

P - III (1+1+1) H / 21 (N)

2021

## PHYSICS (Honours)

Paper Code : VIII - A & B

[New Syllabus]

### Important Instructions for Multiple Choice Question (MCQ)

- Write Subject Name and Code, Registration number, Session and Roll number in the space provided on the Answer Script.

**Example** : Such as for Paper III-A (MCQ) and III-B (Descriptive).

Subject Code : 

III	A	&	B
-----	---	---	---

Subject Name : 

--

- Candidates are required to attempt all questions (MCQ). Below each question, four alternatives are given [i.e. (A), (B), (C), (D)]. Only one of these alternatives is 'CORRECT' answer. The candidate has to write the Correct Alternative [i.e. (A)/(B)/(C)/(D)] against each Question No. in the Answer Script.

**Example** — If alternative A of 1 is correct, then write :

1. — A

- There is no negative marking for wrong answer.

### মাল্টিপল চয়েস প্রশ্নের (MCQ) জন্য জরুরী নির্দেশাবলী

- উত্তরপত্রে নির্দেশিত স্থানে বিষয়ের (Subject) নাম এবং কোড, রেজিস্ট্রেশন নম্বর, সেশন এবং রোল নম্বর লিখতে হবে।

উদাহরণ — যেমন Paper III-A (MCQ) এবং III-B (Descriptive)।

Subject Code : 

III	A	&	B
-----	---	---	---

Subject Name :

- পরীক্ষার্থীদের সবগুলি প্রশ্নের (MCQ) উত্তর দিতে হবে। প্রতিটি প্রশ্নে চারটি করে সম্ভাব্য উত্তর, যথাক্রমে (A), (B), (C) এবং (D) করে দেওয়া আছে। পরীক্ষার্থীকে তার উত্তরের স্বপক্ষে (A)/(B)/(C)/(D) সঠিক বিকল্পটিকে প্রশ্ন নম্বর উল্লেখসহ উত্তরপত্রে লিখতে হবে।

উদাহরণ — যদি 1 নম্বর প্রশ্নের সঠিক উত্তর A হয় তবে লিখতে হবে :

1. – A

- ভুল উত্তরের জন্য কোন নেগেটিভ মার্কিং নেই।

**Paper Code : VIII - A**

Full Marks : 20

Time : Thirty Minutes

Choose the correct answer.

Each question carries 2 marks.

1. The state of polarization represented by the following equations

$$E_x = E_0 \sin(\omega t + kz) \text{ and } E_y = E_0 \cos(\omega t + kz) \text{ is —}$$

- (A) Ellipse
- (B) Circle
- (C) Hyperbola
- (D) Parabola

2. Energy stored in magnetic field is —

- (A)  $U_m = \int_V \vec{H} \cdot \vec{B} dV$
- (B)  $U_m = 2 \int_V \vec{H} \cdot \vec{B} dV$
- (C)  $U_m = \int_V \vec{H} \times \vec{B} dV$
- (D)  $U_m = \frac{1}{2} \int_V \vec{H} \cdot \vec{B} dV$

3. Which of the following is a unique property of laser?

- (A) Non-coherence
- (B) Speed
- (C) Coherence
- (D) Wavelength

4. The fractional refractive index change for a given optical fibre with refractive indices of core and cladding 1.5 and 1.49, respectively, is —
- (A) 0.0415
  - (B) 0.415
  - (C) 1.415
  - (D) 0.514
5. If the light of wavelength 546 nm becomes a plane polarized light when it is reflected at an angle of  $60^\circ$ , then the refractive index of glass is —
- (A) 1.414
  - (B) 1.33
  - (C) 1.732
  - (D) 0.866
6. How fast a particle must travel so that its mass becomes twice of its rest mass ?
- (A)  $0.5c$
  - (B)  $2c$
  - (C)  $c$
  - (D)  $\frac{\sqrt{3}}{2}c$
7. The Lorentz transformation will be converted to Galilean transformation when the relative velocity  $v$  between two frames will satisfy the condition —
- (A)  $v \gg c$
  - (B)  $v \ll c$
  - (C)  $v = c$
  - (D)  $v = \infty$

8. The miller indices of a plane having intercepts 2,3,4 units along X, Y and Z axes, respectively, are —
- (A) (6, 4, 3)
  - (B) (3, 4, 5)
  - (C) (2, 3, 4)
  - (D) (3, 2, 1)
9. For bcc crystal, the atomic radius is —
- (A)  $\frac{\sqrt{3}}{2}a$
  - (B)  $\frac{\sqrt{3}}{4}a$
  - (C)  $\frac{\sqrt{2}}{3}a$
  - (D)  $a$
10. If a 400 watt laser beam is concentrated by a lens into a cross-sectional area of  $2 \times 10^{-10}\text{m}^2$ , the value of Poynting vector is —
- (A)  $4 \times 10^{12}$  watt/m<sup>2</sup>
  - (B)  $4 \times 10^{10}$  watt/m<sup>2</sup>
  - (C)  $2 \times 10^{10}$  watt/m<sup>2</sup>
  - (D)  $2 \times 10^{12}$  watt/m<sup>2</sup>
-

P - III (1+1+1) H / 21 (N)

2021

## PHYSICS (Honours)

Paper Code : VIII - B

[New Syllabus]

Full Marks : 70

Time : Three Hours Thirty Minutes

*The figures in the margin indicate full marks.*

Answer any *five* questions, taking at least *one* from each group.

