WEST BENGAL UNIVERSITY OF TECHNOLOGY

PH-201

PHYSICS-I

Time Allotted: 3 Hours | Full Marks: 70

The questions are of equal value.
The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

GROUP A
(Multiple Choice Type Questions)

1. Answer any *ten* questions. $10\times1 = 10$

(i) An interference pattern is observed by Young's double slit experiment. If the separation between coherent sources is halved and the distance of screen from coherent sources is doubled, the new fringe width-

(A) becomes double (B) becomes one fourth

(C) remains same (D) becomes four times

(ii) In Fraunhofer diffraction the incident wavefront is

(A) plane (B) spherical

(C) cylindrical (D) elliptical

(iii) The ratio of Einstein's A and B co-efficients, i.e., $\frac{A_{21}}{B_{21}}$ is proportional to

(A) v (B) v^2

(C) v^3 (D) v^4

(iv) Effective number of atoms per unit cell for BCC crystal is

(A) 1 (B) 2

(C) 3 (D) 4

(v) The de Broglie wavelength of a particle with mass m and kinetic energy E is

(A) $\frac{2mh}{\sqrt{E}}$ (B) $\frac{h}{\sqrt{(2mE)}}$

(C) $\frac{h}{2mE}$ (D) $\frac{2mh}{E}$

(vi) The potential energy of a particle executing SHM of amplitude a is equal to its kinetic energy when displacement of the particle is

(A) $\pm a$ (B) $\pm\frac{a}{2}$

(C) $\pm\frac{a}{4}$ (D) $\pm\frac{a}{\sqrt{2}}$

(vii) Superposition of two mutually perpendicular SHMs of equal time period, equal amplitude and phase difference is $\frac{\pi}{2}$ form

(A) circle (B) ellipse

(C) straight line (D) oblique ellipse

(viii) For large value of damping constant, the Q-factor

(A) increases (B) decreases

(C) remains same (D) tends to zero

(ix) The output of a laser has a pulse width of 30 ms and average output power of 0.6 Watt. The energy deposited per pulse is

(A) 0.0018 J (B) 0.018 J

(C) 0.18 J (D) 18 J

(x) Heisenberg's uncertainty relation is

(A) $\Delta x \Delta t \geq \frac{h}{2}$ (B) $\Delta x . \Delta p \geq \frac{h}{2}$

(C) $\Delta L \Delta t \geq \frac{h}{2}$ (D) $\Delta L . \Delta E \geq \frac{h}{2}$

(xi) If the velocities of E-Ray and O-Ray are v_e and v_o respectively, then it has been seen that inside the negative crystal

(A) $v_e > v_o$ (B) $v_e = v_o$

(C) $v_o > v_e$ (D) $v_e = v_o = 0$

(xii) When a white light is incident on a plane diffraction grating the central maxima will be

(A) dark (B) white

(C) blue (D) red

(xiii) The wavelength of black body changes with its absolute temperature as

(A) $\lambda \propto \frac{1}{T}$ (B) $\lambda \propto T$

(C) $\lambda \propto \frac{1}{T^2}$ (D) $\lambda \propto T^2$

(xiv) The energy equivalent of 1g of mass is

(A) 9×10^{20} ergs (B) 9×10^{10} ergs

(C) 9×10^{30} ergs (D) 90 ergs

(xv) The optical rotation produced by an optically active substance can be measured by using

(A) Polaroid (B) Interferrometer

(C) Nicol prism (D) Polarimeter

GROUP B
(Short Answer Type Questions)

Answer any *three* questions. 3×5 = 15

2. (a) The potential energy of a particle of mass 'm' is given by $\frac{1}{2}m\omega^2x^2$, where ω is a constant. Show that the particle is executing simple harmonic motion. 3+2

(b) A mechanical oscillator has initial energy $E_0 = 50$ joule, having a damping coefficient $b = 1s^{-1}$. Calculate the relaxation time.

3. Newton's rings are observed in reflected light of wave length $\lambda = 590$ nm. The diameter of the 10th dark ring is 5 mm. Find the radius of curvature of the lens and the thickness of the air film. 3+2

4. What do you mean by absorption of radiation, spontaneous emission of radiation and stimulated emission of radiation? Why stimulated emission is used for laser action instead of spontaneous emission of radiation? 1+1+1+2

5. What is decay constant (or relaxation time)? In damped harmonic motion, calculate the time in which the energy of the system falls to e^{-1} times of its initial value. 2+3

6. (a) What do you mean by a perfectly black body? 2

   (b) Show graphically, how the energy density varies with frequency (or the wavelength) of black body radiation for different temperatures. 3

GROUP C
(Long Answer Type Questions)

Answer any *three* questions. $3 \times 15 = 45$

7. A particle of mass 'm' executes one dimensional motion under a restoring force proportional to displacement from equivalent position and a damping force proportional to its velocity (v).

