EASTERN UNIVERSITY, SRI LANKA

FIRST YEAR SECOND SEMESTER EXAMINATION IN SCIENCE - 2021/2022

(Aug/Sep - 2024)

PH 1033 - GENERAL PHYSICS II

Time : 03 hour

Answer ALL Questions

You may find the following information useful

Velocity of light (c) $= 3 \times 10^{8}$ m s^{-1}

Charge of electron (e) $= 1.6 \times 10^{-19}$ C

Mass of electron (m_e) $= 9.1 \times 10^{-31}$ kg

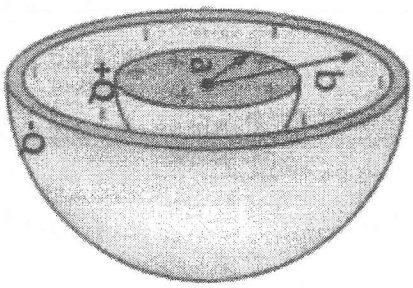
Mass of proton (m_p) $= 1.6 \times 10^{-27}$ kg

Plank's Constant (h) $= 6.62 \times 10^{-34}$ J s

1.

(a). State and Prove Gauss's theorem in electrostatics. (40 Marks)

(b). Consider a spherical capacitor consists of two concentric spherical shells of inner radius a carries charge of +Q and outer radius b carries charge of –Q respectively as shown in the figure.



i. Write down a general expression for electric field intensity E at distance r from the center of the sphere. (10 Mark

ii. Write down a general expression for potential difference between tw points along r. (10 Mark

iii. Hence, find the potential differe..ce between the two coaxial cylinde (20 Marks)

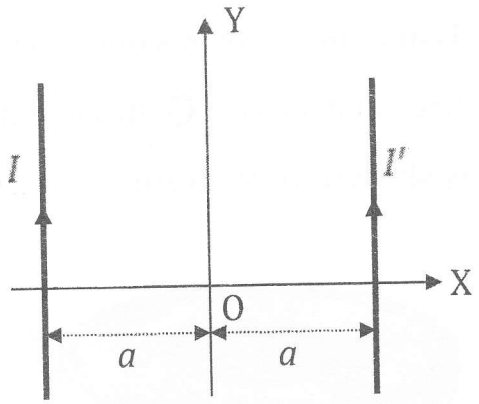
iv. Calculate the capacitance of the spherical capacitor. (20 Mark

v. Find the energy stored in the spherical capacitor. (20 Mark

2.

(a). State and prove Biot-Savart law for magnetic field produced by a lo current carrying wire. (30 Mark

(b) Consider two long straight parallel conducting wires at $2a$ separation carrying currents I and I' in same direction as shown in the figure.



i. If $I = I'$, show that the magnetic field B produced between the wires a distance x from the origin is:

$$\frac{\mu_o I x}{\pi(a^2 - x^2)}$$

Comment on the direction of the B-field. (40 Mar

ii. If $I = 10\ A$, $I' = 5\ A$ and $a = 0.1\ m$, find the magnitude and direction of B field at:

i. x = 0 m

ii. x = 0.2 m

iii. x = - 0.2 m

(15 Marks)

iii. Find the positions when $x > 0$ *and* $x < 0$, where the *B*-field is zero for $I = 10\ A, I' = 5\ A$ *and* $a = 0.1\ m$. (15 Marks)

3.

(a) Draw an LCR series circuit and write down expressions for the reactance of a capacitor and an inductor in complex number system. (15 marks)

(b) State the condition for resonance in an LCR series circuit and write an expression for resonant frequency. (15 marks)

(c) Derive expression for the average power delivered to the circuit.

