Question Booklet No.: Question Booklet Series: **A**

ENTRANCE TEST - 2025

School of Physical & Mathematical Sciences

Physics

Total Questions: 60 **Roll No.** | | | | | | |

Time Allowed: 70 Minutes

Important Instructions for Candidates:

1. Candidates shall compulsorily use only **blue/ black ball point pen**. In no case gel/ink pen or pencil should be used.
2. Compulsorily write your **roll number** in the space provided at the top of this page of the question booklet.
3. Fill up the necessary information in the spaces provided on OMR Answer sheet including **Question Booklet Number** and **Question Booklet Series**.
4. OMR Answer sheet has an original copy and a candidate's copy glued beneath it at the top. While making entries in the original copy, candidate should ensure that the **two copies are aligned properly** so that the entries made in the original copy against each item are exactly copied in the candidate's copy.
5. All entries in the OMR Answer Sheet, including answers to questions, are to be recorded in the Original Copy only.
6. **Choose only one correct/most appropriate response** for each question among the options A, B, C and D and darken the circle of the appropriate response completely. Incompletely darkened circle is not correctly read by the OMR scanner and no complaint to this effect shall be entertained.
7. **Do not darken more the one circle of option for any question. A question with more than one darkened response shall be considered wrong.**
8. **There will be negative marking for wrong answers. Each wrong answer will lead to deduction of 0.25 marks per wrong answer from the score.**
9. Only those candidates who obtain positive score in Entrance Test shall be eligible for admission.
10. Do not make any stray mark on the OMR sheet as this may lead to errors while scanning.
11. OMR answer sheet must be handled carefully and it should not be folded or mutilated, as in such case it will not be properly evaluated by the machine.
12. No Electronic gadgets including calculators, mobiles, smart watches, blue tooth etc. shall be permitted inside the examination hall.
13. Rough work, if any, should be done on the blank sheets provided with the question booklet.
14. Ensure that the OMR Sheet is signed by the Examinee as well as by the invigilator.
15. At the end of the examination, fold the OMR Sheet along the crease on the top and tear off the top strip to separate the Original OMR Sheet from the Duplicate Copy.
16. Hand over the Original OMR answer sheet to the invigilator and retain the candidate's copy of OMR, Question Booklet and Admit card for your reference.
17. If any of the information in the response Sheet/Question Paper has been found missing or not mentioned as stated above, the candidate is solely responsible for that lapse.
18. Any deficiency on the OMR shall be the responsibility of the candidate himself/herself.

Q1. Which of the following correctly describes a non-inertial frame of reference?

A) A frame moving at constant velocity relative to an inertial frame.

B) A frame fixed with respect to the distant stars.

C) A frame undergoing uniform circular motion.

D) A frame where Newton's first law is always valid.

Q2. In spherical coordinates (r,θ,ϕ), the radial component of the velocity v_r, is expressed as:

A) $v_r = r\,(d\phi/dt)\sin\theta$

B) $v_r = dr/dt$

C) $v_r = r\,(d\theta/dt)$

D) $v_r = (1/r)\,(d\theta/dt)$

Q3. One significant application of the Coriolis force is observed in:

A) The formation of trade winds and cyclonic systems.

B) The oscillations of a simple pendulum.

C) The propagation of light in a vacuum.

D) The reflection of sound waves from surfaces.

Q4. Which of the following best exemplifies the conservation of linear momentum in an isolated system?

A) A projectile motion under Earth's gravity.

B) Two ice skaters pushing off against each other on frictionless ice.

C) A car decelerating due to friction with the road.

D) The oscillations of a mass-spring system on a rough surface.

Q5. The work done by a constant force $\vec{F}$ acting on a particle that moves through a displacement $\vec{d}$ is given by:

A) $W=\vec{F}\times\vec{d}$

B) $W=\vec{F}+\vec{d}$

C) $W=\vec{F}\cdot\vec{d}$

D) $W=\vec{F}/\vec{d}$

Q6. The principle of conservation of angular momentum states that:

A) The total angular momentum of a system is constant if the net external torque acting on the system is zero.

B) The angular momentum increases with increasing velocity.

C) The angular momentum of a rotating object is always zero.

D) The total angular momentum of a system remains zero in the absence of external forces.

Q7. In special relativity, length contraction refers to:

A) The decrease in the time interval between two events as observed from a stationary frame.

B) The increase in the length of an object as its speed approaches the speed of light.

C) The shortening of an object's length as observed from a frame moving relative to the object at high velocity.

D) The invariance of length in all reference frames.

Q8. The time dilation effect in special relativity implies that:

A) A moving clock runs faster than a stationary clock.

B) A moving clock runs slower than a stationary clock.

C) The time between two events is the same in all reference frames.

D) Time dilation does not occur in inertial frames.

Q9. If a mechanical system has 5 particles and is subjected to 7 independent holonomic constraints, how many degrees of freedom does the system have?

