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M.Phil / Ph.D. Entrance Examination, July - 2022
PHYSICS

Day and Date : Friday, 15 - 7 - 2022**Total Marks : 100****Time : 02.00 p.m. to 04.00 p.m.**

- 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.
 - 5) Follow the instructions given on OMR Sheet.
 - 6) Rough work shall be done on the sheet provided at the end of question paper.
 - 7) Only non-programmable calculators are allowed.

- 1) A block of mass m is sliding on a wedge of mass M and wedge can slide on the horizontal table. The kinetic and potential energies in this system is given as :

$$T = \frac{1}{2}m[\dot{x}_M^2 + \dot{q}^2 + 2\dot{x}_M\dot{q}\cos\alpha] + \frac{1}{2}M\dot{x}_M^2; V = mg(h - q\sin\alpha).$$

The Lagrangian equation of motion of this system for generalized coordinate 'q' is :

- A) $m(\ddot{q} + \ddot{x}_M \sin\alpha) + mg \cos\alpha = 0$
- B) $M(\ddot{q} + \ddot{x}_M \cos\alpha) - mg \sin\alpha = 0$
- C) $M(\ddot{q} - \ddot{x}_M \cos\alpha) + mg \sin\alpha = 0$
- D) $m(\ddot{q} + \ddot{x}_M \cos\alpha) - mg \sin\alpha = 0$

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- 2) The blackbody at a temperature of 6000 K emits a radiation whose intensity spectrum peaks at 600 nm. If the temperature is reduced to 300 K, the spectrum will peak at:

A) 120 μm

B) 12 μm

C) 120 mm

D) 12 mm
- 3) The incorrect electromagnetic boundary condition for both static and time varying electromagnetic field at an interface between dielectric and perfect conductor is :

A) $E_{1t} = 0$ and $E_{2t} = 0$

B) $H_{1t} = 0$ and $H_{1t} = \rho_s$

C) $D_{1n} = \rho_s$ and $D_{1n} = 0$

D) $B_{1n} = 0$ and $B_{2n} = 0$
- 4) 10% of the bulbs produced in a factory are of red color and 2% are red and defective. If one bulb is picked up at random, determine the probability of its being defective if it is red:

A) 1/10

B) 1/2

C) 1/5

D) 1/4
- 5) Suppose the spin degrees of freedom of a 2-particle system can be described by a 21-dimensional Hilbert subspace. Which among the following could be the spin of one of the particles?

A) $\frac{1}{2}$

B) 3

C) $\frac{3}{2}$

D) 2

- 6) Suppose two fermions have identical coordinates $\vec{x}_1 = \vec{x}_2$. The antisymmetric wave function for this system of two fermions is :

A) $\Phi_A(\vec{x}_1, \vec{x}_1) = \frac{1}{\sqrt{2}}$

B) $\Phi_A(\vec{x}_1, \vec{x}_1) = \frac{1}{\sqrt{2}}[\psi(\vec{x}_1, \vec{x}_2) - \psi(\vec{x}_2, \vec{x}_1)]$

C) $\Phi_A(\vec{x}_1, \vec{x}_1) = \frac{1}{\sqrt{2}}[\psi(\vec{x}_1, \vec{x}_2) + \psi(\vec{x}_2, \vec{x}_1)]$

D) $\Phi_A(\vec{x}_1, \vec{x}_1) = 0$

- 7) If the Rydberg constant of an atom of finite nuclear mass is αR_∞ , where R_∞ is the Rydberg constant corresponding to an infinite nuclear mass, the ratio of the electronic to nuclear mass of the atom is:

A) $(1 - \alpha)$

B) $\frac{(\alpha - 1)}{\alpha}$

C) $\frac{(1 - \alpha)}{\alpha}$

D) $\frac{1}{\alpha}$

- 8) In a two-body elastic collision :

- A) The helicity of a participant cannot change.
- B) All the particle trajectories must lie in the same plane in the center of mass frame.
- C) The helicity of a participant can change
- D) The angular distribution is always spherically symmetric.

