

**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  $\beta$  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.

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  $3 \times 3$  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.*

- Derive the Lagrangian of a free particle in spherical polar co-ordinate system.
- Explain why the ground state of hydrogen shows no first order Zeeman Effect ?
- The saturation magnetic induction of Ni is 0.64 Weber/ m<sup>2</sup>. If the density of Ni is 8906 kg/m<sup>3</sup> and its atomic weight is 58.7, calculate the magnetic moment of Ni atom in Bohr Magnetron.
- 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.
- Copper crystallizes as fcc, its atomic radius is 0.1278 nm. Compute the interplanar spacing for (111) and (3 2 1) planes.
- Explain Fermi-Dirac distribution function. Plot this function for various temperatures including 0K.
- What is the quark model of particle physics ? Draw the diagram of baryon decuplet. Write its spin and parity.
- Discuss the recurrence relations of Legendre differential equation.
- Explain the BCS theory of superconductivity.
- A simple harmonic oscillator of mass  $m_0$  and angular frequency  $w$  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  $\phi$  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)