A) 15

B) 8

C) 7

D) 5

Q10. What is the primary advantage of using the Lagrangian formalism over Newtonian mechanics in the presence of constraints?
A) It eliminates the need for energy conservation
B) It requires no coordinate system
C) It simplifies the equations of motion by incorporating constraints through generalized coordinates
D) It is only applicable to quantum systems

Q11. The Euler-Lagrange equation provides the equation of motion for a system described by a LagrangianL($q_i, \dot{q_i}, t$) Which of the following correctly represents this equation?
A) $\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_i}\right)+\frac{\partial L}{\partial q_i} = 0$
B) $\frac{\partial L}{\partial \dot{q}_i} +\frac{\partial L}{\partial q_i} = 0$
C) $\frac{\partial L}{\partial \dot{q}_i} - \frac{\partial L}{\partial q_i} = 0$
D) $\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_i}\right) -\frac{\partial L}{\partial q_i} = 0$

Q12. If a generalized coordinate q_i does not explicitly appear in the Lagrangian L, it is referred to as a cyclic (or ignorable) coordinate. What is the immediate consequence of this in terms of canonical momenta?
A) q_i is constant in time.
B) The corresponding canonical momentum p_i is conserved.
C) The total energy is conserved.
D) The Lagrangian is time-independent.

Q13. Which of the following vector fields is irrotational (i.e., has zero curl)?
A) $\vec{F}$= y $\hat{i}$ + x $\hat{j}$
B) $\vec{F}$= − y $\hat{i}$ + x $\hat{j}$
C) $\vec{F}$= $\vec{\nabla}\phi$, where ϕ is a scalar.
D) $\vec{F}$= $x^2\hat{i} + y^2\hat{j}$

Q14. Which theorem relates the surface integral of a vector field over a closed surface to the volume integral of its divergence over the region it encloses?
A) Green's theorem
B) Stoke's theorem
C) Gauss's divergence theorem
D) Fundamental theorem of calculus

Q15. Evaluate the line integral $\oint_C \vec{F}.d\vec{r}$,where $\vec{F}$= y $\hat{i}$ - x $\hat{j}$and C is the unit circle $x^2 + y^2$=1 traversed counterclockwise.
A) 0
B) 2π
C) -2π
D) π

Q16. Consider a periodic function f(x)with period 2L. Its Fourier series expansion contains only sine terms if:
A) f(x) is an odd function.
B) f(x)is an even function.
C) f(x)is neither odd nor even.
D) f(x)has discontinuities.

Q17. Which of the following is the correct Laplace transform of the function f(t)= t^n, where n is a non-negative integer?
A) L[t^n] = 1 / s^n+1
B)L[t^n]= n! / (s^n+1)
C)L[t^n]= n! / s^n
D)L[t^n]=1/(n! (s^n+1))

Q18. A function f(z) = u(x,y) + *i*v(x,y) is said to be analytic at a point if it satisfies the Cauchy-Riemann equations. What is one form of these conditions in Cartesian coordinates?
A) ∂u/∂x=∂v/∂x,∂u/∂y=∂v/∂y
B) ∂u/∂x=∂u/∂y,∂v/∂x=∂v/∂y
C) ∂u/∂x=∂v/∂y,∂u/∂y=−∂v/∂x
D) ∂u/∂x=−∂v/∂y,∂u/∂y=∂v/∂x

Q19. Which of the following holds true about probabilities P(A) and P(B) ,if two events A and B are independent?

A) $P(A \cap B) = P(A) \cdot P(B)$

B) $P(A \cup B) = P(A)+P(B)$

C) $P(A \cap B) = P(A)+P(B)$

D) $P(B|A) = 0$

Q20. Which of the following defines the conditional probability P(A|B)?

A) $P(A)/P(B)$: $P(B) > 0$

B) $P(A \cup B)/P(B)$: $P(B) > 0$

C) $P(A \cap B/)P(B)$: $P(B) > 0$

D) $P(B)/P(A \cap B)$: $P(A \cap B) > 0$

Q21. Gauss's law in electrostatics is mathematically expressed as:

A) $\nabla \cdot \vec{E} = \frac{q}{\varepsilon_0}$

B) $\oint \vec{E} \cdot d\vec{A} = \frac{q}{\varepsilon_0}$

C) $\nabla \cdot \vec{D} = 0$

D) $\vec{F} = q\,\vec{E}$

Q22. The electric field inside a uniformly charged spherical shell is:

A) Zero

B) Constant and non-zero

C) Proportional to $\frac{1}{r}$

D) Infinite at the centre

Q23. The capacitance C of an isolated spherical conductor of radius Rin vacuum is:

A) $C = 4\pi\varepsilon_0 R^2$

B) $C = \varepsilon_0 R$

C) $C = 2\pi\varepsilon_0 R$

D) $C = 4\pi\varepsilon_0 R$

Q24. Which of the following best describes the electric potential due to an electric dipole at a point on the axial line at a distance r >>d ? (where d is the length of the dipole)

A) $V \propto \frac{1}{r}$

B) $V \propto \frac{1}{r^2}$

C) $V \propto \frac{1}{r^3}$

D) $V = 0$

Q25. According to Maxwell's equations, the divergence of a magnetic field $\vec{B}$ is:

A) $\nabla \cdot \vec{B} = \varepsilon_0 J$

B) $\nabla \cdot \vec{B} = 0$

C) $\nabla \cdot \vec{B} = \mu_0 J$

D) $\nabla \cdot \vec{B} = \varepsilon_0 E$

Q26. Which of the following correctly defines the magnetic vector potential $\vec{A}$?

