass
- Tweezers
- Wire cutters
- Soldering station soldering gun

**20. List any two first aids for electrical accidents. [2 Marks]**

- Switching off the supply
- Insulate yourself from the ground and pull the patient by using a wooden stick.
- Extinguish any spark in the clothes of the patient.
- Verify whether he is breathing or not.

## PART- B

**Answer all the questions choosing any two sub-divisions from each question under part -B. All questions carry equal marks. (5 x14 = 70) (7+7)**

**21. (a) List the duties and responsibilities of an electrical engineer. [ 7 Marks]**

**(Any 7 points describing the question correctly)**

✓ The role of an electrical engineer is to design, develop, test and supervise the manufacturing of electrical equipment and systems.

✓ Electrical engineers work with various technologies including power generation, transmission, distribution, control systems and communication systems.

✓ Electrical engineers inspect, repair, replace, adjust, install and maintain the electrical equipment in the plant.

✓ Establish the manufacturing processes.

✓ Evaluating the system's safety, reliability and performance.

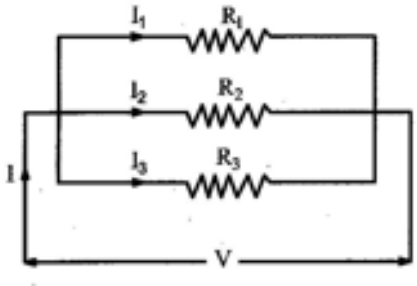
✓ Work together with engineers and technicians to design and apply new system processes.

✓ Prepare product reports by collecting, analyzing and summarizing information.

**21. (b) Derive an expression for equivalent resistance when three resistors are connected in parallel. [ 7 Marks]**

**(Diagram – 3 Marks, Expression – 4 Marks)**

Two or more resistances are connected in such a way that one end of each of them are joined to a common point and the other ends are joined to another common point as shown in figure called parallel circuit.




In fig above resistances R1, R2, R3 are connected in parallel.

V is the applied voltage to the circuit

I is the total circuit current

I1, I2 and I3 are the current through R1, R2, R3 respectively.

In parallel connection the voltage drops across all the resistors is the same but the current in each is different.

The total current in the circuit is the sum of currents flowing through each resistance.

$$\text{i.e., } I = I_1 + I_2 + I_3 \qquad \text{----- (1)}$$

by Ohms law,

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

Substitute the values of $I_1$, $I_2$ and $I_3$ in eqn. (1)

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

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

$$\frac{I}{V} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

(or)

$$R = \frac{R_1R_2R_3}{R_1R_2 + R_2R_3 + R_3R_1}$$

Where R is the total or equivalent resistance of the parallel circuit.

**21. (c) List and explain the various electrical materials. [ 7 Marks]**

**(When 3 Materials are specified – 3 Marks, Explanation & Example – 4 Marks)**

**ELECTRICAL MATERIALS**

Materials are classified as conductors, insulators and semi-conductors according to their electric conductivity.

**Conductor -** Conductors are the materials through which electricity can flow.

**Example**

Copper, Aluminium, Gold, Silver.

**Insulator -** Insulators are the materials through which electricity cannot flow.

**Example**

Glass, Plastic, Rubber and wood.

**Semiconductor - Semiconductors** are the materials which have conductivity between the conductor and the insulator. Semiconductor conduct electricity when its temperature increases.

**Example**

Silicon, germanium.

**22. (a) Expand TANGEDCO and give its functions. [ 7 Marks]**

**(TANGEDCO Expansion – 2 Marks, Functions – 5 Marks)**

**TANGEDCO** stands for **Tamil Nadu Generation and Distribution Corporation Limited.**

- TANGEDCO ensures generation and distribution of quality power supply to the consumers.
- TANGEDCO generate and distribute electricity within the State in the most efficient and economical manner.
- TANGEDCO satisfies the energy requirement of the State.
- TANGEDCO aims to achieve 100% rural electrification.
- Revenue collection from consumer is another important role of TANGEDCO.