- 9) The number of distinct ways in which 4 particles can be distributed in 7 energy levels if i) they are classical particles ii) if they are Photons respectively is :

A) i) $\frac{7!}{4!}$ and ii) $\frac{7!}{4!3!}$

B) i) 4^7 and ii) 210

C) i) $4! 7!$ and ii) $\frac{7!}{4!3!}$

D) i) 7^4 and ii) 210

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- 15) An experiment is performed to search for evidence of the reaction $pp \rightarrow HK^+K^+$. The value of electric charge (Q), strangeness number (S) and baryon number (B) of the particle H is :
- A) $Q = 0, S = 1, B = 1$ B) $Q = 0, S = 2, B = 2$
C) $Q = 0, S = -2, B = 1$ D) $Q = 0, S = -2, B = 2$
- 16) A particle moves in a horizontal plane in a central force potential $U(r)$ with cartesian coordinates $x = r \cos \theta$ and $y = r \sin \theta$. The Hamiltonian of the particle is :
- A) $H = \frac{1}{2}m(\dot{r}^2 - r^2\dot{\theta}^2) + U(r)$ B) $H = \frac{1}{2}m(\dot{r}^2 + r^2\dot{\theta}^2) + U(r)$
C) $H = \frac{1}{2}m(\dot{r}^2 - r^2\dot{\theta}^2) - U(r)$ D) $H = \frac{1}{2}m(\dot{r}^2 + r^2\dot{\theta}^2) - U(r)$
- 17) A negatively charged particle accelerates with acceleration 3 mm/s^2 from East to West in a uniform electric field. The magnitude of the electric field if the particle has charge $q = 30 \text{ } \mu\text{C}$ and mass $m = 1 \text{ mg}$ is :
- A) 0.1 N/C B) 10 N/C
C) 1 N/C D) 100 N/C
- 18) If two vectors $\vec{a} = 2\hat{i} + 6\hat{j} + 27\hat{k}$ and $\vec{b} = \hat{i} + \lambda\hat{j} + \mu\hat{k}$ are parallel to each other, then the value of λ and μ is :
- A) $\lambda = \frac{2}{27}$ and $\mu = 3$ B) $\lambda = 3$ and $\mu = \frac{27}{2}$
C) $\lambda = 3$ and $\mu = \frac{2}{27}$ D) $\lambda = \frac{27}{2}$ and $\mu = 3$
- 19) A particle is moving in a plane with a constant radial velocity of 12 m/s and constant angular velocity of 2 rad/s . When the particle is at a distance $r = 8 \text{ m}$ from the origin, the magnitude of the instantaneous velocity of the particle in m/s is :
- A) $8\sqrt{15}$ B) $2\sqrt{37}$
C) 20 D) 10

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- 20) The highest and the lowest pressure in a Carnot engine that uses the photon gas as the working substance are $3 \times 10^{-8} \text{ Pa}$ and $2 \times 10^{-8} \text{ Pa}$ respectively. The efficiency of the Carnot engine is :

A) $\eta = 1 - \left(\frac{2}{3}\right)^{1/4}$	B) $\eta = 1 - \left(\frac{3}{2}\right)^{1/4}$
C) $\eta = 1 - \left(\frac{2}{3}\right)^4$	D) $\eta = 1 - \left(\frac{3}{2}\right)^4$

- 21) Consider a hypothetical world in which the electron has spin $\frac{3}{2}$ instead of $\frac{1}{2}$. What will be the electronic configuration for an element with atomic number $Z = 5$?

A) $1s^4, 2s^1$	B) $1s^3, 2s^1, 2p^1$
C) $1s^5$	D) $1s^2, 2s^2, 2p^1$

- 22) The Hamiltonian of the quantum mechanical rotator is $\hat{H} = \frac{\hat{L}^2}{2I}$. Assuming that the rotator can take only two angular momentum values $l = 0$ and $l = 1$, the partition function is :

A) $Z = 1 - 3e^{(-\beta\hbar^2/2I)}$	B) $Z = 1 + 3e^{(-\beta\hbar^2/I)}$
C) $Z = 1 + 3e^{(\beta\hbar^2/2I)}$	D) $Z = 1 + 3e^{(2\beta\hbar^2/I)}$

- 23) The two vector potentials are represented as : $\vec{A}_1(r,t) = -\frac{qt}{4\pi\epsilon_0 r^2} \hat{r}$ and

$\vec{A}_2(r,t) = A_0 \sin(kx - \omega t) \hat{y}$. Where A_0 , ω and k are constants. Which one of the following is correct?

- A) Both $\vec{A}_1$ and $\vec{A}_2$ obey coulomb gauge condition
 B) Only $\vec{A}_1$ obey coulomb gauge condition
 C) Only $\vec{A}_2$ obey coulomb gauge condition
 D) Both $\vec{A}_1$ and $\vec{A}_2$ don't obey coulomb gauge condition.