A) $\vec{B} = \nabla \cdot \vec{A}$

B) $\vec{B} = -\nabla \vec{A}$

C) $\vec{B} = \nabla \times \vec{A}$

D) $\vec{B} = \partial \vec{A} \partial t$

Q27. Which of the following best differentiates ferromagnetic materials from paramagnetic materials at the microscopic level?

A) Ferromagnetic materials have no magnetic dipoles.

B) Dipoles in ferromagnetic materials align spontaneously even without an external field.

C) Paramagnetic materials retain magnetism after field removal.

D) Paramagnetic dipoles repel each other under an applied field.

Q28. What does the Poynting vector $\vec{S} = \vec{E} \times \vec{H}$ physically represent in an electromagnetic field?

A) The energy stored per unit volume in the field

B) The magnetic field strength in the direction of wave propagation

C) The rate of change of the electric field with time

D) The directional energy flux (power per unit area) of the electromagnetic field

Q29. In the case of free oscillations of a system (no damping or external force), what determines the frequency of oscillation?

A) The amplitude of motion

B) The damping coefficient

C) The initial velocity only

D) The system's mass and restoring force constant

Q30. In a system undergoing forced oscillations, what primarily characterizes the steady-state response of the system?

A) It depends only on the initial conditions
B) It decays with time and disappears
C) It oscillates at the frequency of the external driving force
D) It oscillates at the natural frequency of the system

Q31. What is the physical significance of the damping coefficient in a damped harmonic oscillator?

A) It quantifies the rate at which mechanical energy is dissipated
B) It increases the restoring force of the system
C) It determines how quickly oscillations grow in amplitude
D) It represents the frequency of oscillation

Q32. In a system of two identical coupled oscillators, what is a "normal mode"?

A) A mode in which both oscillators move randomly
B) A transient mode where only one oscillator vibrates
C) A specific pattern in which all parts of the system oscillate at the same frequency with fixed phase relations
D) A mode that disappears due to damping

Q33. In Fraunhofer diffraction at a single slit of width a, the angular position of the first minimum occurs at which condition?

A) $a \sin\theta = \lambda$
B) $a \cos\theta = \lambda$
C) $a \tan\theta = \lambda/2$
D) $a \sin\theta = \lambda/2$

Q34. According to Rayleigh's criterion, two point sources are just resolvable:(where D represents the aperture diameter of the optical system, and λ is the wavelength of light)

A) Their central maxima overlap completely
B) The maximum of one coincides with the second minimum of the other
C) The minimum of one coincides with the maximum of the other
D) The angular separation is less than λ/D

Q35. A zone plate acts as a focusing element for light because:

A) It reflects light at different angles
B) It absorbs alternate Fresnel zones
C) It refracts light like a lens
D) It transmits only circularly polarized light

Q36. Which of the following best distinguishes circular polarization from linear polarization?

A) The amplitude of the electric field varies with time
B) The electric field vector rotates uniformly in a circle in the transverse plane
C) The electric and magnetic fields are aligned in the same direction
D) The light intensity is maximum along the propagation axis

Q37. The Zeroth Law of Thermodynamics forms the basis for the definition of:

A) Internal energy
B) Pressure equilibrium
C) Temperature
D) Entropy

Q38. For a given amount of an ideal gas, which of the following correctly compares work done in adiabatic vs. isothermal expansion?

A) Adiabatic work > Isothermal work
B) Adiabatic work < Isothermal work
C) Work is the same in both processes
D) Work is zero in both cases

Q39. Which of the following is a defining feature of a reversible process in thermodynamics?

A) It occurs spontaneously and quickly
B) The entropy of the system increases
C) The system and surroundings can be restored to their original states
D. Energy is destroyed in the process

Q40. Which of the following thermodynamic variables is extensive in nature?

A) Temperature
B) Pressure
C) Entropy
D) Density

Q41. The Second Law of Thermodynamics states that:

A) Energy is conserved in all processes.
B) The entropy of an isolated system never decreases.
C) Work done is always equal to heat supplied.
D) Internal energy depends only on pressure.

Q42. In a T–S (Temperature–Entropy) diagram, the area under a reversible path represents:

A) Internal energy change
B) Work done
C) Heat exchanged
D) Change in pressure

Q43. According to the Third Law of Thermodynamics:

A) All processes cease at 0 K
B) Entropy of any substance becomes zero at 0 K
C) Entropy of a perfect crystal approaches zero at 0 K
D) Heat capacity is infinite at 0 K

Q44. During a Joule-Thomson expansion, an ideal gas shows:

A) No temperature change
B) Decrease in pressure and increase in temperature
C) Heat absorption
D) Negative entropy change

Q45. Which of the following thermodynamic potentials is minimized at constant temperature and pressure?

