राष्ट्रीय प्रौद्योगिकी संस्थान दिल्ली

NATIONAL INSTITUTE OF TECHNOLOGY DELHI

(शिक्षा मंत्रालय, भारत सरकार के अधीन एक स्वायत्त संस्थान)

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NOTICE

Advt. No. 08/ 2024: Answer Key and Representations Invited for the Domain

Knowledge Tests held on 10.02.2025

Position	**Applied Sciences (Physics): Assistant Professor Grade II (Pay Level 10) (On Contract Basis)**
Date	**10.02.2025 (Monday)**
Examination Time	**4:00 Pm – 5:00 PM**

Following is the attached answer key. If any appeared candidate for the domain knowledge test has any representations against the questions, may submit by filling up the following Google Form on or before 12.02.2025 11:59 PM. After that no representations will be considered.

Google Form Link:
https://docs.google.com/forms/d/e/1FAIpQLSdSL0LirlHEwHuM5H3WDc2ls6hztZlKe_SeUZG1XVxWfACQ7Q/viewform?usp=preview

Question Paper for the post of (Assistant Professor Grade II)
Applied Science Physics

Q.1 Which of the following quantities is Lorentz invariant, where $\vec{E}$ *and* $\vec{B}$ are electric and magnetic fields?

(a) $\vec{E}^2 - \vec{B}$

(b) $|\vec{E} \times \vec{B}|^2$

(c) $\vec{E}^2 - c^2\vec{B}^2$

(d) $\vec{E}^4 - c^4\vec{B}^4$

Q.2 If $\vec{E}(x,y,z,t) = \vec{E}_0 \cos(2x + 3y - \omega t)$ where 'ω' is a constant, be the electric field of an electromagnetic wave travelling in vacuum. Which of the following directions is a possible choice for $\vec{E}_0$?

(a) $\hat{\imath} - \frac{3}{2}\hat{\jmath}$

(b) $\hat{\imath} + \frac{2}{5}\hat{\jmath}$

(c) $\hat{\imath} + \frac{4}{3}\hat{\jmath}$

(d) $\hat{\imath} - \frac{2}{3}\hat{\jmath}$

Q.3. The electrostatic potential $V(x,y)$ in free space in a region is given by $V(x,y) = e^{4x} + f(x) - y$. If the x-component of the electric field (E_x) and $V(x,y)$are zero at origin, the $f(x)$ is

(a) $-e^{4x}$

(b) $x^2 - e^{4x}$

(c) $x - e^{4x}$

(d) x^2e^{-4x}

Q.4. The electric field of a linearly polarized light in free space is given by $\hat{x}\,E_0 \cos(kz - \omega t)$ where E_0 is the amplitude , ω and k are the angular frequency and the wavevector, respectively. If ε_0 is the permittivity of the vacuum and 'c' is the speed of light .The time averaged energy density associated with the electric field will be given by

(a) $\frac{1}{4}c\varepsilon_0 E_0^2$

(b) $\frac{1}{2}c\varepsilon_0 E_0^2$

(c) $c\varepsilon_0 E_0^2$

(d) $2c\varepsilon_0 E_0^2$

Q.5. A particle with charge 'q' and mass 'm' is subjected to a constant horizontal electric field 'E' and a constant vertical gravitational field characterized by acceleration due to gravity 'g'. If the particle starts from rest, what will be the equation of its trajectory?

