**M/P ENT - 126 Total No. of Pages : 12** 

Seat No.

# M.Phil./Ph.D. Entrance Examination, October - 2021 PHYSICS

Day and Date : Thursday, 28 - 10 - 2021

**Total Marks : 100** 

Time : 10.00 a.m. to 12.00 Noon

**Instructions**: 1) All questions are compulsory.

- 2) Each question carries 2 marks.
- 3) Answers should be marked in the given OMR answer sheet by darkening the appropriate option.
- 4) Use black ball point pen only for marking the circle. Do not make any stray mark on the OMR Answer Sheet.
- Follow the instructions given on OMR Sheet. 5)
- Rough work shall be done on the sheet provided at the end of question 6) paper.
- Only non-programmable calculators are allowed. 7)
- For an  $N \times N$  matrix consisting of all ones, 1)
  - A) all eigenvalues = 1
  - B) all eigenvalues = 0
  - the eigenvalues are  $1, 2, \dots, N$ C)
  - D) one eigen value = N and other = 0
- 2) The mean free path of molecules of a gas at pressure P and temperature T is  $\lambda_1$ . If the pressure of the gas molecule is reduced to P/2 and temperature is increased to 2T then the correct relation is:

(Consider that  $\lambda_2$  is the mean free path after change in pressure and temperature)

- B)  $\lambda_2 = 4\lambda_1$ D)  $\lambda_2 = 16\lambda_1$ A)  $\lambda_2 = 2\lambda_1$ C)  $\lambda_2 = 8\lambda_1$
- 3) For an electromagnetic wave traveling in free space, the electric field is given by  $\vec{E} = 100 \cos(10^8 t + kx) \hat{j} V/m$ . The wavelength of wave in *meter* is:
  - A) 2π B)  $4\pi$
  - C) 6π 3π D)

4) Given that  $\Psi_1$  and  $\Psi_2$  are eigenstates of a Hamiltonian with eigenvalues  $E_1$  and  $E_2$  respectively. The energy uncertainty in the state  $(\Psi_1 + \Psi_2)$  is:

A) 
$$-\sqrt{E_1 E_2}$$
  
B)  $\frac{1}{2} |E_1 - E_2|$   
C)  $\frac{1}{2} (E_1 + E_2)$   
D)  $\frac{1}{\sqrt{2}} |E_2 - E_1|$ 

5) Which of the following statements is true for the energies of the terms of the carbon atom in the ground state electronic configuration  $1s^2 2s^2 2p^2$ ?

A) 
$${}^{3}P < {}^{1}D < {}^{1}S$$
  
B)  ${}^{3}P < {}^{1}S < {}^{1}D$   
C)  ${}^{3}P < {}^{1}F < {}^{1}S$   
D)  ${}^{3}P < {}^{1}F < {}^{1}D$ 

- 6) The radius of the  ${}^{125}_{53}I$  nucleus is given to be 6 *fm*. In a collision with an incoming aluminium nucleus  ${}^{27}_{13}Al$ , the two nuclei have their surfaces just touching each other. The distance between the centres of the two nuclei at this instant is:
  - A) 8 fm
     B) 7.6 fm

     C) 9.6 fm
     D) 5.6 fm
- 7) In Atwood machine, two masses  $m_1$  and  $m_2$  suspended by a massless inextensible string over a frictionless, massless pulley. If the kinetic energy (T)

and potential energy (V) are given by  $T = \frac{1}{2}m_1\dot{x}_1^2 + \frac{1}{2}m_1\dot{x}_2^2$  and  $V = -m_1gx_1 - m_2gx_2$  respectively, then the Lagrangian equation of motion in terms of single variable is:

A) 
$$\ddot{x}_1 = \frac{m_1 - m_2}{m_1 + m_2} g$$
  
B)  $\ddot{x}_1 = \frac{m_2 - m_1}{m_1 - m_2} g$   
C)  $\ddot{x}_1 = \frac{m_2 - m_1}{m_1 + m_2} g$   
D)  $\ddot{x}_1 = \frac{m_1 m_2}{m_1 + m_2} g$ 

- 8) Assume that the intensity of solar radiation at Earth's surface is 1000  $W/m^2$  and that the sunlight is normal to a completely reflecting surface with an area of  $3m^2$ . The total radiation force that exerted on that surface is:
  - A)  $2 \times 10^{-6} N$ B)  $3 \times 10^{-6} N$ C)  $2 \times 10^{-5} N$ D) 3N