A) Helmholtz free energy
B) Enthalpy
C) Internal energy
D) Gibbs free energy

Q46. In statistical mechanics, an ensemble represents:

A) A single particle in isolation
B) All microstates of a single system at one time
C) A large number of identical systems in all possible microstates
D) A system in thermal equilibrium with surroundings

Q47. According to Boltzmann, the entropy S is related to thermodynamic probability W by:

A) $S = kW$
B) $S = (1/k)\ \ln W$
C) $S = k \ln W$
D) $S = W \ln k$

Q48. Which statement correctly distinguishes the three distribution functions?

A) Maxwell–Boltzmann and Fermi–Dirac apply only to photons
B) Bose–Einstein statistics apply to particles obeying the Pauli exclusion principle
C) Fermi–Dirac distribution allows multiple occupancy of states
D) Bose–Einstein distribution allows multiple bosons in a single quantum state

Q49. Which of the following best describes a blackbody in the context of thermal radiation?

A) A body that absorbs and emits radiation at all wavelengths with maximum efficiency
B) A body that reflects all incident radiation
C) A body that transmits all incident radiation
D) A body that emits only visible light

Q50. A blackbody emits radiation with a peak wavelength of 500 nm. What is the approximatetemperature of the blackbody? (Use Wien's constant $b=2.9\times10^{-3}$ mK)

A) 290 K
B) 6980 K
C) 2900 K
D) 5800 K

Q51. What physical inconsistency led to the so-called "ultraviolet catastrophe" in classical blackbody radiation theory?

A) The energy emitted at long wavelengths was predicted to be infinite.
B) The Rayleigh-Jeans law predicted infinite energy emission at short wavelengths.
C) The temperature of the blackbody could not be determined accurately.
D) The energy emitted was independent of frequency in classical theory.

Q52. According to Planck's postulates, the energy of oscillators in a blackbody cavity is:

A) Quantized in units of hv
B) Continuous and proportional to temperature
C) Inversely proportional to the square of frequency
D) Proportional to the square of amplitude

Q53. Which of the following best explains why no photoelectrons are emitted when light of frequency below the threshold is incident on a metal surface, regardless of intensity?

A) The intensity of light is insufficient to knock out electrons
B) The photons lack the required energy to overcome the metal's work function
C) The electrons are tightly bound and require thermal excitation
D) The incident light interferes destructively at the surface

Q54. What did the Davisson-Germer experiment demonstrate about electrons?

A) Electrons can be deflected by magnetic fields
B) Electrons have discrete energy levels
C) Electrons exhibit diffraction, confirming their wave-like nature
D) Electrons cannot penetrate metallic crystals

Q55. In quantum mechanics, the square modulus of the wave function $|\psi(x,t)|^2$ represents:

A) The total energy of the system
B) The momentum distribution of the particle
C) The probability density of finding the particle at position x at time t
D) The electric potential associated with the particle

Q56. Which of the following correctly defines the expectation value $\langle \hat{A} \rangle$ of an operator $\hat{A}$ in state $\psi(x)$?

A) $\langle \hat{A} \rangle = \int \psi(x) \hat{A} \psi(x)\, dx$
B) $\langle \hat{A} \rangle = \int |\hat{A}\psi(x)|^2\, dx$
C) $\langle \hat{A} \rangle = \int \hat{A}\psi(x)^* \psi(x)\, dx$
D) $\langle \hat{A} \rangle = \int \psi(x)^* \hat{A} \psi(x)\, dx$

Q57. In the anomalous Zeeman effect, the energy splitting of levels in a magnetic field is determined by:

A) Only the orbital angular momentum
B) The magnetic moment of the nucleus
C) The Landé g-factor and total angular momentum quantum number J
D) The thermal motion of electrons in atoms

Q58. The Pauli Exclusion Principle states that:

A) Two identical bosons cannot occupy the same quantum state.
B) Electrons in the same orbital must have the same spin.
C) No two identical fermions can occupy the same quantum state simultaneously.
D) Only electrons with opposite spins can be found in different orbitals.

Q59. Which of the following outcomes is a direct result of the Stern-Gerlach experiment?

A) Confirmation of the wave nature of electrons
B) Evidence for the quantization of angular momentum
C) Discovery of the neutron
D) Observation of the Zeeman effect

Q60. Pure rotational spectra of a diatomic molecule are observed in which region of the electromagnetic spectrum?