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- 24) A golf ball has a mass of 50 gm and a speed of 50 m/s. If the speed can be measured within accuracy of 2%, then the uncertainty in the position is :
- A) $\approx 10 \times 10^{-33}m$ B) $\approx 1 \times 10^{-33}m$
C) $\approx 1 \times 10^{-17}m$ D) $\approx 10 \times 10^{-17}m$
- 25) A free particle of mass M is located in a three-dimensional cubic potential well with impenetrable walls. The degeneracy of the fifth excited state of the particle is:
- A) 4 B) 8
C) 6 D) 12
- 26) The research which is mainly concerned with generalizations and with the formulation of a theory is:
- A) Pure research B) Basic research
C) Theoretical research D) Fundamental research
- 27) The thin film deposition technique where temperature and relative vapor pressure plays a crucial role is:
- A) Spin coating B) CBD
C) SILAR D) Dip coating
- 28) A radio technology that allows only one-way communication from transmitter to a receiver is generally referred as:
- A) Half-duplex RF systems B) Full-duplex RF systems
C) Simplex RF systems D) Compound RF systems
- 29) X-ray diffraction patterns are used for studying crystal structure of solids because of:
- A) They have very high energy; hence they can penetrate through solids
B) They are electromagnetic radiation and hence do not interact with matter (crystals)
C) Their wavelengths are comparable to inter-atomic distance in crystals
D) Their high frequency enables rapid analysis

- 30) The area under a DTA peak represents the change in:
A) Weight
B) Enthalpy
C) Temperature
D) Heat
- 31) The wavelength range associated with UV-Visible region is:
A) 400-800 nm
B) 200-800 μm
C) 400-800 μm
D) 200-800 nm
- 32) In electrodeposition method, which electrode is used for potential control and measurement in an electrochemical system is:
A) Counter electrode
B) Working electrode
C) Reference electrode
D) Ground electrode
- 33) The statement that introduces a research question and proposes an expected outcome of scientific study is:
A) Research objective
B) Title of research problem
C) Research hypothesis
D) Research variable
- 34) Chalcogenides refers to:
A) Sulphides, selenides and oxides
B) Ferrites, sulphides and tellurides
C) Tellurides, tungstates and selenides
D) Sulphides, selenides and tellurides
- 35) Which of the following is not a good feature of SEM?
A) high magnification
B) ability to polarize light
C) high resolution
D) great depth of focus
- 36) The correct statement regarding IR spectroscopy.
A) IR radiation is higher in energy than UV radiation
B) IR spectra gives information about the λ_{max} of the molecule
C) IR spectra records the scattering of the radiation
D) IR radiation is higher in wavelength than UV radiation

37) The best mode of an AFM to scan a chemically patterned surface is:

- | | |
|---------------------|----------------------|
| A) Repulsive mode | B) Contact mode |
| C) Non-contact mode | D) Intermittent mode |

38) The verbatim copying or reuse of one's own research is:

- | | |
|---------------|--------------------|
| A) Plagiarism | B) Self-plagiarism |
| C) Repetition | D) Foot notes |

39) The type of LaB_6 electron gun widely used in SEM is:

- | | |
|-------------------|---------------|
| A) Field emission | B) Schottky |
| C) Thermionic | D) Electronic |

40) The conceptual framework in which the research is carried out is:

- | | |
|------------------------|----------------------|
| A) Research hypothesis | B) Research synopsis |
| C) Research paradigm | D) Research design |

41) The chemical method that suitable for synthesis of single crystal:

- | | |
|-----------------|------------|
| A) SILAR | B) CBD |
| C) Hydrothermal | D) Sol-gel |

42) The diameter of an AFM tip is about:

- | | |
|------------------------|-----------------------|
| A) 15-25 μm | B) 15-25mm |
| C) 15-25nm | D) 15-25 $\text{\AA}$ |

43) In spray pyrolysis method, the temperature is not involved in:

- A) Solvent evaporation
- B) Precursor decomposition
- C) Aerosol generation and transportation
- D) Chemical compound formation

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- 44) The relationship between minimum wavelength of X-radiation generated from a target metal and applied voltage is given by:
- A) Bragg's equation
B) Moseley equation
C) Ilkovic equation
D) Duane-Hunt equation
- 45) A book on single specialized topic is termed as:
- A) Journal
B) Magazine
C) Monograph
D) Encyclopedia
- 46) The closeness of agreement between a measured value and a true value is:
- A) Precision
B) Error
C) Accuracy
D) Uncertainty
- 47) The thermal stability and material purity of the sample can be examined by:
- A) Raman analysis
B) FT-IR analysis
C) TGA analysis
D) NMR analysis
- 48) In stokes Raman scattering the energy transfer can take place between:
- A) Photon to molecule
B) Proton to molecule
C) Molecule to photon
D) Molecule to proton
- 49) The Newton Raphson method fails at:
- A) Floating points
B) Continuous points
C) Stationary points
D) Non-stationary points
- 50) The spectroscopy which is concerned with transitions between rotational energy levels in the molecule is:
- A) IR
B) Raman
C) Microwave
D) X-ray

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Rough Work

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