(a) parabolic (b) elliptic

(c) straight line (d) circular

Q.6 A circular loop having radius R and an uniform line charge density λ, the electric field, calculated at a distance 'x' directly above the centre of the loop. The maximum value of electric field is found if 'x' is equal to

(a) $\frac{R}{\sqrt{3}}$ (b) $\frac{R}{\sqrt{2}}$

(b) (c) $\frac{R}{2\sqrt{2}}$ (d) $\frac{R}{2\sqrt{3}}$

Q.7 A conducting sphere of radius R has charge Q on its surface. If the charge on the sphere and its radius are doubled, the energy associated with the electric field will

(a) increase two times (b) increase eight times

(c) remain the same (d) decrease four times

Q.8 The ground state of ^{159}Yb nucleus has spin-parity $J^P = 0^+$, while the first excited state has $J^P = 2^+$. The electromagnetic radiation emitted when the nucleus makes a transition from the first excited state to ground state is like-

(a) Electric dipole (b) Electric quadrupole

(c) Magnetic dipole (d) Magnetic quadrupole

Q.9 The Compound nucleus has property

(a) Longer life time (b) Independent of entrance channel

(c)Narrow resonance (d) Above all

Q.10 A particle, which is a composite state of three quark u, d, and s has electric charge, spin and strangeness respectively, equal to

(a) 1, 0, 1 (b) $\frac{1}{2}$, 0 -1

(c) 0, $\frac{1}{2}$, -1 (d) -1, 0, $-\frac{1}{2}$

Q.11 What will be strangeness of a neutral particle if it has baryon no = +1 and Isospin projection $I_3 = \frac{1}{2}$

(a) -1 (b) -2

(c) +1 (d) +2

Q.12 Spin and parity of $^{19}_{8}$O nuclei as predicted by shell model are

(a) 5/2 and odd (b) 5/2 and even

(c) 3/2 and odd (d) 3/2 and even

Q.13 The radius of a $^{64}_{29}Cu$ nucleus is measured to be $4.8 \times 10^{-13}\ cm$. The radius of a $^{27}_{12}Mg$ nucleus can be estimated to be

(a) $3.6 \times 10^{-13}\ cm$ (b) $2.86 \times 10^{-13}\ cm$

(c) $5.2 \times 10^{-13}\ cm$ (d) $8.6 \times 10^{-13}\ cm$

Q.14 The vector field $yz\,\hat{\imath} + x\,\hat{\jmath}$ in cylindrical polar coordinates is

(Symbols have their usual meanings)

(a) $\rho \sin\varphi \cos\varphi\,[z+1]\hat{\rho} + \rho\,[cos^2\varphi - zsin^2\varphi\,]\hat{\varphi}$

(b) $\rho \sin\varphi \cos\varphi\,[z-1]\hat{\rho} + \rho\,[cos^2\varphi + zsin^2\varphi\,]\hat{\varphi}$

(c) $\rho \sin\varphi \cos\varphi\,[z+1]\hat{\rho} - \rho\,[cos^2\varphi - zsin^2\varphi\,]\hat{\varphi}$

(d) $\rho \sin\varphi \cos\varphi\,[z-1]\hat{\rho} - \rho\,[cos^2\varphi + zsin^2\varphi\,]\hat{\varphi}$

Q.15 The value of the definite integral $\int_0^{\pi} \frac{d\theta}{5+4\cos\theta}$ is

(a) $\frac{2\pi}{3}$ (b) $\frac{4\pi}{3}$

(c) $\frac{\pi}{3}$ (d) π

Q.16 The trace of a real 4×4 matrix $M = \exp(P)$, where $P = \begin{bmatrix} 0 & 0 & 0 & \frac{\pi}{4} \\ 0 & 0 & -\frac{\pi}{4} & 0 \\ 0 & \frac{\pi}{4} & 0 & 0 \\ -\frac{\pi}{4} & 0 & 0 & 0 \end{bmatrix}$ is

(a) $2\sqrt{2}$ (b) $\frac{\pi}{4}$

(c) 0 (d) 2

Q.17 The scale factors corresponding to the covariant metric tensor g_{ij} in spherical polar coordinates are

(a) $1, r^2, r^2 sin^2\theta$ (b) $1, r, 1$

(c) $1, r, \theta$ (d) $1, r, r \sin\theta$

Q.18 The value of the integral $\int_0^\infty x^3 e^{-x^2} dx$ is equal to

(a) 2.5 (b) 3.5

(c) 0.5 (d) 1.5

Q.19 The function (x) satisfies the differential equation $x\frac{dy}{dx} + 2y = \frac{\cos \pi x}{x}$. If (1)=1, the value of $y(2)$ is