9) If a unit vector  $\vec{a}$  makes an angle  $\pi/3$  with  $\hat{i}$ ,  $\pi/4$  with  $\hat{j}$  and an acute angle  $\theta$  with  $\hat{k}$  then, the value of  $\theta$  is:

- A)  $\theta = 45^{\circ}$ B)  $\theta = 30^{\circ}$ C)  $\theta = 60^{\circ}$ D)  $\theta = 90^{\circ}$
- 10) The root mean square *(rms)* speeds of Hydrogen atoms at 500 K,  $V_{H}$  and Helium atoms at 2000 K,  $V_{He}$  are related as:
  - A)  $V_H > V_{He}$ B)  $V_H = V_{He}$ C)  $V_H^2 = V_{He}^2$ D)  $V_H < V_{He}$
- 11) Consider a one-dimensional infinite potential well of width *a*. The system contains five non-interacting electrons, each of mass *m*, at temperature T = 0K. The energy of the highest occupied state is:

A) 
$$\frac{25\pi^2\hbar^2}{2ma^2}$$
  
B)  $\frac{10\pi^2\hbar^2}{2ma^2}$   
C)  $\frac{5\pi^2\hbar^2}{2ma^2}$   
D)  $\frac{9\pi^2\hbar^2}{2ma^2}$ 

- 12) Which of the vibrational mode of CO<sub>2</sub> molecule is degenerate?
  - A) Symmetric stretching mode
  - B) Asymmetric stretching mode
  - C) Both symmetric as well as asymmetric stretching mode
  - D) Bending mode

13) Two blocks of mass  $m_1$  and  $m_2$  coupled by a spring of force constant k are placed on a smooth horizontal surface. If the Lagrangian of the system is

given by  $L = \frac{1}{2}m_1\dot{x}_1^2 + \frac{1}{2}m_2\dot{x}_2^2 - \frac{1}{2}k(x_1 - x_2)^2$ , then natural frequencies of the system in terms of reduced mass  $\mu$  are:

A) 
$$\omega_1 = \sqrt{\frac{k}{\mu}} \text{ and } \omega_2 = \sqrt{-\frac{k}{\mu}}$$
  
B)  $\omega_1 = 0 \text{ and } \omega_2 = \sqrt{\frac{k}{\mu}}$   
C)  $\omega_1 = 0 \text{ and } \omega_2 = \sqrt{\frac{\mu}{k}}$   
D)  $\omega_1 = 0 \text{ and } \omega_2 = \sqrt{-\frac{k}{\mu}}$ 

14) Antineutrino has :

A) Charge = 0, Spin = 0, Helicity = 
$$+1$$
 and Lepton number =  $-1$ 

B) Charge = 0, Spin = 
$$\frac{1}{2}$$
, Helicity = +1 and Lepton number = 1

C) Charge = 0, Spin = 
$$\frac{1}{2}$$
, Helicity = +1 and Lepton number = -1

D) Charge = 
$$-1$$
, Spin =  $\frac{1}{2}$ , Helicity =  $-1$  and Lepton number = 1

- 15) Which of the following is not a correct differential form of thermodynamic potential?
  - A) dU = TdS PdV B) dH = TdS + VdP
  - C) dF = SdT + PdV D) dG = -SdT + VdP
- 16) A charged particle *A* is moving at a speed much less than *c*, deaccelerates uniformly. A second particle *B*, has one-half the mass, twice the charge, three times the velocity and four times the acceleration than particle *A*. According

to classical electrodynamics, the ratio  $\frac{P_B}{P_A}$  of the power radiated is:

C) 48 D) 64

- 17) The Lagrangian of a charged particle in an electromagnetic field is described as  $L = \frac{1}{2}mv^2 - q\varphi + q\vec{v}.\vec{A}$ . The corresponding Hamiltonian is : A)  $H = \frac{1}{2}(\vec{P} + q\vec{A})^2 - q\varphi$ B)  $H = \frac{1}{2}(\vec{P} - q\vec{A})^2 - q\varphi$ C)  $H = \frac{1}{2}(\vec{P} + q\vec{A})^2 + q\varphi$ D)  $H = \frac{1}{2}(\vec{P} - q\vec{A})^2 + q\varphi$
- 18) Which of the following assumptions does Fermi's Golden Rule make?
  - A) Inelastic scattering and infrequent scattering
  - B) Weak scattering and infrequent scattering
  - C) Time independent scattering and weak scattering
  - D) Time dependent scattering and weak scattering
- 19) The transformation for a system of one degree of freedom is given by,  $Q = q \cos \alpha - p \sin \alpha$  and  $P = q \sin \alpha + p \cos \alpha$ . The generating function  $(F_1)$  for the transformation is:
  - A)  $F_1(q,Q) = \frac{1}{2}(q^2 Q^2)\cot\alpha + Qq\csc\alpha$
  - B)  $F_1(q,\mathbf{Q}) = \frac{1}{2}(q^2 Q^2)\cot\alpha Qq\csc\alpha$
  - C)  $F_1(q,Q) = \frac{1}{2}(q^2 + Q^2)\cot\alpha Qq\csc\alpha$
  - D)  $F_1(q,Q) = \frac{1}{2}(q^2 + Q^2)\cot\alpha + Qq\csc\alpha$
- 20) An ideal gas of N spinless atoms occupies a volume V at temperature T. Each atom has only two energy levels separated by an energy  $\Delta$ . The chemical potential ( $\mu$ ) of the system is:

A) 
$$\mu = -kTlog(e^{-\beta\varepsilon_1} + e^{-\beta\varepsilon_2})$$
 B)  $\mu = kTlog(e^{-\beta\varepsilon_1} + e^{-\beta\varepsilon_2})$ 

C) 
$$\mu = -kTlog(e^{-\beta\varepsilon_1} - e^{-\beta\varepsilon_2})$$
 D)  $\mu = -kTlog(e^{\beta\varepsilon_1} + e^{\beta\varepsilon_2})$ 

21) The average speed of an electron in the first Bohr orbit of an atom of atomic number Z is:

(Take, fine structure constant =  $\alpha = \frac{e^2}{\hbar c}$ )

A) 
$$v = Zc$$
  
B)  $v = \frac{Z\alpha}{c}$   
C)  $v = Zc\alpha$   
D)  $v = \frac{Zc}{\alpha}$ 

- 22) If the gauge function is given as  $\lambda = -\frac{qt}{4\pi\varepsilon_0 r}$ . The relation between transformed and original vector potential is :
  - A)  $\vec{A}' = \vec{A} \frac{qt}{4\pi\varepsilon_0 r^2}\hat{r}$ B)  $\vec{A}' = \vec{A} + \frac{qt}{4\pi\varepsilon_0 r^2}\hat{r}$ C)  $\vec{A}' = \vec{A} - \frac{qt}{4\pi\varepsilon_0 r}\hat{r}$ D)  $\vec{A}' = \vec{A} + \frac{qt}{4\pi\varepsilon_0 r}\hat{r}$
- 23) Fourier sine transform of  $\frac{1}{x}$  is :

A) 
$$\frac{\pi}{2}$$
  
B)  $\sqrt{\frac{\pi}{2}}$   
C)  $\frac{\sqrt{\pi}}{2}$   
D)  $\frac{\pi}{\sqrt{2}}$ 

24) The ground state and first excited state wave function of a one-dimensional infinite potential well are  $\psi_1$  and  $\psi_2$  respectively. When two spin-up electrons are placed in this potential. Which one of the following with  $x_1$  and  $x_2$  denoting the position of the two electrons correctly represents the space part of the ground state wave function of the system?

A) 
$$\frac{1}{\sqrt{2}} \Big[ \psi_1(x_1) \psi_2(x_1) - \psi_1(x_2) \psi_2(x_2) \Big]$$
  
B) 
$$\frac{1}{\sqrt{2}} \Big[ \psi_1(x_1) \psi_2(x_2) + \psi_1(x_2) \psi_2(x_1) \Big]$$

C) 
$$\frac{1}{\sqrt{2}} \left[ \psi_1(x_1) \psi_2(x_1) + \psi_1(x_2) \psi_2(x_2) \right]$$

D)  $\frac{1}{\sqrt{2}} \Big[ \psi_1(x_1) \psi_2(x_2) - \psi_1(x_2) \psi_2(x_1) \Big]$ 

25) Solution of linear differential equation  $xy' + 2y = 4x^2$  is:

A) 
$$y = x^{2} + \frac{c}{x}$$
  
B)  $y = x^{2} + \frac{c}{x^{2}}$   
C)  $y = x^{2} + \frac{c}{x^{2}}$   
D)  $y = x + \frac{c}{x^{2}}$ 

26) The method which involves controlled precipitation of a compound from the solution on a suitable substrate is:

A)	CVD	B)	SILAR
C)	Sol-gel	D)	CBD

- 27) The research which aims to find a solution for an immediate problem facing a society or an industrial/business organization is:
  - A) Applied research B) Industrial research
  - C) Theoretical research D) Fundamental research