**22. (b) Explain the construction and working principle of a generator. [ 7 Marks]**

**(Working principle – 3 Marks, Construction – 4 Marks)**

**D.C GENERATOR**

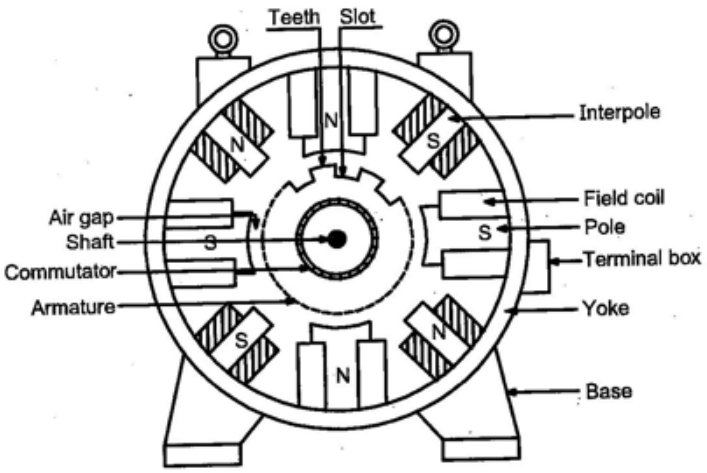
**Principle -** An electrical generator is a machine which converts mechanical energy into electrical energy.

A direct current machine can be used as a DC generator or as a DC motor.

**Constructional details of DC Generator**

DC generator or DC motor has the following parts: -

1. Yoke
2. Pole
3. Field coil
4. Inter pole
5. Armature
6. Commutator
7. Brushes
8. Bearings and end cover




**1. Yoke (or) magnetic frame**

(i) It provides mechanical support for the machine and acts as a cover for the machine.

(ii) It carries the magnetic flux produced by the poles. The yoke is made up of cast iron for smaller machines. For larger machines it is made up of cast steel.

**2. Magnetic poles**

The magnetic poles consist of pole cores and pole shoes.

(i) They spread out the flux in the air gap.
(ii) They support the field coils.
The pole cores and pole shoes are built with thin laminations of steel. These laminations are held together using rivets. The cores are laminated to reduce the eddy current loss. The magnetic poles are fitted inside the yoke by means of screws.

**3. Field coils**

Field coils are usually wound with enamelled copper wire. Field coils are wound over the pole core. The magnetic field strength depends upon the current flowing through the coil. The north and south pole depend upon the direction of current flow through the field coil. This is shown in the figure.

**4. Inter poles (or) commutating poles**

The function of inter pole is to improve the commutation and to reduce the armature reaction. The coils on the interpoles are connected in series with the armature.

**5. Armature**

The armature core is keyed to the machine shaft and it rotates between the field poles. It consists of slotted steel laminations. These laminations are stacked to form a cylindrical core. The laminations are insulated from each other by thin coating of varnish. The purpose of laminating the core is to reduce the eddy current loss. The laminations are slotted to accommodate the armature winding.

**6. Commutator**

The emf induced in the armature is AC in nature. Commutator converts this AC into DC. The commutator is made up of copper segments insulated from one another by mica sheets. The commutator segments are mounted on the shaft of the machine as shown in the figure. The armature conductors are soldered to the commutator segments in a suitable manner.