(a) $\frac{1}{2}$ (b) $\frac{1}{4}$

(c) $\frac{1}{3}$ (d) $\frac{1}{8}$

Q.20 Identify the CORRECT statement for the following vectors $\vec{a} = 3\hat{\imath} + 2\hat{\jmath}$ and $\vec{b} = \hat{\imath} + 2\hat{\jmath}$

(a) The vectors $\vec{a}$ and $\vec{b}$ are linearly independent

(b) The vectors $\vec{a}$ and $\vec{b}$ are orthogonal

(c) The vectors $\vec{a}$ and $\vec{b}$ are linearly dependent

(d) The vectors $\vec{a}$ and $\vec{b}$ are normalized

21. The total number of Zeeman component for the $^1F_3$-$^1D_2$ transition is
(a) 4 (b) 3 (c) 6 (d) 10

22. Two levels in an atom whose nuclear spin is I = 3, have the designations $^2D_{3/2}$ and $^2P_{1/2}$. The expected number of components in the hyperfine structure of the corresponding spectral line is
(a) 4 (b) 10 (c) 3 (d) 6

23. The rotational energies of a diatomic molecule of rotational constant B joule are-
(a) 0, 2B, 6B, 12B,.... (b) 0, 2B, 4B, 6B,...
(c) 2B, 4B, 8B, 12B... (d) 0, 4B, 8B, 12B,...

24. Population inversion in the He-Ne laser is produces by -
(a) the collisions of the excited helium atoms with the excited neon atoms
(b) the collisions of the ground state helium atoms with the excited state neon atoms
(c) the collisions of the excited helium atoms with the ground state of neon atoms
(d) the collisions of the ground state helium atoms with the ground state neon atoms

25. In a band structure calculation, the dispersion relation for electrons is found to be $\varepsilon_k = \beta\,[\cos k_x a + \cos k_y a + \cos k_z a]$, where β is a constant and a is the lattice constant. The effective mass at the boundary of the first Brillouin zone is:

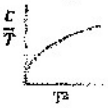
(a) $\frac{\hbar^2}{2\beta a^2}$ (b) $\frac{4\hbar^2}{5\beta a^2}$ (c) $\frac{\hbar^2}{3\beta a^2}$ (d) $\frac{2\hbar^2}{5\beta a^2}$

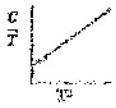
26. Choose the *incorrect* statement from the following:
(a) Conductivity of metals decreases with increase in temperature
(b) Conductivity of semiconductors increases with increase in temperature
(c) Silicon is an indirect band gap semiconductor
(d) Galium Arsenide is an indirect band gap semiconductor

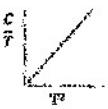
27. Experimental study shows that there exists an energy gap in a superconductor. Which statement is true?
(a) The temperature dependence of electronic specific heat indicates the existence of an energy gap
(b) The gap separate the lowest excited state in a superconductor from the ground state
(c) The energy gap in superconductor is similar to that of insulator.
(d) The existence of energy gap is accounted for the BCS theory.

28. Which one of the following graphs best represents the behavior of $\frac{C}{T}$ vs.T^2 for a non-magnetic metal, where C is the heat capacity and T is the temperature?

(a) 

(b) 

(c) 

(d) 

29. Which statement(s) is/are correct-
I. Magnetism in solids arises solely due to spins of unpaired electrons.
II. Diamagnetic materials exhibit a small negative susceptibility.
III. The spontaneous magnetization of a ferromagnetic material vanishes above a Curie temperature.
IV. For $T < T_N$, the antiferromagnetic material behaves as paramagnetic (where, T_N is Neel Temperature).