A) Ultraviolet
B) Visible
C) Infrared
D) Microwave

Sr. No. 261

ENTRANCE TEST-2024

SCHOOL OF PHYSICAL & MATHEMATICAL SCIENCES

PHYSICS

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SEAL

1. A unit cell of a lattice has the following primitive vectors :

$$\vec{a}_1 = \frac{a}{2}(\hat{i}+\hat{j})$$

$$\vec{a}_2 = \frac{a}{2}(\hat{j}+\hat{k})$$

$$\vec{a}_3 = \frac{a}{2}(\hat{i}+\hat{k})$$

The reciprocal lattice corresponding to the above direct lattice is

(A) Face centred cubic
(B) Body centred cubic
(C) Simple cubic
(D) Hexagonal

2. Which of the following statement is correct for an anomalously dispersive medium ?

(A) Phase velocity of waves, v_p is greater than the Group velocity, v_g
(B) Phase velocity of waves, v_p is equal to the Group velocity, v_g
(C) Phase velocity of waves, v_p is less than the Group velocity, v_g
(D) $\frac{dvp}{d\lambda} < 0$, where λ represents the wavelength

3. The quantum mechanical operator for the kinetic energy of radial motion for a free particle is given by :

(A) $\frac{\hbar}{2m}\left[-\frac{d^2}{dr^2}-\frac{2}{r}\frac{d}{dr}\right]$

(B) $-\frac{\hbar^2}{2m}\left[-\frac{d^2}{dr^2}-\frac{2}{r}\frac{d}{dr}\right]$

(C) $\frac{\hbar^2}{2m}\left[-\frac{1}{r^2}\frac{d^2}{dr^2}-\frac{d}{dr}\right]$

(D) $-\frac{\hbar^2}{2m}\left[-\frac{1}{r^2}\frac{d^2}{dr^2}-\frac{d}{dr}\right]$

4. At low temperatures, the behaviour of the electronic contribution to the specific heat, C_v of a normal metal will depend as a function of temperature T :

(A) C_v is proportional to T
(B) C_v is proportional to T^3
(C) C_v is proportional to T^2
(D) C_v is inversely proportional to T

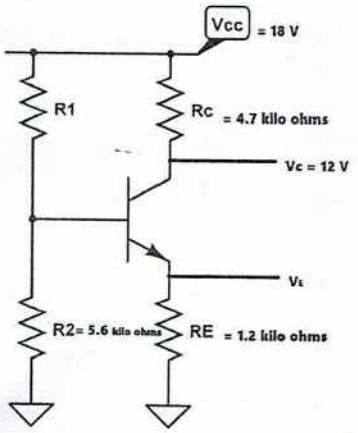
5. Which of the following is not the fundamental principle of quantum mechanics ?

(A) Principle of superposition of states
(B) Bohr angular momentum quantization principle
(C) Pauli exclusion principle
(D) Uncertainty Principle

6. Which of the following is correct in Fresnel type of diffraction ?

(A) The distance between the source or the observation screen or both of them are at an infinite distance from the diffracting aperture
(B) The distance between the source or the observation screen or both of them are at finite distances from the diffracting aperture
(C) The wave fronts falling on the diffracting aperture or reaching the observation screen will be plane wave fronts
(D) None of the above statements is correct

7. In the given circuit employing a voltage-divider biasing method, the value of emitter voltage V_E is approximately equal to :



(A) 2.25 V
(B) 1.54 V
(C) 12 V
(D) 2.54 V

8. Which of the following statement is not correct ?
(A) One of the most important characteristics of the FET is its low input impedance
(B) FETs are more temperature stable than BJTs
(C) The output impedance of FETs is similar in magnitude to that of conventional BJTs
(D) There is no direct electrical connection between the gate terminal and the channel of a MOSFET

9. A quantized lattice vibration mode (phonon) can be represented by a harmonic oscillator, which has a characteristic frequency ω, wave vector q, then according to quantum theory, the energy of the oscillator is given by

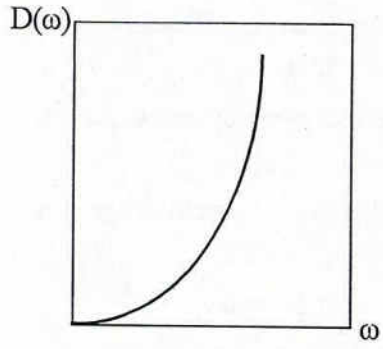
(A) $E = \frac{h\omega}{2\pi}\left(n+\frac{1}{2}\right)$

(B) $E = \frac{h\omega}{2\pi}(n+1)$

(C) $E = \frac{h\omega}{4\pi}\left(n+\frac{1}{2}\right)$

(D) $E = \frac{h\omega}{4\pi}(n+1)$

10. If the dispersion relation between ω and q is $\omega = uq$, where 'u' is the velocity of sound, then the plot of phonon density of states as a function of frequency is best represented by :

(A)


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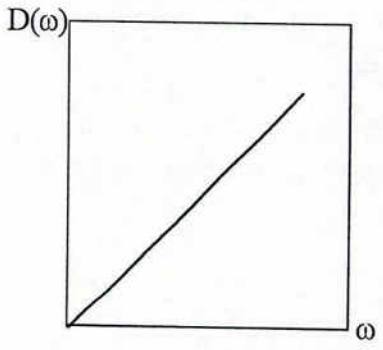