**7. Brushes**

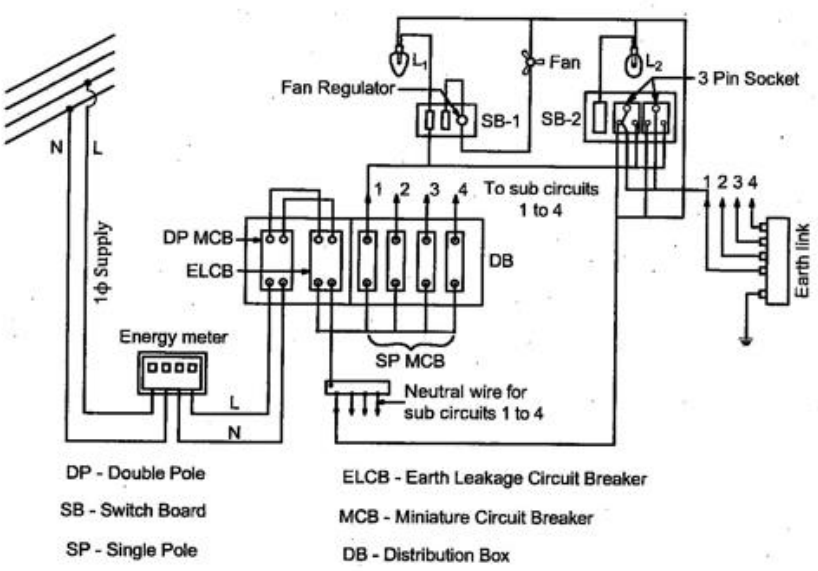
Brushes are made up of carbon and rest on the commutator. The function of the brushes is to collect current from the commutator to the external stationary load. The brushes are put inside the brush holders. The brush holders are kept pressed against the commutator by a spring.

**8. Bearings and end cover**

End covers are made up of cast iron or steel. They are fitted to both ends of the yoke. Ball bearings or roller bearings are fitted inside the end cover. Armature shaft is mounted over these bearings.

**22. (c) Draw and explain the domestic house wiring circuit. [ 7 Marks]**

**(Diagram – 4 Marks, Explanation – 3 Marks)**




Domestic wiring is defined as the wiring done in houses for providing electrical power for lighting, fans and domestic appliances with all the safety precautions.

A simple domestic wiring circuit is shown in figure. Single phase AC supply from the EB pole is taken and connected to the energy meter.

The energy meter is located at the meter board. In the meter board ELCB (Earth Leakage Circuit Breaker), DPMCB (Double Pole Miniature Circuit Breaker)/Isolator (main switch) are provided for the main control of the wiring.

The output from the energy meter is connected through the above units and finally to the Distribution Box (DB).

Number of SP-MCBs (Single Pole MCB) are installed in the DB to provide phase line to individual sub circuits.

From the SP-MCB. Phase wire is drawn and connected to the lights, fans etc through independent switches as shown in the circuit diagram.

**23. (a) Discuss about the various properties of inductor. [ 7 Marks]**

The important properties of Inductor are discussed

**i) Nominal inductance**

The inductance of inductor depends upon the material used as the core, shape of the core, number of turns of the coil, shape and size of the inductor.

**ii) Tolerance**

It is the maximum variation in the value of inductance under all possible test conditions.

**iii) Operating temperature range**

This is the range of temperature that an inductor can withstand without losing its magnetic properties or damaging itself.

**iv) Maximum DC current**

This is the maximum level of direct current that can pass though the inductor without damage.

**v) Maximum DC resistance**

This is the maximum resistance offered by the coil of the inductor with DC.

