

The figures in the margin indicate full marks.

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USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION - A

There are **FOUR** questions in this section. Answer any **THREE** questions.

1. (a) Explain how the capacitance of a capacitor depends on the geometry of each plate, the spatial relationship between the plates, and the medium in which the plates are immersed. Also, show that energy density of capacitor is proportional to the square of electric field involved. (8)
- (b) Draw an RC circuit and explain the mechanism of rise and fall of current in the circuit. Show that the equation of charge, current and voltage after time t are given by $Q(t) = CV_b(1 - e^{-t/RC})$, $I(t) = \frac{V_b}{R}e^{-t/RC}$ and $V_C(t) = V_b(1 - e^{-t/RC})$, where the terms have their usual meaning. (17)
- (c) In an RC series circuit, emf $V_b = 15.0 V$, resistance $R = 1.5 M\Omega$, and capacitance $C = 1.80 \mu F$. (i) Calculate the time constant, (ii) Find maximum charge that will appear on the capacitor during charging. (10)

2. (a) State and explain Amper's law and Faraday's law of induction. Mention the practical applications of these laws. (10)
- (b) Two long parallel wires carrying currents exert forces on each other as shown in Fig. for Q 6 (b). Describe the mechanism of exerting force on each other and hence show the force is given by $F_{ba} = i_b L B_a = \frac{\mu_0 L i_a i_b}{2\pi d}$, where the terms have their usual meaning.

The field due to a at the position of b creates a force on b .

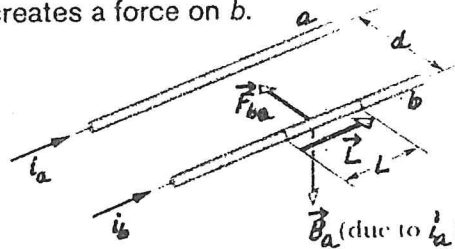


Fig. for Q 6 (b)

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- (c) Draw the step down and step-up transformer and indicates the components involved clearly. Mention two applications of transformers. What is the function of an iron core? (10)
3. (a) What are spin motion and orbital motion of electron? Briefly describe the origin of permanent magnetic dipoles of a magnetic material. (10)
- (b) Define paramagnetism, diamagnetism, ferromagnetism, antiferromagnetism and ferrimagnetism with examples of their respective materials. (15)
- (c) Draw magnetic hysteresis loop of a ferromagnetic material. Based on the hysteresis loop, briefly explain the terms saturation magnetization, remnant magnetization, coercivity and clearly indicate in the loop. (10)
4. (a) State the postulates of the special theory of relativity. Distinguish between inertial and non-inertial frames of reference. (7)
- (b) Establish an expression for the variation of mass with velocity according to the theory of relativity. (20)
- (c) A proton moves with kinetic energy equal to its rest mass energy. Find its velocity. (8)

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE** questions.

5. (a) Briefly describe a photo-multiplier tube with a schematic diagram. (10)
- (b) What is Compton scattering? Derive an expression for the change in wavelength of the photon due to Compton scattering. What is the Compton wavelength? (16)
- (c) Violet light of wavelength 3700 \AA falls upon a silver photocathode. If the photoelectric threshold wavelength for silver is 6500 \AA , calculate the minimum potential difference that must be applied between the anode and the photocathode to prevent electrons to reach in the anode. (9)
6. (a) What are the basic features of the shell model of a nucleus? (10)
- (b) Briefly describe the various components of a nuclear fission reactor with a schematic diagram. (16)

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Contd... Q. No. 6

(c) Using the semi-empirical mass formula, calculate the atomic number of the most stable nucleus for an atomic mass number of 20. Given that, $a_1 = 15.76$, $a_2 = 17.81$, $a_3 = 0.711$, $a_4 = 23.702$, and $a_5 = 34$. (9)

7. (a) What are the differences between crystalline and amorphous solids? Discuss the similarities and dissimilarities between orthorhombic, tetragonal, and cubic crystal systems. (13)

(b) What do you mean by the term crystal defect? Explain with diagram how the Burgers vector is related to the dislocation line in (a) edge dislocation, and (b) screw dislocation. (12)

(c) Iron of density 7.86 g/cm^3 crystallizes in a body centered cube (BCC) unit cell at room temperature. (i) Compute the radius of an iron atom in this crystal. At high temperature (usually larger than 910°C) it prefers to be face centered cubic (FCC). (ii) If this phase transformation does not change the radius of iron, determine whether iron expands or contracts when it undergoes from the BCC to the FCC structure. (10)

8. (a) What are the Miller indices? Determine the Miller Indices of a plane which is parallel to x-axis and cuts intercepts of 2 and $1/2$, respectively along y and z axes. (10)

(b) Show that relation between interplanar spacing (d_{hkl}) and Miller indices (hkl) for cubic system of lattice constant 'a' is (12)

$$d_{hkl} = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$$

(c) State and explain Bragg's law for X-ray diffraction. For a cubic crystal system, the powder X-ray diffraction pattern recorded using Cultural- K_α source of wavelength 1.54 \AA which shows a peak at 33.60 (in 2θ scale) for (111) plane. Calculate the lattice parameter 'a' in \AA unit (rounded of two decimal places). (13)