   (a) Set up the equation of motion and solve it. 2+3

   (b) Find the condition for weakly damped, critically damped and over damped motion. 3

   (c) Show that for weakly damped motion, the logarithm of the ratio of successive amplitude on the same side of mean position is constant. 2

   (d) Show that the average energy E of vibration decays according to the law: $E = E_0 e^{-2\gamma t}$ (where the damping force is $-bv$ and $\gamma = b/2m$). 5

8. (a) Estimating the average human body to have a total surface area of $1.5 m^2$ and skin temperature of 30° C, find the energy that one would lose in space in 30 sec (Assume the emissivity of the skin surface to be 0.9). 3

   (b) In a two slit interference experiment with electrons, calculate the fringe width if the electrons are accelerated through a potential difference of 50V (Take the separation between the slits to be 0.1 mm and the screen distance to be 10 m). What is the change in fringe width if the electrons are replaced by protons? (Take $M_p = 2000\ M_e$) 2+2

   (c) In Compton Effect a free electron collides with a photon. Now if the electron is replaced by a Helium nucleus, find the minimum wavelength of light that is to be used to observe the Compton shift. (Assume that the apparatus measuring the shift can unambiguously measure a shift of 10% of the wavelength used). Would you suggest the use of X- rays ($\lambda = 0.1$ nm) for measuring the Compton shift with Helium nucleus as target? (Justify your answer). 3+1

(d) In quantum mechanics why is it important to introduce the concept of group velocity? (Illustrate using both relativistic and non relativistic cases) 2

(e) To what velocity must we accelerate a particle so that its Compton wavelength equals its de Broglie wavelength? 2

9. (a) What are the physical significance of Miller indices? Deduce the expression for the interplanar spacing d of the set of (hkl) plane of a cubic lattice. 1+3

(b) Find the Miller indices of a plane having intercepts of $6a$, $4b$ and $2c$ on the x–, y– and z– axes respectively. Determine also the intercepts of two other planes one on each side of this plane and having these indices. 2+2

(c) Metallic iron changes from B.C.C. to F.C.C. at 910°C. At this temperature, the atomic radii of iron atom in the two structures are 0.1258 nm and 0.1292 nm respectively. Calculate the volume change in percentage during this structural change. 3

(d) Draw a characteristic X-ray spectrum showing the K_α, K_β and L_α, L_β lines. Explain the significance of higher wavelength of K_α with respect to K_β line and lower wavelength of K_α with respect to L_α line. Which of these lines shows maximum intensity? 1+2+1

10.(a) In Newton's ring arrangement if the incident light consists of two wavelengths 4000Å and 4002Å. Calculate the distance (from the point of contact) at which the rings will disappear. Assume that the radius of curvature of the curved surface is 400 cm. 4+4+2+2+3

(b) A single slit Fraunhofer diffraction pattern is formed using white light at normal incidence. For what wavelength of light does the third maximum coincides with the fourth minimum for light of wavelength 4000Å?

(c) What is Rayleigh's criterion?

(d) What is numerical aperture (N.A) of a microscope?

(e) Two spectrum line (λ = 6200Å) have a separation of 0.652Å. Find the minimum number of lines a diffraction grating must have to just resolve the doublet in the second-order spectrum.

11.(a) Define Einstein's A, B coefficients. What are their units? Relate spontaneous and stimulated emission probabilities and hence derive the relations among Einstein's A, B coefficients. 1+2+3

(b) A pulsed laser is constructed with a ruby crystal as the active element. The ruby rod contains typically a total of 3×10^{19} Cr^{3+} ions. If the laser emits light at 6943Å wavelength, then find the total energy available per pulse, assuming the total population inversion to occur. 2

(c) A quarter-wave plate is placed between two crossed-polaroids. If the optic axis of the quarter-wave plate makes an angle of 45° with the pass axis of either polaroid and an unpolarized light of intensity I_0 is incident on the first polaroid, find out the intensity of light that comes out of the second polaroid. If the quarter-wave plate is replaced by a half-wave plate, obtain the intensity of the light from the second polaroid. 2+2

(d) What is Brewster's law? How is Brewster's angle connected to the refractive index of the medium? Discuss the nature of polarization of the reflected and refracted rays when unpolarized light is incident at the Brewster's angle. 1+1+1