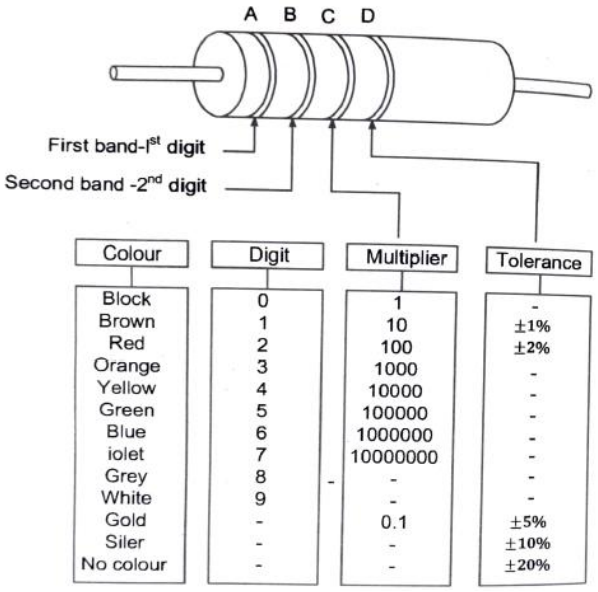
**vi) Quality factor (Q)**

It is an indication of operating losses of the inductor. It is defined as the ratio of inductive reactance and effective resistance.

**vii) Inductance temperature co-efficient**

It indicates the rate of change in the inductance of the inductor per unit centigrade.

**23. (b) Explain about the colour coding of resistors.** **[ 7 Marks]**




| Colour | Digit | Multiplier | Tolerance |
|---|---|---|---|
| Block | 0 | 1 | - |
| Brown | 1 | 10 | ±1% |
| Red | 2 | 100 | ±2% |
| Orange | 3 | 1000 | - |
| Yellow | 4 | 10000 | - |
| Green | 5 | 100000 | - |
| Blue | 6 | 1000000 | - |
| iolet | 7 | 10000000 | - |
| Grey | 8 | - | - |
| White | 9 | - | - |
| Gold | - | 0.1 | ±5% |
| Siler | - | - | ±10% |
| No colour | - | - | ±20% |

- The colour codlings of resistors are used to find the value of resistance and tolerance.
- As shown in the figure there are four colour bands (A, B, C and D) in resistors.
- The first two bands (A and B) denote the first and second digits of the resistance value.
- The third band (C) indicates multiplier, denotes how many zeros follow the first two digits.
- The fourth band (D) indicates the tolerance.
- The colour number and tolerance table are shown in the tabular column above.

**23. (c) Explain the different types of capacitors with its applications.** **[7 Marks]**

**(Mentioning the types – 4 Marks, Explanation – 3 Marks)**

Capacitors are broadly classified into two major types. They are fixed capacitors and variable capacitors. The fixed capacitors are then subdivided into the following types.

**(i) Electrolytic capacitors.**

This capacitor has a metallic anode, and an oxide film layer acts as dielectric. t is surrounded by electrolyte, which acts as cathode.

(i) Polarized electrolytic capacitors
(ii) Non-polarized electrolytic capacitors
  (a) Aluminium type
  (b) Tantalum type

**(ii) Non-electrolytic capacitors**

Non-electrolytic capacitors have no polarity. They can be connected in either direction in a circuit. They can be then subdivided into the following types.

**(A) Ceramic capacitors**

(a) Disc capacitors
(b) Tubular capacitors
(c) Monolithic capacitors
(d) Barrier layer capacitors

**(B) Plastic capacitors**

(a) Polystyrene capacitors
(b) Polyster capacitors
(c) Polycarbonate capacitors

**(C) Mica capacitors**

(a) Stacked mica capacitors
(b) Silvered mica capacitors.

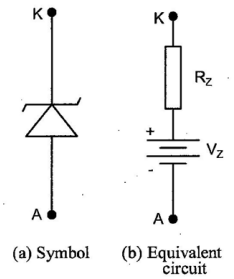
**(D) Paper capacitors**

(a) Impregnated paper capacitors
(b) Metalized paper capacitors.

