Seat No.	

M.Phil / Ph.D. Entrance Examination, September - 2022
PHYSICS
Sub. Code : 58795

Day and Date : Friday, 23 - 09 - 2022   **Total Marks : 100**
Time : 04.00 p.m. to 06.00 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) Let ω_p, ω_d and ω_α be the cyclotron frequencies of proton, deuterons and alpha particles, respectively in the same magnetic field. The correct relation of their frequencies is: (Assume that the particle masses are in the ratio 1:2:4)

a) $\omega_p = \omega_d = \omega_\alpha$ b) $\omega_p = \omega_d > \omega_\alpha$

c) $\omega_p > \omega_d = \omega_\alpha$ d) $\omega_p < \omega_d = \omega_\alpha$

2) The correct statement related to the Fermi energy (E_F) and the chemical potential (μ) of a metal is:

a) $\mu < E_F$ at 0 K   b) $\mu < E_F$ at finite temperature

c) $\mu = E_F$ only at 0 K   d) $\mu = E_F$ at finite temperature

3) A particular mechanical system depending on two coordinates u and v has kinetic energy $T = v^2 u^2 + 2v^2$, and potential energy $V = v^2 - u^2$. Its Lagrangian equations of motion are:

a) $v^2 \ddot{u} - 2\dot{v}\dot{u} + 2u = 0; 2\ddot{v} + v(\dot{u}^2 - 1) = 0$

b) $v^2 \ddot{u} - 2\dot{v}\dot{u} + 2u = 0; 2\ddot{v} + v(\dot{u}^2 + 1) = 0$

c) $v^2 \ddot{u} - 2\dot{v}\dot{u} + 2u = 0; 2\ddot{v} - v(\dot{u}^2 - 1) = 0$

d) $v^2 \ddot{u} - 2\dot{v}\dot{u} + 2u = 0; 2\ddot{v} + v(\dot{u}^2 + 1) = 0$

P.T.O.

4) If the $\vec{a}, \vec{b}$ and $\vec{c}$ are unit vectors such that $(\vec{a} + \vec{b} + \vec{c}) = 0$, then value of $(\vec{a}.\vec{b} + \vec{b}.\vec{c} + \vec{c}.\vec{a})$ is:

a) 2

b) $-\dfrac{2}{3}$

c) $-\dfrac{3}{2}$

d) $\dfrac{2}{3}$

5) If L_x, L_y and L_z are respectively the x, y and z components of angular momentum operator L. The commutator $[L_x L_y, L_z]$ is equal to:

a) $i\hbar\left(L_x^2 + L_y^2\right)$

b) 0

c) $i\hbar\left(L_x^2 - L_y^2\right)$

d) $2i\hbar L_z$

6) Which of the following molecules give no infrared or microwave spectra but rotational Raman spectra?

a) HC1, HCN

b) CO_2, CH_4

c) O_2, H_2

d) CO, H_2O

7) The particle decay $d + d \rightarrow {}_2^4 He + \pi^0$ is forbidden, because it violates conservation of:

a) Baryon number

b) Isospin

c) Charge

d) Strangeness

8) The specific heat (C_v) or heat capacity of a lattice at temperature T is C. If the temperature of lattice is doubled then assuming the Debye model of specific heat at low temperature, the new specific heat of the lattice is:

a) 2C

b) 4C

c) C/2

d) 8C

9) For a medium $\sigma = 0, \mu = 2\mu_0, \varepsilon = 4\varepsilon_0$ and $\vec{B} = 2\mu\cos(\omega t - 5y)\hat{z}$. The value of ω is:

a) $\dfrac{5c}{2\sqrt{2}}$

b) $\dfrac{c}{2\sqrt{2}}$

c) $\dfrac{2c}{5\sqrt{2}}$

d) $\dfrac{5c}{2\sqrt{5}}$

10) A person measures the period of a simple pendulum inside a stationary lift and finds it to be T seconds. If the lift accelerates upward with an acceleration $\dfrac{9}{4}$, then the time period will he:

a) T

b) $\dfrac{T}{4}$

c) $\dfrac{2T}{\sqrt{5}}$

d) $2T\sqrt{5}$

11) The ground state of the realistic helium atom is of course nondegenerate. Consider a hypothetical helium atom in which two electrons are replaced by two identical spin-one particles of negative charge. Neglect spin dependent forces. For this hypothetical atom, the degeneracy of the ground state is:

a) 4

b) 10

c) 8

d) 6

12) The wavefunction of a hydrogen atom is given by the following superposition of energy eigen functions $\psi_{n/m}(\vec{r})$ (n, l, and m are the usual quantum numbers) :

$$\psi(\vec{r}) = \frac{\sqrt{2}}{\sqrt{7}}\psi_{100}(\vec{r}) - \frac{3}{\sqrt{14}}\psi_{210}(\vec{r}) + \frac{1}{\sqrt{7}}\psi_{322}(\vec{r})$$

