RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. FOURTH SEMESTER EXAMINATION, JUNE 2022

SECOND YEAR [BATCH 2020-23]

PHYSICS (GENERAL)

Paper : IV

Date : 27/06/2022

Time : 11 am – 1 pm

Full Marks : 50

Answer **any five** questions: [5×10]

1. a) State and explain Gauss' theorem in mathematical form and mention its advantages over coulomb law.

   b) Prove energy stored in the magnetic field of an inductive circuit is $\frac{1}{2}Li^2 0$. [(1+2+2)+5]

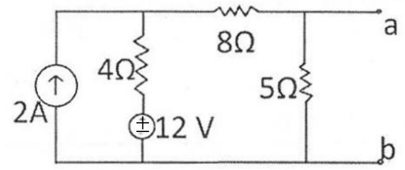
2. a) Define self-induction and mutual induction.

   b) Calculate the self inductance of a solenoid carrying current *i*.

   c) A charge of $3\mu C$ moves with a speed of $3\times10^6 ms^{-1}$ along the positive x-axis. A magnetic field $\vec{B}\left(0.20\hat{j}+0.04\hat{k}\right)$ tesla exists in space. Calculate the magnetic force on the charge. [2+4+4]

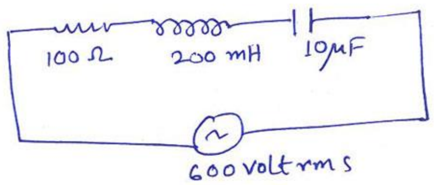
3. a) State the maximum power transfer theorem for a circuit. Show that the maximum power transfer efficiency of a circuit is 50%.

   b) Find the Norton equivalent circuit in Fig. below at terminal a-b.



[(2+3)+5]

4. A resistor, capacitor and inductor are connected in series across on ac voltage source shown in figure



   a) Find the magnitude of the inductive reactance X_L of the inductor and capacitive reactance X_c of the capacitor.

   b) Find the total current through the register.

   c) Find the phase angle between supply voltage and current through the circuit.

   d) Find the voltage across R,C and L and show these on a phasor diagram.

   e) What is the condition for resonance to occur in this type of circuit and at what frequency would this occur? [2+2+2+2+2]

5. a) Suppose visible light of wavelength$4500\mathring{A}$falls on a piece of sodium. If the work function of sodium be 2.3 Volts, then what is the maximum kinetic energy of the emitted photoelectrons ? What is the value of the stopping potential?

   b) In the previous question , if light of different wavelength is used it is seen that above a certain wavelength, there is no emission of photoelectrons. How does particle nature of radiation explains this observation ?

   c) What do you understand by Compton effect ? Deduce an expression for the Compton shift in wavelength in terms of the scattering angle.

d) X-rays of wavelength$0.8\mathring{A}$are allowed to suffer Compton scattering from a carbon target. The radiation observed at any angle contains two wavelengths. One of the wavelengths is equal to the incident wavelength and the other is the compton shifted wavelength. At what scattering angle the compton shifted wavelength is longest ? What is its value? [2+2+(1+3)+2]

6. a) State the basic postulates of Bohr's model. Using Bohr's postulates, derive an expression for the energy of an electron moving in the n^{th} orbit round a nucleus with charge Ze.

b) A hydrogen atom in the normal state is bombarded with electrons of kinetic energies (a) 11.8 eV and (b) 5.5 eV respectively. What are the minimum kinetic energies of the electrons in the two cases after the bombardment ?

c) Hydrogen has three isotopes of mass numbers 1, 2 and 3. Careful experiments on the spectra of these three isotopes have revealed that the corresponding Balmer lines on the spectra of these three atoms have slightly different wavenumbers. Which among these three isotopes has the largest wavenumbers for the Balmer lines ? Provide an explanation which accounts for the difference in the wavenumbers for the isotopes despite the fact that the nucleus of all these three isotopes has the same charge. [(1+4)+3+2]

7. a) What physical quantities do the quantum numbers 'n' , 'l' , 'm_l' and 'm_s' quantify for a hydrogen atom ?

b) Suppose that the electron inside a hydrogen atom is in the 3^{rd} orbit, that is n=3. What are the possible values of the magnitude of the orbital angular momentum and the spin angular momentum for this electron ?

c) What do you mean by the uncertainty principle ? An electron is confined to a box of length $1.1 \times 10^{-8} m$. Calculate the minimum uncertainty in its velocity. Given, $m_e = 9.1 \times 10^{-31} kg$, $\hbar = 1.05 \times 10^{-34} Joule - sec.$

d) If an electron is accelerated from rest in a potential$V$, then show that the de Brogli wavelength associated is$\frac{1.22}{\sqrt{V}} nm.$

e) A golf ball of mass 10g is moving with a speed 50m/s. Calculate the de-brogile wavelength associated with it. Explain why do not we normally encounter wave phenomena associated with such objects in our day to day life . [1+2+3+2+2]

8. a) Draw a square lattice in your paper and construct two unit cells for the drawn lattice- one primitive unit cell and one non- primitive unit cell.

b) There are four crystal systems in two dimensional space namely, oblique, rectangular, square and hexagonal. In all there are five Bravais lattices, with the rectangular system contributing two of them- rectangular primitive and rectangular centered. Square crystal system has only one such lattice. It does not have a square centered lattice as is present in a rectangular system. Give reasons.

c) A plane makes intercepts of $1\mathring{A}$, $2\mathring{A}$and $3\mathring{A}$on the crystallographic axes of an orthorhombic crystal with *a:b:c* = 2*:2:1* . Here *'a', 'b'* and *'c'* are the lattice parameters along the three crystallographic axes. Determine the Milner indices of this plane.

d) An experimental setup is arranged to study Bragg's reflection with the use of electron beam instead of X – rays. For this purpose the electrons are first accelerated through a potential difference, 'V' and the beam is then made to fall on the crystal. The metal crystal which is scattering the electron wave possesses a Simple Cubic(SC) structure. The lattice parameter for this crystal is, $a = 2\mathring{A}$. The setup is arranged in such a way that the Bragg reflection takes place from the successive (1 1 0) planes and the first order reflection is observed at glancing angle, θ = 25.69 . Find the approximate value of the potential difference , 'V' needed to achieve this. [2+1+3+4]

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