**24. (a) Explain the construction and working principle of Zener diode. [7 Marks]**

**(Construction – 3 Marks, Working Principle – 4 Marks)**

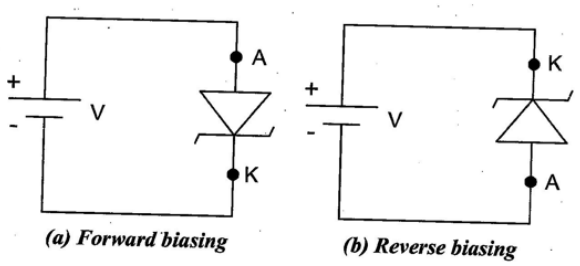
Zener diode is a specially designed PN junction diode. It is a heavily doped PN junction diode. The symbol and equivalent circuit of Zener diode is shown below



(a) Symbol (b) Equivalent circuit

**Working of Zener Diode**

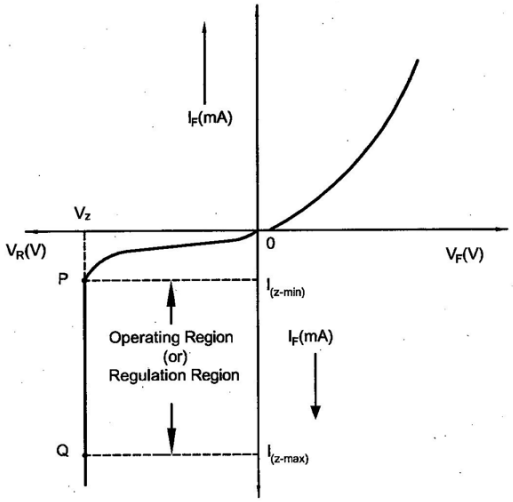
In forward biasing the positive terminal of the battery is connected to the Anode (A) and the negative terminal of the battery is connected to the Cathode (K) as shown in the figure (a). Similarly, during reverse biasing the positive terminal of the battery is connected to the Cathode (K) and the negative terminal of the battery is connected to the Anode (A) as shown in the figure.




**Biasing of Zener diode**

During forward biasing, when the voltage is increased the potential barrier is reduced and the current starts flowing through the diode. Its operation is same as other ordinary PN junction diode.

The forward current increase slowly up to the knee voltage. Beyond this voltage the current increases sharply with increase in applied voltage.




**VI characteristics of Zener diode**

Under reverse bias condition a small reverse current flow through the zener diode. When the reverse voltage across the zener diode is increased, a critical voltage called breakdown voltage is reached at which the reverse current increases sharply as shown by the curve PQ. The minimum voltage at which breakdown occurs and current increases rapidly is called zener breakdown voltage. The VI characteristics of zener diode is shown in the figure above.

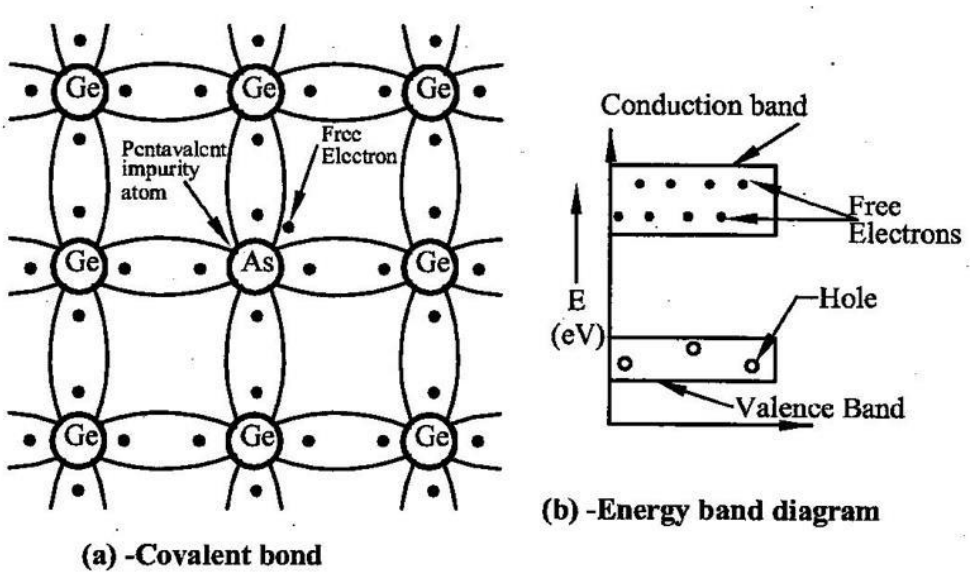
**24. (b) Elaborate on P - type and N - type semiconductors. [ 7 Marks]**