The expectation value of the energy $\langle E \rangle$ and the expectation value of L^2 are, respectively :

a) $\dfrac{229}{504}E_0$ and $\dfrac{12\hbar^2}{7}$

b) $\dfrac{101}{504}E_0$ and $\dfrac{12\hbar^2}{7}$

c) $\dfrac{229}{504}E_0$ and $\hbar^2$

d) $\dfrac{101}{504}E_0$ and $\hbar^2$

13) If $f_1(z) = z^2 + z$ and $f_2(z) = z^3$ where $z = (x+iy)$, then which one of following statement is correct:

   a)   Both $f_1(z)$ and $f_2(z)$ are not analytic everywhere

   b)   Only $f_2(z)$ is analytic everywhere

   c)   Both $f_1(z)$ and $f_2(z)$ are analytic everywhere

   d)   Only $f_1(z)$ is analytic everywhere

14) A classical particle with total energy E moves under the influence of a potential $V(x) = 3x^3 + 2x^2y + 2xy^2 + y^3$. The average potential energy, calculated over a long time is equal to :

   a) $\dfrac{2E}{3}$ b) $\dfrac{E}{3}$

   c) $\dfrac{E}{5}$ d) $\dfrac{2E}{5}$

15) Consider a particle with three possible spin states: $s = 0$ and $s = \pm 1$. There is a magnetic field h present and the energy for a spin state 's' is $-hs$. The system is at a temperature T. Which of the following statements is true about the entropy $S(T)$?

   a) $S(T) = $ In 3 at $T = 0$ and $S(T) = 0$ at higher T

   b) $S(T) = 0$ at $T = 0$ and $S(T) = $ In 3 at higher T

   c) $S(T) = 0$ at $T = 0$ and $S(T) = 3$ at higher T

   d) $S(T) = $ In 3 at $T = 0$ and $S(T) = 3$ at higher T

16) If $\vec{E}_1 = xy\hat{i} + 2\,yz\hat{j} + 3xz\hat{k}$ and $\vec{E}_2 = y^2\hat{i} + \left(2xy + z^2\right)\hat{j} + 2\,yz\hat{k}$ then :

   a)   Both are impossible electrostatic fields

   b)   Both are possible electrostatic fields

   c)   Only $\vec{E}_1$ is a possible electrostatic field

   d)   Only $\vec{E}_2$ is a possible electrostatic field

17) A particle of mass m is moving in a potential $V(x) = \dfrac{1}{2}m\omega_0^2 x^2 + \dfrac{a}{2mx^2}$ where

ω_0 and a are positive constants. The angular frequency of small oscillations for the simple harmonic motion of the particle about a stable minimum of the potential $V(x)$ is:

a) $4\omega_0$

b) $\sqrt{2}\omega_0$

c) $4\sqrt{2}\omega_0$

d) $2\omega_0$

18. The wave function of a free particle in one dimension is given by $\psi(x) = A\sin x + B\sin 3x$. Then $\psi(x)$ is an eigen state of:

a) the position operator

b) the Hamiltonian

c) the momentum operator

d) the parity operator

19. A simple harmonic one-dimensional oscillator has energy levels $E_n = (n + 1/2)\hbar\omega$, where ω is the characteristic oscillator (angular) frequency and $n = 0, 1, 2, ..$ Suppose the oscillator is in thermal contact with a heat reservoir kT at temperature T. The mean energy of the oscillator as a function of the temperature T is :

a) $\langle E \rangle = -\dfrac{\hbar\omega}{2}\coth(\beta\hbar\omega/2)$

b) $\langle E \rangle = \dfrac{\hbar\omega}{2}\cot(\beta\hbar\omega/2)$

c) $\langle E \rangle = \dfrac{\hbar\omega}{2}\coth(-\beta\hbar\omega/2)$

d) $\langle E \rangle = \dfrac{\hbar\omega}{2}\coth(\beta\hbar\omega/2)$

20) The induced emf in a loop having 12 turns of wire has a magnitude of 1.5 V when the magnetic flux is changed from 6 $T.\ m^2$ to 9 $T.\ m^2$. The time required for this flux change is:

   a) 6s

   b) 9s

   c) 24s

   d) 18s

21) Solution of differential equation $\dfrac{dy}{dx} + 3x^2 y = 6x^2$ is:

   a) $y = 2 + Ce^{-x3}$

   b) $y = 2 - Ce^{-x3}$

   c) $y = 2 + Ce^{x3}$

   d) $y = 2 - Ce^{x3}$

22) The violation of CP invariance theorem was observed in:

   a) Decay of beta particles

   b) Decay of alpha particles

   c) Decay of heavy ions

   d) Decay of K^0 meson

23) The scattering of particles by a potential can be analysed by Born approximation. In particular, if the scattered wave is replaced by an appropriate plane wave, the corresponding Born approximation is known as the first-Born approximation. Such an approximation is valid for

   a) large incident energies and weak scattering potentials.

   b) large incident energies and strong scattering potentials.

   c) small incident energies and weak scattering potentials.

   d) small incident energies and strong scattering potentials.