# 28) The magnetometer whose working principle is characterized by Lorentz force is termed as:

- A) Induction magnetometer B) Magnetic magnetometer
- C) Magneto-resistive magnetometer D) SQUID magnetometer

29) Minimum interplanar spacing required for Bragg's diffraction is:

- A)  $\lambda/4$  B)  $\lambda/2$
- C)  $\lambda$  D)  $2\lambda$
- 30) Which of the following is not a role of hypothesis?
  - A) Guides the direction of the study
  - B) Determine feasibility of conducting the study
  - C) Identifies relevant and irrelevant facts
  - D) Provides framework for organizing the conclusions

31) Tapping mode in AFM is also called as:

C) Contact mode

- A) Non-contact mode B) Intermittent contact mode
  - D) Intermittent non-contact mode

32) Failure to acknowledge the borrowed material is a:

- A) Foot notes B) Casual Ignoring
- C) Copyrights D) Plagiarism
- 33) Which spectroscopy is based on the interaction of light with the chemical bonds within a material?
  - A) Atomic Absorption Spectroscopy (AAS)
  - B) Raman Spectroscopy
  - C) Nuclear Magnetic Resonance (NMR) Spectroscopy
  - D) Flame Spectroscopy

34) How closely individual measurements agree with each other is refers as?

- A) Error B) Accuracy
- C) Uncertainty D) Precision

35) In which technique, the difference in temperature between the sample and a reference material is examined against time or temperature.

A)	Raman	B)	DSC
C)	DTA	D)	NMR

36) The main stages for film formation in spin coating technique are:

- A) Deposition, spin up, spin off and pyrolysis
- B) Deposition, spin up, spin off and sublimation
- C) Deposition, spin up, spin off and evaporation
- D) Deposition, spin up, spin off and coating

- 37) The report written by a researcher for a specific field, reviewed by peer scholars before publication is known as:
  - A) Research monograph B) Research article
  - C) Patent D) Thesis

38) Which of the following is not a type of modulation scheme in RF systems?

- A) Shift Modulation (SM) B) Amplitude Modulation (AM)
- C) Frequency Modulation (FM) D) Phase Modulation (PM)

39) In SEM, the fraction of emission current leaving through the anode is known as:

- A) Heating current B) Filament current
- C) Beam current D) Probe current

40) Which of the electronic transition is not involved in UV-Visible region?

- A)  $\sigma \rightarrow \sigma^*$  B)  $n \rightarrow \sigma^*$
- C)  $\lambda \rightarrow \sigma^*$  D)  $n \rightarrow \Pi^*$

41) The quantitative standard of the published research article is judged by:

- A) Number of references used in research article
- B) Impact factor
- C) Number of citations to that article
- D) *h*-index
- 42) For IR spectroscopy, the molecule must have:
  - A) Spin moment B) Dipole moment
  - C) Round moment D) Linear moment

- 43) The method of deposition that requires an external current source for the deposition of metallic ions on the substrate:
  - A) Dip coating B) Spin coating
  - C) Electroplating D) Electroless plating
- 44) Microwave spectroscopy is used to get information about:
  - A) Accurate bond lengths and angles
  - B) Electric dipole moments
  - C) Centrifugal distortion constant
  - D) All of the above
- 45) In AFM, one of the disadvantages of contact mode scanning is:
  - A) Slow scan speed
  - B) Can't be done for rough surface samples
  - C) Higher possibility of tip damage
  - D) Very poor resolution of scanning
- 46) The weight loss in TGA is not attributed to:
  - A) Evaporation B) Decomposition
  - C) Reduction D) Absorption
- 47) In electrodeposition method, which electrode is used to close the current circuit in the electrochemical cell.
  - A) Counter electrode B) Working electrode
  - C) Reference electrode D) Ground electrode

- 48) The advantage of W filament for use in SEM is:
  - A) Large energy spread, and  $\Delta E$  is 3eV
  - B) Replacement is fairly straightforward
  - C) High work function of 4.7eV
  - D) Short service lifetime
- 49) Simultaneous displacement method is also known as:
  - A) Jacobi's method
  - B) Monte-Carlo method
  - C) Gauss Seidel method
  - D) Hamiltonian method
- 50) If (220), (311), (222), and (511) are the Bragg reflections of zinc ferrite, then the unit cell of zinc ferrite is:
  - A) FCC
  - B) HCP
  - C) BCC
  - D) Data is insufficient for interpretation

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# Rough Work