**(Diagram – 4 Marks, Explanation – 3 Marks)**

**N-TYPE SEMICONDUCTOR**

N-type semiconductor is formed by adding a small amount of pentavalent impurities (such as arsenic, antimony or phosphorous) to a semiconductor (such as Silicon or Germanium) material. The added impurities are called donar impurities because they will donate electrons.

Germanium atom has four valence electrons, and antimony has five valence electrons. The antimony atom forms co-valent bonds with their surrounding four germanium atoms. The co-valent bond structure and energy band diagram of N-type semiconductor is shown in the figure below. The four valence electrons of antimony atom form co-valent bonds with four valence electrons of individual germanium atom. The fifth valence electron of antimony is left free, loosely bound to the antimony atom.




(a) -Covalent bond

(b) -Energy band diagram

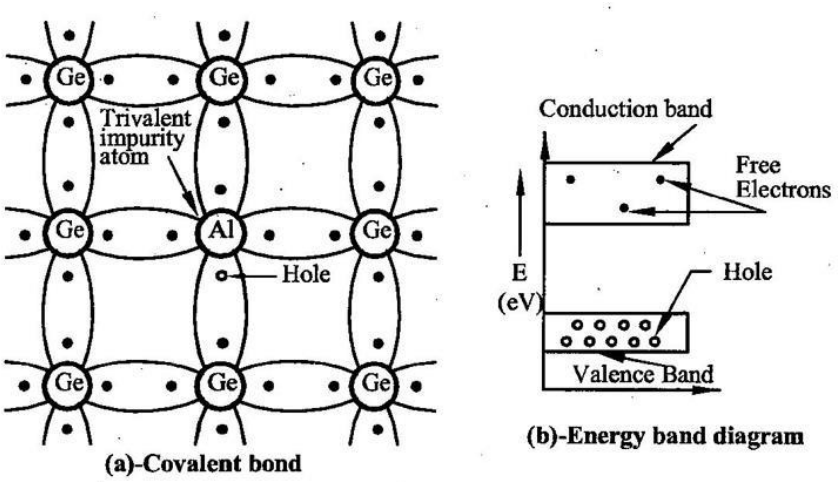
**N-type semiconductor**

This loosely bound electron can be easily excited from the valence band to the conduction band by the application of small electric field. The extra electron creates impurity because it can donate one electron for conduction.

Thus, the addition of pentavalent impurities increases the number of electrons in the conduction band, thereby increasing the conductivity of the semiconductor. Now the semiconductor contains more electrons and less holes. Hence it is called N-type semiconductor. So, the electrons are called majority carriers and holes are called minority carriers.

## P-TYPE SEMICONDUCTOR

P-type semiconductor is formed by adding a small amount of trivalent impurities (such as Aluminium or Boron) to a pure semiconductor (such as Silicon or Germanium) material. Three valence electrons in aluminium form co-valent bond with four surrounding atoms of Ge. Now one co-valent bond is incomplete, which gives rise to a hole. The co-valent bond structure and energy band diagram are shown in the figure.




(a)-Covalent bond

(b)-Energy band diagram

For this, more number of holes (positive charge) are generated. The holes increase the conductivity of the P-type semiconductor. These impurities are known as acceptor Impurities, because the holes created can accept electrons

The number of holes is more than the number of electrons. In P-type semiconductors holes are majority carriers and electrons are minority carriers.