(a) only I and II (b) only II and III

(c) only I and III (d) only II and IV

30. The Lagrangian of a particle of mass m moving in one dimension is $L = \exp(\beta t)\left[\frac{m\dot{x}^2}{2} - \frac{kx^2}{2}\right]$, where β and k are positive constant. The equation of motion of the particle is:
(a) $\ddot{x} + \frac{k}{m}x = 0$ (b) $\ddot{x} + \dot{x} = 0$ (c) $\ddot{x} + \beta\dot{x} + \frac{k}{m}x = 0$ (d) $\ddot{x} - \beta\dot{x} + \frac{k}{m}x = 0$

31. Two particles each of rest mass, m, collides head on and stick together. Before collision the speed of each mass was 0.8 times the speed of light in free space. The mass of final entity is
(a) $\frac{5m}{4}$ (b) $\frac{5m}{3}$ (c) $\frac{5m}{6}$ (d) $\frac{10m}{3}$

32. Let (p, q) and (P, Q) be two pairs of canonical variables. The transformation equations $Q = q^x \cos yp$, and $P = q^x \sin yp$ present a canonical transformation, if

(a) $x = \frac{1}{2}, y = 2$ (b) $x = 2, y = \frac{1}{2}$ (c) $x = 1, y = \frac{1}{2}$ (d) $x = \frac{1}{2}, y = 1$

33. Two bodies of mass m and 3m are connected by a spring constant, k. The frequency of normal mode is
(a) $\omega = \sqrt{(3k/4m)}$ (b) $\omega = \sqrt{(4k/3m)}$ (c) $\omega = \sqrt{(2k/3m)}$ (d) $\omega = \sqrt{(3k/2m)}$

34. A satellite is moving in a circular orbit around the earth. If **T**, **V** and **E** are its average kinetic, average potential and total energies respectively, then which one of the following options is correct?

(a) $\mathbf{V} = -\frac{\mathbf{T}}{2}, \mathbf{E} = \frac{\mathbf{T}}{2}$ (b) $\mathbf{V} = -2\mathbf{T}, \mathbf{E} = -\mathbf{T}$

(c) $\mathbf{V} = -\mathbf{T}, \mathbf{E} = 2\mathbf{T}$ (d) $\mathbf{V} = -2\mathbf{T}, \mathbf{E} = \mathbf{T}$

35. The Hamilton's canonical equations of motion in terms of Poisson Brackets are-

(a) $\dot{q} = [p, H]$; $\dot{p} = [q, H]$ (b) $\dot{q} = [H, p]$; $\dot{p} = [H, q]$

(c) $\dot{q} = [H, q]$; $\dot{p} = [H, p]$ (d) $\dot{q} = [q, H]$; $\dot{p} = [p, H]$

Q36. Consider the trasition of liquid water to steam as water boils at a temperature of 100°C under a pressure of 1 atmosphere. Which one of the following quantities does **not** change discontinuously at the transition?

(a) The Gibbs free energy

(b) The internal energy

(c) The entropy

(d) The specific Volume

Q37. Let ΔW be the work done in a quasistatic reversible thermodynamic process. Which of the following statements about ΔW is correct?

a) ΔW is a perfect differential if the process is isothermal.

b) ΔW is a perfect differential if the process is adiabatic.

c) ΔW is always a perfect differential.

d) ΔW cannot be a perfect differential.

Q38. If ψ_{nlm} denotes the eigenfunction of the Hamiltonian with a potential V = V(r), then then the expectation value of the operator $L_x^2 + L_y^2$ in the state

$$\Psi = \frac{1}{5}\left[3\psi_{211} + \psi_{210} - \sqrt{15}\ \psi_{21-1}\right]$$

is -

(a) $39\hbar^2/25$

(b) $13\hbar^2/25$

(c) $9\hbar^2/25$

(d) $26\hbar^2/25$

Q39. The physical phenomenon that cannot be used for memory storage applications is

(a) large variation in magnetoresistance as a function of applied magnetic field

(b) variation in magnetization of a ferromagnet as a function of applied magnetic field

(c) variation in polarization of a ferroelectric as a function of applied electric field

(d) variation in resistance of a metal as a function of applied electric field

Q40. A ripple counter's speed is limited by the propagation delay of:

a) Each flip-flop

b) All flip-flops and gates

c) The flip flops only with gates

d) Only circuit gates

Q41: An operational amplifier of gain 10 is used to amplify a sinusoidal signal with a peak amplitude of 0.5 V and frequency of 25kHz. What should be the minimum slew rate of the op-amp used?