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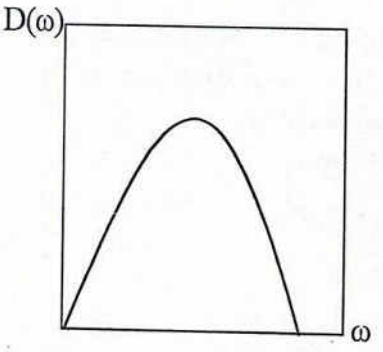
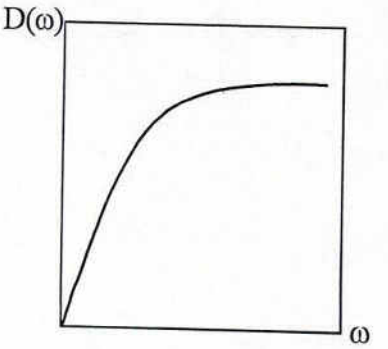


(D)


11. If n_o and p_o denote the equilibrium electron and hole densities in a semiconductor, then the product, $n_o p_o$:
    (A) Does not depend on Temperature
    (B) Depends on Band gap energy only
    (C) Does not depend on Effective mass of electrons and holes
    (D) The product $n_o p_o$ depends on all the above parameters

12. An electric charge can be held in a position of stable equilibrium:
    (A) by a purely electrostatic field
    (B) by a mechanical force
    (C) by a magnetic field
    (D) none of the above

13. If **P** is the polarization vector and **E** is the electric field, then in the equation $\mathbf{P} = \alpha \mathbf{E}$, α in general is:
    (A) scalar
    (B) vector
    (C) tensor
    (D) none of the above

14. The magnetic field due to a long conductor carrying 30,000 amperes at a distance of one meter is approximately equal to:
    (A) 3×10^{-3} Tesla
    (B) 6×10^{-3} Tesla
    (C) 0.6 Tesla
    (D) 0.3 Tesla

15. The force on a small electric current loop of magnetic moment $\boldsymbol{\mu}$ in a magnetic field **B** is given by:
    (A) $F = (\mu \times \nabla).B$
    (B) $F = (\mu \times \nabla) \times B$
    (C) $F = (B \times \nabla) \times \mu$
    (D) $F = (\nabla \times B) \times \mu$

16. A steady dc current I is established in a simple LR series circuit as shown in figure 1. As the switch **S** is suddenly opened, the energy $\frac{1}{2}LI^2$, which was stored in the circuit when the current I was present, will

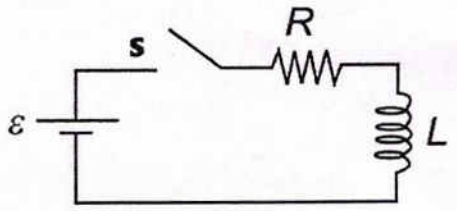


Figure 1

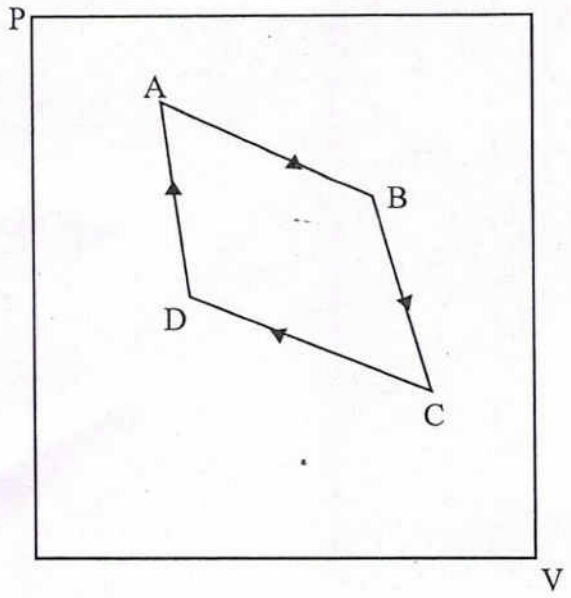
    (A) be converted into heat energy through resistance R
    (B) be converted into electric energy
    (C) be radiated in the form of electromagnetic waves
    (D) still be stored in the circuit

17. The electric field of an electromagnetic wave in vacuum is given by:

$$E_x = 0,\ E_z = 0,\ E_y = 10\cos\left(2\pi \times 10^8\, t - \frac{2\pi}{3}x\right)$$

where E is in V/m, t in seconds and x in meters. Which of the following statements is correct?
    (A) The wave is propagating along the negative x direction with frequency 10^8 Hz and wavelength 3 m.
    (B) The wave is propagating along the negative x direction with frequency 10^8 Hz and wavelength 6 m.
    (C) The wave is propagating along the positive x direction with frequency 10^8 Hz and wavelength 3 m.
    (D) The wave is propagating along the positive x direction with frequency 10^8 Hz and wavelength 6 m.

18. A Carnot engine has a cycle pictured below :



Which of the following statement is not correct ?