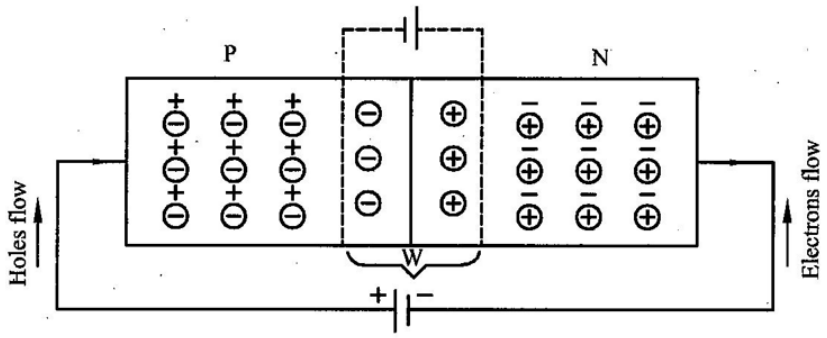
**24. (c) Explain about the forward bias operation of PN junction diode. [ 7 Marks]**

**(Diagram – 4 Marks, Explanation – 3 Marks)**

The conduction of any diodes, depends on their biasing. There are two types of biasing, known as Forward biasing and Reverse biasing.

**(i) Forward biasing**

In forward biasing, the positive terminal of the battery is connected to the P-type and the negative terminal of the battery is connected to the N-type materials of the diode, as shown in the figure below.




**PN-junction under forward bias**

Under the forward bias condition, the applied positive potential repels the holes in P-type region. The negative potential repels the electrons in N-type region. Now the electrons in N-type region and the holes in the P-type region move towards the junction. This reduces the width of the depletion region and also the barrier potential.

**25. (a) Explain about the hazards of electricity.** **[ 7 Marks]**

**(Mentioning of hazards – 4 Marks, Explanation – 3 Marks)**

**HAZARDS OF ELECTRICITY**

**Electric Shock**

Human body is a conductor. When the live wire touches the body, current completes its path through body and earth. Hence the muscular functions of the body are paralysed due to the current's action on the nervous system and causing breathing to stop, severe burns and resulting in death.

**Electric Burns**

An electric burn is a skin burn that happens when electricity comes in contact with the human body. When this happens, the electricity can damage the tissues and organs of the human body. The severity of damage to the human body depends on the duration and intensity of the current flow to the human body.

**Arc blast**

When an electric arc occurs, immediately the surrounding air is super heated. Hence high pressure is developed in that area. The level of the pressure developed will be very high, that it may cause explosion of the equipments and causes severe injuries to the workers: The arc blast can cause serious damage to brain and organs of the human body.

**Thermal radiation**

Thermal radiation occurs due to inisation of air when arc is produced. Thermal radiation causes skin burns, eye injuries and fire hazards.

**Explosions**

A high current fault can create an electrical explosion. Due to this a high energy arc is formed which vapourises the metal and insulation material. An electrical explosion is the sudden release of energy due to short circuit between the phases or a phase to ground.

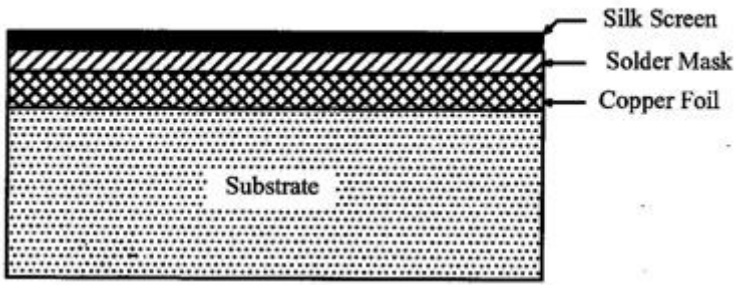
**Fires**

Electrical fire occurs due to ignitions coming from overheating, malfunctioning, or damaged electrical components, equipment or wiring. This is harmful to the surrounding residential, commercial and industrial areas.