(a) 0.185 V/μs

(b) 0.385 V/μs

(c) 0.785 V/μs

(d) 0.985 V/μs

Q42: Square Wave response of an amplifier shows its behavior at –

(a) Low frequencies

(b) High frequencies

(c) Both low and high frequencies

(d) None of these

Q43: Current I_1 and I_2 flow when large forward voltage V_1 and V_2 are Applied to a semiconductor diode. If $V_1 = 2V_2$, then the value of the reverse saturation current is –

(a) $\frac{I_1 I_2}{I_1 + I_2}$

(b) $\frac{I_1^2}{I_2}$

(c) $\frac{I_2^2}{I_1}$

(d) $\frac{I_1^2 + I_2^2}{I_1 + I_2}$

Q.44. For two assemblies of equal volumes and at same temperature and pressure, the entropy on removing partition becomes

$$S_T = 2S + 2Nk\ In\ 2$$

The factor $2Nk\ In\ 2$ arises due to –

(a) The Indistinguishability of classical particles

(b) The distinguishability of classical particles

(c) The steady flow of particles

(d) The absence of interparticle interaction

Q45. Choose the correct alternatives.

At the same temperature-

(a) A fermion gas will exert the greatest pressure

(b) A boson gas will exert the greatest pressure

(c) A fermion gas will exert the least pressure

(d) A boson gas will exert the least pressure

Q46. The pressure for a non-interacting Fermi gas with internal energy U at temperature T is

(a) $P = \frac{3U}{2V}$

(b) $P = \frac{2U}{3V}$

(c) $P = \frac{3U}{5V}$

(d) $P = \frac{1U}{2V}$

Q47. The entropy of a photon gas is proportional to –

(a) T

(b) T^2

(c) T^3

(d) T^4

Q48: The Born's approximation is applicable for –

(a) High energy, low atomic number for scatterer

(b) Low energy, low atomic number for scatterer

(c) High energy, high atomic number for scatterer

(d) Low energy, high atomic number for scatterer

Q49: For a one dimensional harmonic oscillator, if xe^{-vx^2} is a solution then the value of v and energy E, respectively is –

(a) $\frac{m\omega}{2\hbar}, \frac{\hbar\omega}{2}$

(b) $\frac{m\omega}{2\hbar}, \frac{3\hbar\omega}{2}$

(c) $\frac{m\omega}{\hbar}, \frac{\hbar\omega}{2}$

(d) $\frac{m\omega}{\hbar}, \frac{3\hbar\omega}{2}$

Q50. Non-interacting bosons undergo Bose-Einstein condensation (BEC) when trapped in a three-dimensional isotropic simple harmonic potential. For BEC to occur, the chemical potential must be equal to –

(a) $\hbar\omega/2$

(b) $\hbar\omega$

(c) $3\hbar\omega/2$

(d) 0

Key – 10/2/2025

Assistant Professor Grade-II (Physics)

Question No.	Correct Option
1	c
2	d
3	a
4	b
5	c
6	b
7	a
8	b
9	d
10	c
11	b
12	b
13	a
14	a
15	c
16	a
17	d
18	c
19	b
20	a
21	b
22	d
23	a
24	c
25	c
26	d
27	b
28	c
29	b
30	c
31	d
32	a
33	b
34	b
35	d
36	a
37	b
38	d
39	d
40	a
41	c
42	c
43	c
44	b
45	a
46	b
47	c
48	a
49	b
50	c