

Ph.D. ENTRANCE EXAMINATION, APRIL 2021

PHYSICS

Time : Two Hours

Maximum : 100 Marks

Part A

*Answer all questions.**Each question carries 2 marks.**Circle the most appropriate choice in the given answer sheet.*

1. The largest wavelength of light falling on double slits separated by $1.5\mu\text{m}$, for which there is a first order maximum is in the :
(a) Ultraviolet range. (b) Visible range.
(c) Infrared range. (d) X-ray range.
2. In a multi-stage R-C coupled amplifier, the coupling capacitor :
(a) Limits the low frequency response.
(b) Limits the high frequency response.
(c) Reduces the amplitude of input signal.
(d) Blocks d.c. component without affecting the frequency response.
3. Are the three points whose position vectors are $2i + 3j - 4k$, $i - 2j + 3k$ and $-7j + 10k$ collinear ?
(a) Yes. (b) No.
(c) Cannot be determined. (d) None of these.
4. The number of independent fundamental solutions in n -th order ordinary differential equation is
(a) $n - 1$. (b) n .
(c) $n + 1$. (d) $2n - 1$.
5. The continuity equation is a combination of which of the two laws ?
(a) Ohm's law and Gauss law.
(b) Ampere law and Gauss law.
(c) Ohm's law and Ampere law.
(d) Maxwell law and Ampere law.

Turn over

6. The inductance of a coaxial cable with inner radius a and outer radius b , from a distance d is, given by :

(a) $L = \frac{\mu_0 d}{2\pi} \ln\left(\frac{b}{a}\right)$.

(b) $L = 2\pi\mu d \ln\left(\frac{b}{a}\right)$.

(c) $L = \frac{\mu_0}{\pi} \ln\left(\frac{b}{a}\right)$.

(d) 0.

7. The Clausius-Mossotti equation of dielectrics is :

(a) $\frac{n\alpha}{3\epsilon_0} = \frac{\epsilon_r - 1}{\epsilon_r + 2}$.

(b) $\frac{n\alpha}{3\epsilon_0} = \frac{\epsilon_r + 1}{\epsilon_r - 2}$.

(c) $\frac{n\alpha}{3\epsilon_0} = \frac{\epsilon_r + 1}{\epsilon_r + 2}$.

(d) $\frac{n\alpha}{3\epsilon_0} = \frac{\epsilon_r - 1}{\epsilon_r + 2}$.

8. A particle is confined in a one dimensional potential box with impenetrable walls at $x = \pm a$. Its energy eigenvalue is 2 eV and corresponds to the Eigen function of the first excited state. The lowest possible energy of the particle is :

(a) 2.0 eV.

(b) 0.5 eV.

(c) 4.0 eV.

(d) 1.0 eV.

9. According to Dulong-Petit's law, the specific heat of a solid :

(a) Is proportional to the temperature.

(b) Does not depend on temperature.

(c) Depends on square of temperature.

(d) Is inversely proportional to temperature.

10. An atom is placed in a magnetic field of sufficient strength for splitting the 3p level. The number of levels resulting due to splitting will be :

(a) 1.

(b) 2.

(c) 3.

(d) 4.

11. Thermal runaway in a transistor biased in the active region is due to :
- (a) Change in reverse collector saturation current due to rise in temperature.
 - (b) Breakdown under reverse biasing.
 - (c) Changes in β which increases with temperature.
 - (d) Base-emitter voltage which decreases with rise in temperature.
12. Which of the following can be a wave function ?
- (a) $\cot x$.
 - (b) $\sin x$.
 - (c) $\tan x$.
 - (d) $\sec x$.
13. The number of degrees of freedom of two particles moving on a space curve and having constant distance between them is :
- (a) 2.
 - (b) 1.
 - (c) 3.
 - (d) 4.
14. The quark content of neutron is :
- (a) uud.
 - (b) uds.
 - (c) uss.
 - (d) udd.
15. The packing fraction of BCC lattice is :
- (a) 52 %.
 - (b) 68 %.
 - (c) 74 %.
 - (d) 34 %.
16. The number of optical branches in a primitive cell consisting of 'n' atoms is :
- (a) $3n$.
 - (b) $3n - 3$.
 - (c) $3n + 1$.
 - (d) $3n - 1$.
17. Which among the following is/are the properties of a particle moving under central forces ?
- (a) The path of the orbit is a plane curve.
 - (b) The angular momentum is constant.
 - (c) Areal velocity is constant.
 - (d) All of these.