(A) AB and CD are isothermal processes

(B) DA and BC are adiabatic processes

(C) Work is put in during the processes CD and DA; it is extracted in the processes AB and BC

(D) If the above is a steam engine with $T_{in} = 450$ K, operating at room temperature, its efficiency is equal to 1/2

19. Which statistics would be appropriate in solving the problem for density of electrons and holes in semiconducting Silicon at room temperature ? (silicon band gap is approx. 1eV)

(A) Classical Maxwell-Boltzmann

(B) Fermi-Dirac

(C) Bose-Einstein

(D) Both Bose-Einstein and Classical Maxwell-Boltzmann

20. A system of two energy levels E_1 and E_2 is populated by N particles at temperature T. If the particles populate the energy levels according to the classical distribution law, then the average energy per particle is given by :

(A) $\dfrac{E_1 e^{-\frac{E_1}{kT}} + E_2 e^{-\frac{E_2}{kT}}}{E_1 + E_2}$

(B) $\dfrac{E_1 e^{-\frac{E_1}{kT}} + E_2 e^{-\frac{E_2}{kT}}}{E_2 e^{-\frac{E_1}{kT}} + E_1 e^{-\frac{E_2}{kT}}}$

(C) $\dfrac{E_1 e^{-\frac{E_1}{kT}} + E_2 e^{-\frac{E_2}{kT}}}{e^{-\frac{E_1}{kT}} + e^{-\frac{E_2}{kT}}}$

(D) $\dfrac{E_2 e^{-\frac{E_1}{kT}} + E_1 e^{-\frac{E_2}{kT}}}{e^{-\frac{E_1}{kT}} + e^{-\frac{E_2}{kT}}}$

21. According to the van der Waal's equation of state for an ideal gas ,the critical temperature, pressure and volume are related to each other by the following relation :

(A) $\dfrac{p_c V_c}{RT_c} = \dfrac{8}{27}$

(B) $\dfrac{p_c V_c}{RT_c} = \dfrac{8}{3}$

(C) $\dfrac{RT_c}{p_c V_c} = \dfrac{8}{27}$

(D) $\dfrac{RT_c}{p_c V_c} = \dfrac{8}{3}$

where R is Universal gas constant.

22. Which of the following statement is not correct ?

(A) According to second law of thermodynamics, for a mechanically isolated system at constant temperature, the Helmholtz free energy never increases

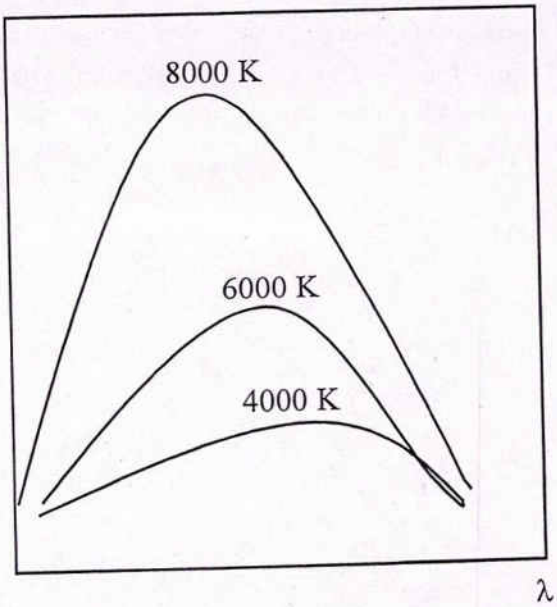
(B) Helmholtz free energy provides a link between Statistical mechanics and thermodynamics.

(C) At constant temperature and pressure, a spontaneous change of the system will occur in the direction of increasing Gibbs energy

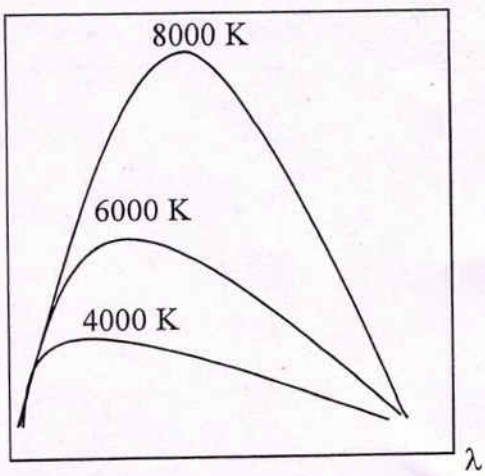
(D) At constant temperature and pressure, a spontaneous change of the system will occur in the direction of decreasing Gibbs energy

23. Which of the following graphs represents the variation of spectral energy density with wavelength at different temperatures for the Blackbody radiation ?

