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PHY–552

Electromagnetic Theory and Spectroscopy

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

Second Year, Examination, 2018

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

Note : This paper is of **eighty (80)** marks containing **three (03)** Sections A, B, C. Learners are required to 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 *two* (02) questions only.

1. Discuss the qualitative features observed in electronic spectrum of a diatomic molecule and explain how are they modified if vibration-rotation interaction is also considered.
2. Illustrate the splitting of energy levels of sodium D_1 and D_2 lines and allowed transitions with the help of diagrams giving rise to (a) Anomalous Zeeman Effect (b) Paschen Back Effect.

3. Deduce the expression for Lienard-Wiechart potentials due to a charged particle in motion.
4. Starting from Maxwell's equations deduce :
   (a) Coulomb's law
   (b) Equation of continuity.

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 *four* (04) questions only.

1. Find the Zeeman structure of spectral line which results from the transition $^4F_{3/2} - {}^4D_{5/2}$.
2. Determine the rotational energy of CO molecule on the quantum levels J = 1 and J = 2 if the equilibrium nucleus distance of CO is 1.131 Å.
3. State and prove Ampere's circuital law in magnetic statics.
4. Write a short note on Franck-Condon principle.
5. An atom with net magnetic moment $\vec{\mu}$ and net angular momentum $\vec{L}$ ($\vec{\mu} = \gamma \vec{L}$) is kept in a uniform magnetic induction $\vec{B} = B_0 \hat{k}$. The magnetic moment is $\vec{\mu}$ ($= \mu_x$), then show that $\frac{d^2 \mu_x}{dt^2} + \gamma^2 B_0^2 \mu_x = 0$.
6. Define diamagnetism, paramagnetism, ferromagnetism hysteresis.

7. Three consecutive absorption lines at 64.275 cm^{-1}, 77.130 cm^{-1} and 89.985 cm^{-1} have been observed in a microwave spectrum for a linear rigid diatomic molecule. Compute the moment of inertia with respect to the bond axis passing through the centre of mass and moment of inertia with respect to an axis passing through centre of mass and perpendicular to the bond axis.

8. Obtain the expression for the rotational energy of rotating rigid diatomic molecule.

Section–C
(Objective Type Questions)

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

1. The moment of inertia of two point masses about an axis through their centre of mass in a plane perpendicular to the massless rigid rod is given by (Given r_0 = separation between point masses and μ = reduced mass) :

   (a) $\frac{1}{2}\mu r_0^2$

   (b) μr_0^2

   (c) $\frac{3}{2}\mu r_0^2$

   (d) $\frac{2}{3}\mu r_0^2$

2. The energy change in an electronic transition is of the order of :

   (a) 5 – 10 eV

   (b) 10^{-2} eV

   (c) 0.1 eV

   (d) 1 keV

3. Pure rotational spectrum of a diatomic molecule consists of :

   (a) two equally spaced lines

   (b) three equally spaced line

   (c) many equally spaced lines

   (d) no regular pattern

4. The correct matching pair of spectral term with Lande factor 'g' is :

   (a) $^2d_{5/2}$ $5/6$

   (b) $^2d_{5/2}$ $6/5$

   (c) $^2d_{3/2}$ $3/2$

   (d) $^2d_{3/2}$ $2/3$

5. In normal Zeeman effect, the d-energy level is split into :

   (a) 3

   (b) 4

   (c) 5

   (d) 6

6. The differential form of Gauss law in CGS system is :

(a) $\vec{V} . \vec{E} = \frac{\rho}{\varepsilon_0}$

(b) $\varepsilon_0 \, \text{div} \, \vec{E} = \rho$

(c) $\vec{V} . \vec{E} = 4 \pi \rho$

(d) $\text{div} \, \vec{E} = 4 \pi \sigma$

7. The total electrostatic energy of a system of sphere of radius r with uniform charge density q within it is given by :

(a) $\frac{q^2}{2r}$

(b) $\frac{q}{2r^2}$

(c) $\frac{3}{5} \frac{q^2}{r}$

(d) $\frac{2q}{r^2}$

8. The ration 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. The Poisson's equation in CGS Gaussian system is :

(a) $\nabla^2 V = -\frac{\rho}{\varepsilon_0}$

(b) $\nabla^2 V = -4\pi\rho$

(c) $\nabla^2 V = -4\pi r$

(d) $\nabla^2 V = 0$

10. The value of $\oint_C \vec{A} \cdot d\vec{l}$ along a square loop of side L in a uniform field $\vec{A}$ is :

(a) zero

(b) 2 LA

(c) 4 LA

(d) L^2A