Turn over

18. In a microcanonical ensemble, a system A of fixed volume is in contact with a large reservoir B. Then :

Select one :

- (a) A can exchange neither energy nor particles with B.
- (b) A can exchange both energy and particles with B.
- (c) A can exchange only energy with B.
- (d) A can exchange only particles with B.

19. Two unbiased coins are tossed. What is the probability of getting at most one head ?

- (a) $\frac{1}{2}$.
- (b) $\frac{2}{3}$.
- (c) $\frac{1}{4}$.
- (d) $\frac{3}{4}$.

20. Carnot cycle consists of :

- (a) Two constant volume and two reversible adiabatic processes.
- (b) Two isothermal and two reversible adiabatic processes.
- (c) Two constant pressure and two reversible adiabatic processes.
- (d) One constant volume, one constant pressure and two reversible adiabatic processes.

21. If A is a 3×3 matrix with $\det[A] = 5$ then $\det[2A]$ is :

- (a) 5.
- (b) 10.
- (c) 20.
- (d) 40.

22. Stock and Anti-stock lines are observed in _____.

- (a) Infrared spectrum.
- (b) Fluorescence spectrum.
- (c) Raman spectrum.
- (d) Mossbauer spectrum.

23. Which law signifies conservation of energy of a thermodynamic system ?

- (a) Zeroth law of thermodynamics.
- (b) First law of thermodynamics.
- (c) Second law of thermodynamics.
- (d) Third law of thermodynamics.

24. The value of $\sqrt{i} + \sqrt{-i}$ is :

(a) i .

(b) $\sqrt{2}$.

(c) 1.

(d) $\sqrt{3}$.

25. Laser printing and Xerox copier works on the principles of _____.

(a) Magnetic lensing.

(b) Adsorption.

(c) Refraction and reflection.

(d) Electrostatics.

(25 × 2 = 50 marks)

Part B

Answer any **ten** questions.

Each question carries 5 marks.

1. Derive the Lagrangian of a free particle in spherical polar co-ordinate system.
2. Explain why the ground state of hydrogen shows no first order Zeeman Effect ?
3. The saturation magnetic induction of Ni is 0.64 Weber/ m². If the density of Ni is 8906 kg/m³ and its atomic weight is 58.7, calculate the magnetic moment of Ni atom in Bohr Magneton.
4. A two-level system has energies zero and E. The level with zero energy is non- degenerate while the level with energy E is triply degenerate. Calculate the mean energy of a classical particle in this system at temperature T.
5. Copper crystallizes as fcc, its atomic radius is 0.1278 nm. Compute the interplanar spacing for (111) and (3 2 1) planes.
6. Explain Fermi-Dirac distribution function. Plot this function for various temperatures including 0K.
7. What is the quark model of particle physics ? Draw the diagram of baryon decuplet. Write its spin and parity.
8. Discuss the recurrence relations of Legendre differential equation.
9. Explain the BCS theory of superconductivity.
10. A simple harmonic oscillator of mass m_0 and angular frequency ω is perturbed by an additional potential bx^3 . Evaluate the first order correction to the ground state energy of the oscillator.

Turn over

11. Starting from Maxwell's equations, derive inhomogeneous wave equations in terms of scalar potential Φ and vector potential $\vec{A}$.
12. Calculate the energy of an electron below the Fermi level at a temperature 200K for $f(E) = 0.9$ and Fermi energy $E_F = 3 \text{ eV}$.
13. Define following terms used for OPAMP :
 - (i) Slew rate.
 - (ii) Unity gain bandwidth.
 - (iii) Gain error factor.
 - (iv) CMRR.
14. (a) Define Dirac matrices and discuss the relations among them.
(b) Setup Klein-Gordon equation.
15. Discuss the Gamow's theory of Alpha decay.

(10 × 5 = 50 marks)