(25 marks)

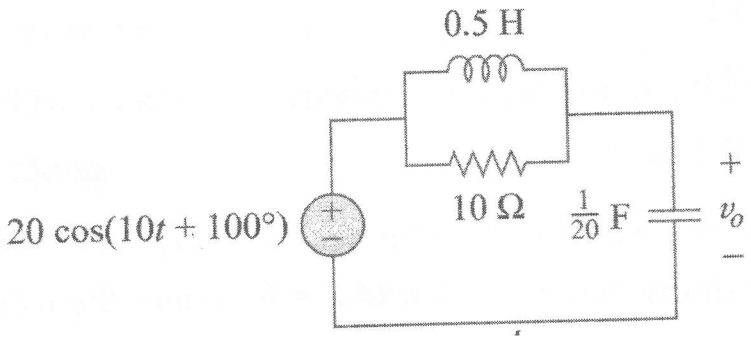
(d) Consider an RLC circuit as shown below, connected to an AC voltage source that has $V(t) = 20\ cos(10t + 100°)$. If the values of the passive elements are $R = 10\ \Omega$, C = 0.05 F and L = 0.5 H, find the following;

i. Input impedance in the circuit,

ii. The current through the capacitor.

iii. The voltage across the capacitor.

(45 marks)



4.

(a) Distinguish between the n- and p-type semiconductors. (20 marks)

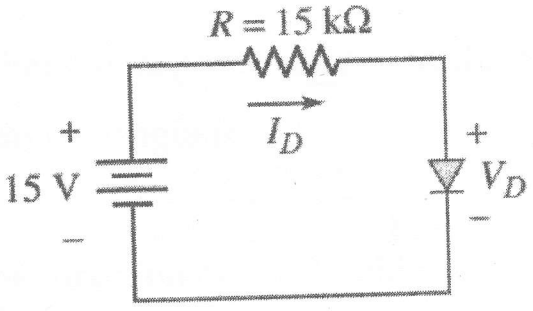
(b) How a pn junction is formed? What is meant by a built-in potentia barrier, and how is it formed? (20 marks)

(c) Draw a circuit diagram of a p-n junction diode that is in forward bia with a battery and discuss the forward bias operation. (20 marks)

(d) Consider the circuit shown below. Assume that the diode has a revers saturation current of $I_S = 10^{-13}\ A$ at T = 300 K. If the diode voltage V_D 0.6 V, find the forward current I_D.

The Boltzmann's diode equation is given by; $I = I_S\left(e^{\frac{V_D}{V_T}} - 1\right)$ where I_S the reverse saturation current and $V_T = 0.026\ V$ is thermal voltage.

(40 marks)



5. What is photoelectric effect? By means of a labeled schematic diagram of a photoelectric effect experimental arrangement, describe stopping potential, work function and cut-off frequency. Hence, introduce Einstein's photoelectric equation which describes the energy transfer.

(50 marks)

(a) Light of frequency 1.5×10^{15} Hz is incident on an aluminium surface, which has a work function of 4.2 eV. Calculate,

(i) the maximum kinetic energy of the photoelectrons; (10 marks)

(ii) the stopping potential; (10 marks)

(iii) the cut-off frequency. (10 marks)

(b) What is De Broglie's hypothesis regarding matter waves? (10 marks) Find the De Broglie's wavelength of the highest energetic photoelectrons in part (a)-(i).

(10 marks)

6.

(a) State the postulates of Bohr Model of hydrogen atom and write down the resulting equations. (30 marks)

(b) Obtain an expression for the velocity of electron in the Bohr orbit.

(10 marks)

(c) Obtain an expression for the Bohr radius. (10 marks)

(d)Hence, show that the total energy of the electron in the n^{th} Bohr Orb of the hydrogen atom is given by

$$E_n = -\frac{me^4}{8\varepsilon_o^2 h^2 n^2}.$$

Here the symbols have their usual meaning. (20 mark

(e) Obtain a relation in terms of Rydberg Constant to calculate t wavelength of the photon emitted when an electron jumps from a outer orbit to an inner orbit. (15 mark

(f) The Balmer series for the hydrogen atom corresponds to an electron transition that terminates in the quantum state $n = 2$. Find the longe wavelength of the photon emitted in this series.

(15 mark

You may take the Rydberg Constant to be 1.097×10^7 m^{-1}.

--The end.--