**25. (b) Discuss the steps involved in the preparation of PCB.** **[7 Marks]**

**(Diagram – 3 Marks, Explanation of Steps – 4 Marks)**

PCB stands for Printed Circuit Board. It is a non-conductive material with conductive lines printed or traced. Electronic components are mounted on the board and the traces connect the components together to form a working circuit.




PCB generally consists of four layers, which are laminated together into a single piece. The different types of PCB materials used in PCB from bottom to top are,

1. Substrate
2. Copper
3. Solder mask
4. Silk screen

The construction of PCB is shown in figure

**1. Substrate**

The bottom layer of PCB is substrate. The substrate is made of fiber glass. It is a non-conducting material. This layer provides a strong foundation for the PCB.

**2. Copper**

The second layer of PCB is copper. It is laminated onto the substrate with a mixture of heat and adhesive. The copper layer is very thin. In some boards, there are two layers, one above and one below the substrate.

**3. Solder mask**

The solder mask is placed on the top of the copper layer. This gives the PCB its green colour. Solder mask is a protective layer of epoxy liquid that is silk screened. The purpose of solder mask is to prevent the leakage of liquid solder. Solder mask keeps the dust and dirt away from the electric connection and the substrate.

**4. Silk screen**

Silk screen is layer of ink traces used to identify the components, test points, parts of the PCB, warning symbols. The silk screen is usually applied on the component side. The ink is a nonconductive epoxy ink.

**25. (c) What are the safety precautions to be followed during soldering? Explain.**

**[ 7 Marks]**

**(Mentioning of Precautions – 4 Marks, Explanation – 3 Marks)**

**1. Never touch the tip of the soldering iron.**

- Soldering irons can reach extremely high temperatures, often exceeding 400 degrees Celsius (752 degrees Fahrenheit). Direct contact with the tip can cause severe burns.
- While less common with modern soldering irons, older models or damaged equipment can pose a risk of electric shock, especially if the tip is wet or in contact with conductive materials.
- Touching the tip can damage its coating, leading to oxidation and reduced heat transfer efficiency. This can negatively impact the soldering process and shorten the lifespan of the iron.

**2. Use tweezers or clamps to hold the wires to be soldered.**

- Tweezers or clamps provide a stable platform for holding the wires in the desired position. This helps maintain the correct alignment of the wires and ensures a clean, precise solder joint.
- Using tweezers or clamps to hold the wires prevents your fingers from coming into contact with the hot soldering iron tip, reducing the risk of burns.
- By holding the wires securely, tweezers or clamps minimize vibration, which can disrupt the soldering process and lead to a poor solder joint.

**3. Always keep the soldering iron in the stand when not in use.**

- A hot soldering iron left unattended on a workbench can easily cause fires or burns. Placing it in a stand ensures it's stable and out of reach of accidental contact.
- Soldering iron tips can be easily damaged by contact with surfaces like workbenches. The stand provides a safe, heat-resistant surface to protect the tip from damage and maintain its effectiveness.
- Many soldering iron stands are designed to help maintain the tip's temperature. This can save time and energy by reducing the need to reheat the iron frequently, especially during short breaks in your work.

**4. Turn off the soldering iron when not in use.**

- By turning off the iron, you can conserve energy and reduce your electricity consumption, especially if you take frequent breaks during your soldering work.
- Continuous heat exposure can shorten the lifespan of a soldering iron tip. Turning off the iron when not in use can help extend the tip's life and reduce the need for frequent replacements.
- A hot, unattended soldering iron poses a fire hazard. Turning it off eliminates this risk and ensures a safer working environment.

**5. Safety goggles and face shields should be used while soldering.**

- Soldering can produce small particles of molten metal and hazardous fumes. Safety goggles protect your eyes from these particles, preventing potential eye injuries.
- A face shield offers additional protection for your face and neck from flying debris, spatter, and harmful fumes.
- In case of accidental spills or splashes of hot solder, a face shield can help minimize the risk of burns to your face and neck.

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