Module 8: Illumination and Basic Electronics

30 Important Questions and Answers

1. Illumination and Laws of Illumination

Q1. What is illumination? State its unit and formula.

Ans: Illumination (illuminance) is the luminous flux falling on a unit area of a surface. E = flux / area. Unit: lux (lumen per square metre).

Q2. Define luminous flux, luminous intensity and luminous efficacy with their units.

Ans: Luminous flux: the light energy emitted per second by a source, unit lumen (lm). Luminous intensity: flux per unit solid angle in a given direction, unit candela (cd). Luminous efficacy: lumen output per watt of input power, unit lm/W.

Q3. State the inverse square law of illumination.

Ans: The illumination of a surface is directly proportional to the luminous intensity of the point source and inversely proportional to the square of the distance from it: $E = I / d^2$, when the light falls at right angles to the surface.

Q4. State Lambert's cosine law of illumination.

Ans: The illumination at a point on a surface is proportional to the cosine of the angle between the incident light and the normal to the surface: $E = (I \times \cos\theta) / d^2$.

Q5. A 100 cd point source hangs 2 m directly above a table. Find the illumination on the table.

Ans: $E = I / d^2 = 100 / (2 \times 2) = 25$ lux.

2. Types of Lamps

Q6. Classify electric lamps.

Ans: Incandescent (filament) lamps, discharge lamps (fluorescent tube, CFL, mercury vapour, sodium vapour and metal halide) and LED lamps.

Q7. Describe the incandescent lamp.

Ans: A tungsten filament in a glass bulb filled with an inert gas (argon or nitrogen) glows white hot when current passes through it. It is cheap and simple, but has low efficacy and a short life, since most input energy turns to heat.

Q8. Explain the working of a fluorescent tube light with choke and starter.

Ans: The tube holds low-pressure mercury vapour and its inner wall is coated with phosphor. The starter first pre-heats the electrodes and then opens, and the choke gives a high voltage kick that starts the discharge. The choke then limits the current. Ultraviolet from the discharge makes the phosphor glow with visible light.

Q9. State the advantages of LED and CFL lamps over incandescent lamps.

Ans: They have much higher efficacy (less energy for the same light), longer life, and produce less heat. LEDs also start instantly, contain no mercury and last longest, while CFLs use an electronic ballast and contain a little mercury.

Q10. Name discharge lamps used for street and industrial lighting.

Ans: High-pressure sodium vapour lamps (golden-yellow light, high efficacy) and mercury vapour lamps for streets and factories, and metal halide lamps for stadiums, showrooms and high-mast lighting.

3. Domestic Appliances

Q11. Why is nichrome used as the heating element material?

Ans: Nichrome (about 80% nickel and 20% chromium) has high resistivity, a high melting point, and resists oxidation at high temperature, so it gives good heat without burning out. It is used in heaters, irons, toasters and geysers.

Q12. Describe the construction of an electric iron.

Ans: A nichrome heating element is placed between mica sheets in the sole plate. A bimetallic thermostat controls the temperature, an indicator lamp shows heating, and a three-core cord carries the earth wire to the metal body.

Q13. Explain the working of an electric water heater (geyser).

Ans: A heating element immersed in the water tank heats the water when current flows. A thermostat switches the element off at the set temperature, a thermal cut-out protects against overheating, and a pressure relief valve and earthing provide safety.

Q14. Which motors are used in common household appliances?

Ans: Ceiling fans use a capacitor (PSC) motor with a regulator for speed. Mixer-grinders and vacuum cleaners use universal motors. Refrigerators, air conditioners and washing machines use capacitor-start or capacitor-run motors. Metal-bodied appliances must be earthed and protected by MCB or ELCB.

4. Semiconductors: P-Type and N-Type

Q15. What are intrinsic and extrinsic semiconductors?

Ans: Intrinsic: pure silicon or germanium, with four valence electrons and covalent bonds, poor conductivity that rises with temperature. Extrinsic: an intrinsic semiconductor doped with a small amount of impurity to increase its conductivity.

