# RAMAKRISHNA MISSION VIDYAMANDIRA

**(Residential Autonomous College affiliated to University of Calcutta)**

**B.A./B.Sc. SECOND SEMESTER EXAMINATION, JUNE 2022**

**FIRST YEAR [BATCH 2021-24]**

Date : 24/06/2022 **PHYSICS (GENERAL)**

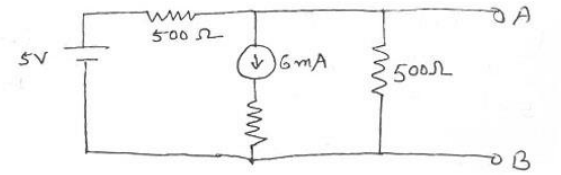
Time : 11 am – 1 pm **Paper : II** Full Marks : 50

Answer **any five** questions: [5×10]

1. a) What is an electric dipole?
   b) Find torque on an electric dipole placed in an electric field.
   c) In a region of space near the point (-3m, 2m, 5m) the potential is $\phi = 40x^2 + 30y^2 - 10z^2$ volt. Find the three components of electric field at that point. What is the value of the total intensity there? [1+4+5]

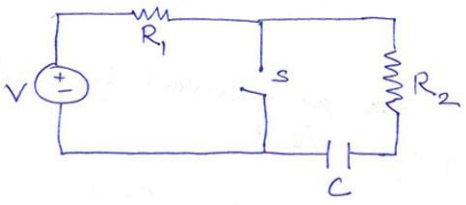
2. a) Define $\vec{D}, \vec{E}, \vec{P}$ and find a relation between them.
   b) Prove energy density in magnetic field is $\frac{1}{2\mu_0}B^2$ unit. [(3+3)+4]

3. a) What do you understand by quality factor Q of a circuit?
   b) An inductor of Q-factor $Q_L$ is connected in a series with a capacitor having Q-factor $Q_C$. Show that overall Q-factor of the system is
   $$Q_T = \frac{Q_L Q_C}{Q_L + Q_C}$$
   c) Draw Thevenin equivalent circuit of the circuit given below




[2+3+5]

4. a) Define current density and find an expression for law of conservation of charge.
   b) In the circuit (shown in figure below) after switch has been open for a long time, it suddenly closed at t =0.




   (i) What are the time constant before and after switch is closed?
   (ii) Find the current through the switch as a function of time after switch is closed. [(1+4)+2+3]

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 V, then what is the maximum kinetic energy of the emitted photoelectrons? What is the value of the stopping potential?
   b) In the previous question, how does the stopping potential vary with the variation in the intensity of light falling on the piece of sodium. How does the particle nature of radiation account for 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) Molybdenum $K_\alpha$ X-rays of wavelength $0.709\mathring{A}$ are allowed to suffer Compton scattering from a carbon target. The radiation observed at any angle contains two wavelengths. What are those wavelengths for the photons scattered at angle $\phi = 30^o$? [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) Naturally occuring hydrogen has two isotopes having mass numbers 1 and 2. The latter is known as deuterium. They both have one electron revolving in their orbits and their nuclei have the same charge but different masses. Careful experiments involving the spectra of these atoms have revealed that the spectra of deuterium have slightly higher wave numbers than the corresponding lines of the hydrogen spectra. Provide an explanation.

c) For a particular hydrogen like atom, the energy of an electron revolving in the $n^{th}$ orbit is found to bear the relation, $E_n = \frac{-K}{n^2}$ , where $K$ is some physical quantity and is positive. An electron accelerated through a potential difference V has acquired energy just sufficient to ionise the atom when bombarded on it. Calculate the minimum potential difference required in principle to achieve this. [(2+4)+2+2]

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

b) State Pauli's exclusion principle. Show using Pauli's exclusion principle that the total number of electrons that can reside in the $n^{th}$ orbit is $2n^2$ .

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, $m_e = 9.1 \times 10^{-31}kg$, $\hbar = 1.05 \times 10^{-34}Js$.

d) An electron and a proton are both accelerated through a potential V. Calculate the ratio of the de-Brogile wavelength of the electron to that of the proton. Take the mass of the proton to be 1836 times to that of an electron.

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 associated. [1+(1+2)+3+1+2]

8. a) Write the names of any two Bravais lattice in two dimensions. Draw one such lattice in you paper and construct two unit cells for the drawn lattice – one primitive unit cell and another non-primitive unit cell.

b) 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 = 3:2:1* . Here *'a', 'b'* and *'c'* are the lattice parameters along the three crystallographic axes. Determine the Miller indices of this plane.

c) The first order Bragg reflection is formed when X- rays of wavelength $0.842\ \mathring{A}$ is made incident on a crystal at glancing angle $8^o\,35'$ .What will be the glancing angle for third order reflection? [(1+2)+3+4]

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