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PHY-552

Electromagnetic Theory and Spectroscopy

M.Sc. Physics (MSCPHY-12/13/16)

Second Year Examination, 2019 (June)

Time : 3 Hours] **Max. Marks : 80**

Note : This paper is of Eighty (80) marks divided into three (03) sections A, B and C. Attempt the questions contained in these sections according to the detailed instructions given therein.

SECTION–A

(Long Answer Type Questions)

Note : Section 'A' contains four (04) long answer type questions of Nineteen (19) marks each. Learners are required to answer any two (02) questions only.

(2×19=38)

1. A charge Q is uniformly distributed in a spherical volume of radius R, discuss its variation with (i) electric intensity (ii) Potential as the field point moved from centre of sphere to infinity.

2. Discuss the Normal and Anomalous Zeeman effect. Compute the Zeeman pattern for $^2D_{3/2}–^2P_{1/2}$ transition.

3. Explain the vibrational-rotational spectrum of a diatomic molecule. Discuss how diatomic molecule having rotating vibrator could explain the main feature of new IR absorption spectra.

4. Discuss the Biot-Savart law. Determine the magnetic field due to a straight current carrying filamentary conductor of finite length along Z-axis.

SECTION–B

(Short Answer Type Questions)

Note : Section 'B' contains eight (08) short answer type questions of eight (08) marks each. Learners are required to answer any four (04) questions only. (4×8=32)

1. Define ampere's circuital law and calculate the magnetic field at any point due to an infinitely long wire.

2. The first line in the rotational spectra of CO is 3.8423 cm^{-1}. Find the moment of inertia and bond length.

3. Starting from Gauss's theorem deduce that the tubes of force can only begin or end on charges. Also prove that the strength of the tubes of force is constant along its length.

4. The intermolecular distance for CO molecule is r = 1.128 Å, calculate the rotational frequency for J = 1 and J = 10 transitions.

5. The force constant of the bond in CO molecule is 1870 Newton/metre. Calculate the frequency of vibration of the molecule and the spacing between its vibrational energy levels in eV. Given that reduced mass of CO = 1.14×10^{-26} kg, h = 6.63×10^{-27} erg.-sec and 1 eV= 1.60×10^{-12} erg.

6. A sphere of radius 2R has uniform charge density ρ. Show that the difference in the electrostatic potential at r = R and r = 0 from the centre is $\frac{-\rho R^2}{6\varepsilon_0}$.

7. The ground state of chlorine is $^2P_{3/2}$. Find its magnetic moment. Into how many substrates will the ground state be split in a weak magnetic field?

8. The first line in the rotational spectra of CO is 3.8423 cm^{-1}. Find the moment of inertia. Also find the bond lengths.

SECTION–C

(Objective Type Questions)

Note : Section 'C' contains ten (10) objective type questions of one (01) mark each. All the questions of this section are compulsory. (10×1=10)

1. An electrostatic field $\vec{E}$ exists in a given region R. Choose the wrong statement,

(a) Circulation of $\vec{E}$ is zero

(b) $\vec{E}$ can always be expressed as the gradient of a scalar field

(c) The potential difference between any two arbitrary points in the region R is zero

(d) The work done in a closed path lying entirely in R is zero.

2. The electric field $\vec{E}$ at a point $\vec{r}$ outside the sphere in above question (8) is given by

(a) $\vec{E} = 0$

(b) $\vec{E} = \dfrac{kR(R^2 - r^2)}{\varepsilon_0 r^3}\hat{r}$

(c) $\vec{E} = \dfrac{kR(R^2 - r^2)}{\varepsilon_0 r^5}\hat{r}$

(d) $\vec{E} = \dfrac{k3(r - R)}{4\pi\varepsilon_0 r^4}\hat{r}$

3. The vector potential at the position defined by vector $\vec{r}$ in a uniform magnetic field may be written by

(a) $\vec{B} \times \vec{r}$

(b) $\frac{1}{2}(\vec{B} \times \vec{r})$

(c) $\vec{B} \cdot \vec{r}$

(d) $-(\vec{B} \times \vec{r})$.

4. Choose the correct matching pairs

(a) Normal Zeeman effect – weak magnetic effect

(b) Paschen back effect – strong magnetic field

(c) Stark effect – electric field

(d) Anomalous Zeeman effect – electric field.

5. An electromagnetic wave is propagating in a dielectric medium of permittivity ε and permeability μ, having an electric field vector $\vec{E}_0$. The associated magnetic field vector $\vec{H}$ is

(a) parallel to $\vec{E}_0$ with magnitude $E_0\sqrt{\frac{\varepsilon}{\mu}}$

(b) perpendicular to $\vec{E}_0$ with magnitude $E_0\sqrt{\frac{\mu}{\varepsilon}}$

(c) perpendicular to $\vec{E}_0$ with magnitude $E_0\sqrt{\frac{\varepsilon}{\mu}}$

(d) parallel to $\vec{E}_0$ with magnitude $E_0\sqrt{\frac{\mu}{\varepsilon}}$.

6. The electric and magnetic fields share the energy of electromagnetic wave in the ratio

(a) 1 : 2

(b) 2 : 1

(c) 1 : 1

(d) 1 : 4.

7. The magnetic field due to a long straight current carrying conductor of radius R, when $r > R$ [$r \rightarrow$ distance between the point and the axis of wire] proportional to

(a) r

(b) r^{-1}

(c) r^2

(d) r^{-2}.

8. The ratio of the intensity of magnetic field at the centre of a very long solenoid to that at the extreme ends is

(a) 2

(b) $\frac{1}{2}$

(c) 4

(d) $\frac{1}{4}$.

9. A thin conducting wire is bent into a circular loop of radius r and placed in a dependent magnetic field of magnetic induction $\vec{B}(t) = B_0 e^{\alpha t}\hat{e}_z$, ($B_0 > 0$ and $\alpha > 0$), such that, the plane of the loop is perpendicular to $\vec{B}(t)$. Then the induced emf in the loop is

(a) $\pi r^2 \alpha B_0 e^{-\alpha t}$

(b) $\pi r^2 B_0 e^{-\alpha t}$

(c) $-\pi r^2 \alpha B_0 e^{-\alpha t}$

(d) $-\pi r^2 B_0 e^{-\alpha t}$.

10. If a straight wire carries a current I and lies along the axis of a circular loop of radius R carrying another current i, then the magnitude of force on the loop is given by

(a) $2\pi\mu_0 i IR$

(b) Zero

(c) $\mu_0 i IR^2$

(d) $\frac{2\pi\mu_0 iI}{R}$.