Q16. What is an N-type semiconductor?

Ans: Pure semiconductor doped with a pentavalent impurity such as phosphorus, arsenic or antimony (donor). Each impurity atom gives a free electron, so electrons are the majority carriers and holes are the minority carriers.

Q17. What is a P-type semiconductor?

Ans: Pure semiconductor doped with a trivalent impurity such as boron, gallium or indium (acceptor). Each impurity atom creates a hole, so holes are the majority carriers and electrons are the minority carriers.

Q18. What is a PN junction and depletion region?

Ans: It is the boundary between P-type and N-type material. Electrons and holes diffuse across it and combine, leaving a region with no free carriers (the depletion region) and a barrier potential of about 0.7 V for silicon and 0.3 V for germanium.

5. Classification of Diodes

Q19. Explain the working of a PN junction diode in forward and reverse bias.

Ans: Forward bias (P to positive, N to negative): the depletion region narrows and the diode conducts once the voltage exceeds the knee voltage. Reverse bias: the depletion region widens and only a tiny leakage current flows, so it blocks current.

Q20. Classify diodes according to their use.

Ans: Signal diode, rectifier (power) diode, zener diode, LED, photodiode, varactor (varicap) diode, Schottky diode, tunnel diode and laser diode.

Q21. What is a zener diode? State its use.

Ans: A specially doped diode designed to operate in the reverse breakdown region, where the voltage across it stays almost constant. It is used as a voltage regulator and voltage reference.

Q22. What are an LED and a photodiode?

Ans: An LED (light emitting diode) gives off light when forward biased, and is used in indicators, displays and lighting. A photodiode is reverse biased, and its reverse current rises with the light falling on it, so it is used in light sensors, remote-control receivers and optocouplers.

6. Rectifiers

Q23. What is a rectifier? Explain the half-wave rectifier.

Ans: A rectifier converts AC into pulsating DC. In a half-wave rectifier one diode conducts only during the positive half cycle and blocks the negative half. $V_{dc} = V_m / 3.14$, efficiency about 40.6% and ripple factor 1.21.

Q24. Explain the full-wave and bridge rectifiers.

Ans: The full-wave centre-tap type uses two diodes and a centre-tapped transformer, and the bridge type uses four diodes with no centre tap. Both give output in both half cycles. $V_{dc} = 2 V_m / 3.14$, efficiency about 81.2% and ripple factor about 0.48.

Q25. What is the function of a filter in a rectifier circuit?

Ans: It smooths the pulsating DC output into steady DC by removing the ripple. A capacitor filter is connected across the load, and inductor, LC and pi filters are also used.

Q26. A full-wave rectifier has a peak output voltage of 12 V. Find the average DC output.

Ans: $V_{dc} = 2 \times V_m / 3.14 = 2 \times 12 / 3.14 = 7.64$ V.

7. Transistor

Q27. What is a transistor? Name its terminals and types.

Ans: A three-layer semiconductor device (bipolar junction transistor) with three terminals: emitter, base and collector. Types are NPN and PNP. The emitter is heavily doped, the base is very thin and lightly doped, and the collector is larger.

Q28. Name the transistor configurations and the most common one.

Ans: Common base (CB), common emitter (CE) and common collector (CC). CE is the most widely used, with high voltage and current gain and a 180 degree phase shift. CC (emitter follower) has high input impedance.

Q29. State the current relations of a transistor. If beta = 100 and I_B = 20 microampere, find I_C and I_E.

Ans: $I_E = I_B + I_C$; alpha = I_C / I_E; beta = I_C / I_B. $I_C = 100 \times 20$ microampere = 2 mA and I_E = 2 mA + 0.02 mA = 2.02 mA.

Q30. How does a transistor work as an amplifier and as a switch?

Ans: As an amplifier it works in the active region, where a small base current controls a much larger collector current. As a switch it works between cut-off (OFF) and saturation (ON). Uses: amplifiers, oscillators, relay and LED drivers and logic circuits.