24) Let A be the $N \times N$ matrix. The incorrect statement for matrix A is:

   a) A scalar λ is an eigenvalue of the $N \times N$ matrix. A if and only if the matrix $(A - \lambda I)$ is singular.

   b) An $N \times N$ matrix. A has at least one and at most N distinct complex eigenvalues.

   c) If $\lambda_1, \lambda_2, \ldots \lambda_k$ are distinct eigenvalues of the same matrix A, then the corresponding eigenvectors $V_1, V_2, \ldots V_k$ are linearly dependent.

   d) The product of the eigenvalues equals its determinant.

25) A beam of neutral atom passes through a Stern-Gerlach apparatus and split up into five equally spaced lines. The total angular momentum (P_J) of the atom is:

a) $\sqrt{11}\,\hbar$

b) $\sqrt{6}\,\hbar$

c) $\sqrt{5}\,\hbar$

d) $\sqrt{12}\,\hbar$

26) The research which is relies on only experience or observation is:

a) Pure research

b) Basic research

c) Conceptual research

d) Empirical research

27) Which of the following is not a main step in spray pyrolysis method?

a) Atomization of the precursor solution

b) Control on pH

c) Transportation of aerosol

d) Decomposition of precursor on substrate

28) Which of the following RF system that can transmit and receive frequency simultaneously at each end?

a) Half-duplex

b) Full-duplex

c) Simplex RF system

d) Compound RF system

29) Which of the following substrate is not suitable for thin film deposition by electrodeposition technique?

a) FTO

b) ITO

c) Ceramic

d) Ti foil

30) In XRD, the broadening of diffraction peaks at half of the maximum intensity is effects on:

a) Peak intensity

b) Crystallite size

c) Miller indices

d) Peak position

31) In AFM. the normal force between the probe and the sample is measured by the cantilever bending. which follows :

a) Brewster's law

b) Hook's law

c) Pascal's law

d) Moseley's law

32) The difference between measured value and true value of a quantity represents:

a) Accuracy of measurement.

b) Precision of measurement.

c) Error in measurement.

d) Uncertainty in measurement.

33) *Turnitin* and *iThenticate* are the leading tools in research fleld for the use of :

a) Reference management

b) Data visualization and analysis

c) Plagiarism detection

d) Making graphical abstracts

34) The thickness of the film synthesized by spin coating method is related to the:

a) square root of rotation time

b) square of rotation speed

c) square of rotation time

d) square root of rotation speed

35) The samples which cannot be imaged in SEM:

a) Metals and alloys

b) Liquids and biological specimens in their native state

c) Ceramic and rocks

d) Powders and polymers

36) To be a Raman active material, molecule must have:

a) Isotropic polarizability

b) Isotropic dipole moment

c) Anisotropic polarizability

d) Anisotropic dipole moment

37) Chromophore exhibits absorption of electromagnetic radiations in:

a) IR region

b) Microwave region

c) Visible or UV region

d) X-ray region

38) Which one of the following is not an indication of quality of researcher?

    a)   Impact factor   b) h - index

    c)   Number of citations   d) i -10 index

39) The formula does not require that the interval of integration be divided into an even number of intervals is:

    a)   Trapezoidal   b)   Newton Raphson

    c)   Euler   d)   Simpson's 1/3

40) In SILAR, the forces which causes the adsorption of the ions in the solution on the surface of substrate are:

    a)   Cohesive forces   b)   Van-der Waals forces

    c)   Chemical attractive forces   d)   All of the above

41) In NaCl crystal, a family of planes separated by 200 *nm*. If the first order maximum is observed at an incidence angle of 30°, then the wavelength of X-ray scattered from this crystal is:

    a)   2 *nm*   b)   200 *μm*

    c)   200 *nm*   d)   20 *nm*

42) For microwave spectroscopy, the molecule must possess permanent:

    a)   Polarizability   b)   Quadrupole moment

    c)   Dipole moment   d)   Linear moment

43) The social networking platform for people doing research is:

    a)   Scopus   b)   ResearchGate

    c)   SciFinder   d)   Web of Science

44) IR spectrum is a plot of:

    a)   % Transmittance, wavenumber   b)   % Reflectance, time

    c)   % Reflectance, wavenumber   d)   % Transmittance, time

45) Disadvantage of LaB_6 filaments over W filaments is:
   a) Five to ten times brighter than W filaments
   b) Longer service life
   c) Chemically reactive when it gets hot
   d) Improved image quality

46) A research problem is feasible only when :
   a) It has utility and relevance
   b) It is new and adds something to knowledge
   c) It is researchable
   d) All of the above

47) In which electrochemical technique, the constant current is imposed between the working and auxiliary electrodes while the resulting potential response is monitored.
   a) Chronocoulometry
   b) Chronoamperometry
   c) Chronopotentiometry
   d) Both a) and b)

48) AFM can measure forces as small as:
   a) $10^{-2}N$
   b) $10^{-12}N$
   c) $10^{-7}N$
   d) $10^{-5}N$

49) In Simpson's 1/3 rule, the order of fitting polynomial is:
   a) 2
   b) 3
   c) 1
   d) 4

50) In which technique, the change in mass of the sample due to evaporation, decomposition and interaction with the atmosphere is taken into account for analysis.
   a) AAS
   b) DSC
   c) TGA
   d) NMR

OOOO

Rough Work

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