### Group - A

#### (Physical Optics II)

1. (a) Give the construction, theory and principle of operation of a Babinet's compensator to produce and analyse elliptically polarized light. How is it superior to quarter wave plate ?
- (b) A parallel beam of light is incident normally on the plane surface of a quartz crystal. Construct both the refracted wave front and the refracted rays when the optic axis of the crystal is perpendicular to the plane of the incidence. (2+3+3+2)+4
2. (a) Define specific rotation in an optically active substance. Discuss Fresnel's theory of rotation of the plane of polarization by an optically active substance. Derive an expression for the angle by which the plane of polarization of a plane polarized light is rotated in passing through a thickness  $t$  of the crystal. How can you experimentally justify the Fresnel's theory?
- (b) The rotation in the plane of polarization in a certain substance is  $10^\circ$  per cm. Calculate the difference between the refractive indices for right-handed and left handed circularly polarized light in the substance ( $\lambda = 589.3\text{nm}$ ).
- (c) State Brewster's law and show that the reflected and refracted components are mutually perpendicular to each other. (1+2+3+2)+3+3

3. (a) What is population inversion? With the help of simple energy level diagram, show how population inversion is achieved in *He-Ne* gas laser.
- (b) What do you mean by Einstein *A*, *B* coefficients? Show that the ratio  $\frac{A_{mn}}{B_{mn}} = \frac{8\pi h\nu^3}{c^3}$ , the symbols used here have their usual meanings.
- (c) Define numerical aperture (*NA*) of an optical fibre and show that it is related to fractional index change  $\Delta$ , by the relation  $NA = n_1\sqrt{2\Delta}$ , where  $n_1$  is the refractive index of core of the fibre. (1+5)+5+3

### Group - B

#### (Electromagnetic Theory and Special Theory of Relativity)

4. (a) Consider the electromagnetic fields

$$E_y = -H_0\mu_0\omega\left(\frac{a}{\pi}\right)\sin\left(\frac{\pi x}{a}\right)\sin(kz - \omega t)$$

$$H_x = H_0k\left(\frac{a}{\pi}\right)\sin\left(\frac{\pi x}{a}\right)\sin(kz - \omega t)$$

$$H_z = H_0\cos\left(\frac{\pi x}{a}\right)\cos(kz - \omega t)$$

All other components are zero.  $a$ ,  $H_0$ ,  $k$  and  $\omega$  are constants. Verify by direct substitution that the given components satisfy Maxwell's curl equations for vacuum containing no free charges or currents provided  $\mu_0\epsilon_0\omega^2 = k^2 + (\pi/a)^2$ .

Also find the displacement current and the Poynting vector.

- (b) Obtain the wave equation for electromagnetic waves in a conducting medium. How does it differ from that for an insulating medium? (6+2+2)+4
5. (a) Derive an expression for Rayleigh scattering cross-section. Distinguish between Rayleigh scattering and Thomson scattering.

- (b) Write down Cauchy's formula for dispersion and hence show that the dispersive power varies inversely as the cube of wavelength.
- (c) The kinetic energy of an electron is 0.1MeV. Find the speed of the electron according to classical mechanics and relativistic mechanics. (Given rest mass energy of the electron = 0.511MeV) 6+4+4
6. (a) Derive an expression for the relativistic Doppler effect of light. Compare your result with classical Doppler effect.
- (b) Prove that photon has zero rest mass.
- (c) The proper mean life of a particle is  $2.2 \times 10^{-8}$ sec. It is found to be  $1.1 \times 10^{-5}$ sec. when the particle is in motion. Calculate the speed of the particle.
- (d) What is the norm of a four vector? What are space like and time like four vectors? (4+3)+2+2+3

### Group - C

#### (Solid State Physics and Electric and Magnetic Properties of Matter)

7. (a) What are Miller indices? Determine the interplanar spacing between two parallel planes with Miller indices  $(h, k, l)$  in a cubic crystal of sides  $a$ .
- (b) Derive Laue's equation and hence deduce Bragg's law of diffraction of X-rays by crystal planes.
- (c) The spacing of planes in a crystal is  $1.2 \text{ \AA}$  and the angle for the 1st order Bragg's reflection of X-rays is  $30^\circ$ . Determine the energy of the beam of X-rays in eV. (1+4)+(4+2)+3
8. (a) Deduce Langevin's theory of para magnetism and hence show that the susceptibility of a paramagnetic substance is inversely proportional to the absolute temperature. What is Curie temperature?
- (b) The magnetic field strength in a piece of a material of  $Fe_2O_3$  at 300K is  $1.2 \times 10^6 \text{ A/m}$ . If the magnetic susceptibility of  $Fe_2O_3$  at 300K is  $1.4 \times 10^{-3}$ , determine the flux density and intensity of magnetization in  $Fe_2O_3$ .
- (c) What are Ferrites ? (7+1)+4+2

9. (a) Deduce Clausius-Mossotti relation for non-polar dielectric materials. How is the relation modified if the dielectric is polar?
- (b) What do you mean by Hall effect? Find the expression for Hall co-efficient.
- (c) Calculate the conductivity of intrinsic germanium at 300K temperature. Given that at 300K the intrinsic carrier concentration, electron mobility and hole mobility are  $2.4 \times 10^{19} \text{m}^{-3}$ ,  $0.38 \text{m}^2 \text{v}^{-1} \text{s}^{-1}$  and  $0.19 \text{m}^2 \text{v}^{-1} \text{s}^{-1}$ , respectively.  
(4+2)+(2+3)+3
-