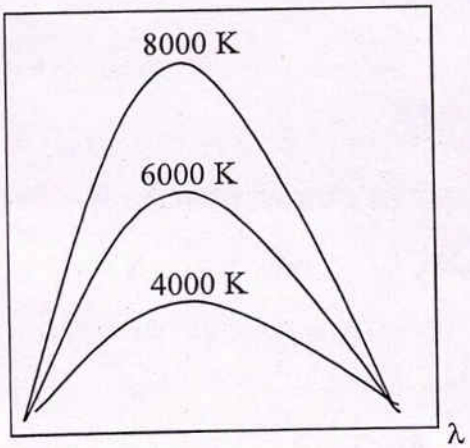
(A)



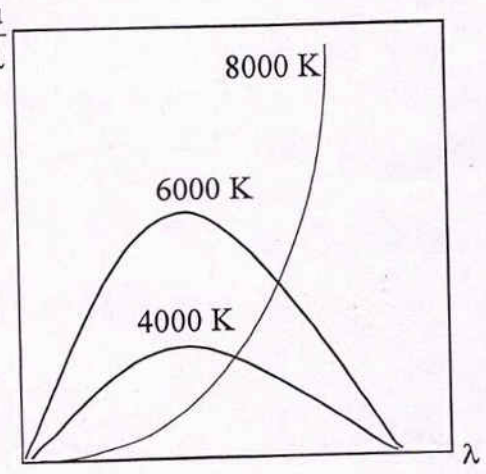
(B)



(C)



(D)



24. A Planck's oscillator is vibrating with frequency 1.5×10^{14} Hz at T = 1800 K , its average energy is approximately equal to :

(A) 0.115 eV

(B) 0.225 eV

(C) 0.335 eV

(D) 0.135 eV

25. Six distinguishable particles are to be distributed over three non-degenerate levels of energies 0 eV , 1 eV and 2 eV . The total energy of distribution for which the probability is maximum is equal to:

(A) 3 eV

(B) 6 eV

(C) 1 eV

(D) 9 eV

26. For a system in equilibrium at temperature T, the total energy is equally distributed among the several degrees of freedom and energy associated with each degree of freedom is equal to:

(A) $\frac{k_B}{2}T$

(B) $\frac{3k_B}{2}T$

(C) $\frac{k_B}{2T}$

(D) k_BT

27. A certain gas, obeying simple kinetic theory , has coefficients of viscosity and diffusion as 1.95×10^{-5} Nsm^{-2} and 1.22×10^{-5} m^2s^{-1}respectively. If the average molecular speed is 440 m/s , the mean free path is approximately equal to:

(A) 10.22×10^{-8} m

(B) 1.83×10^{-8} m

(C) 8.32×10^{-8} m

(D) 3.82×10^{-8} m

28. Observer A observes two events that are spatially and temporally separated by 600 meters and 8×10^{-7} seconds, respectively. What velocity must observer B have relative to A for the events to appear simultaneous to B?

(A) v = 0.3 c

(B) v = 0.4 c

(C) v = 0.8 c

(D) v = 0.99 c

29. A cube has a (proper) volume of 1000 cm^3. The volume as determined by an observer O who moves at a velocity of 0.8c relative to the cube in a direction parallel to one edge is approximately equal to :

(A) 600 cm^3

(B) 6000 cm^3

(C) 300 cm^3

(D) 3000 cm^3

30. Which of the following statements is not correct ?

(A) If a particle is moving under the action of a position-dependent force, then the sum of its kinetic energy and potential energy remains constant throughout its motion

(B) If a particle is moving under the action of a time-dependent force, then the sum of its kinetic energy and potential energy remains constant throughout its motion

(C) If a particle is moving under the action of a time-dependent force, then the sum of its kinetic energy and potential energy does not remain constant

(D) If the potential energy of a particle is independent of time, then the sum of its kinetic energy and potential energy is conserved

31. Which of the following statement is not correct ?

(A) The centre of gravity is the point through which the force of gravity acts on the body or a system

(B) Centre of mass is a point at which the whole mass of a body can be assumed to act as a point mass

(C) Centre of mass of a body will always be inside the body

(D) Centre of mass of a body will not always coincide with the centre of gravity

32. The moment of inertia of a thin circular disk, having mass M and radius R, about its diameter is :

(A) $\frac{1}{4}MR^2$

(B) $\frac{1}{2}MR^2$

(C) $\frac{1}{3}MR^2$

(D) MR^2

33. What type of body experiences rotational kinetic energy equal to half its translational kinetic energy when it is in a state of pure rolling ?

(A) Circular Ring

(B) Solid Cylinder

(C) Solid Sphere

(D) Hollow Sphere

34. If total energy of moon, supposed to be moving in a circular orbit around the earth, is equal to E. Its potential energy is equal to :

(A) E

(B) E/2

(C) 2E

(D) E^2

35. Which of the following statement is correct ?

(A) The Earth's rotation causes a centrifugal force, which slightly counteracts the gravitational force, leading to an increase in the value of acceleration due to gravity at the equator

(B) The effect of rotation of the earth on the value of g at the equator is minimum and at the poles is maximum

(C) The effect of the Earth's rotation causes the value of g to be slightly lower at the equator and slightly higher at the poles compared to what it would be if the Earth were not rotating

(D) Rotation of earth does not affect the value of acceleration due to gravity (g)

36. A particle is executing simple harmonic motion according to the following equation :

$$y = 10\,Sin\left(2\pi t - \frac{\pi}{3}\right)$$

Its velocity is given by :

(A) $10\,Cos\left(2\pi t - \frac{\pi}{3}\right)$

(B) $20\,Cos\left(2\pi t - \frac{\pi}{3}\right)$

(C) $20\pi\,Cos\left(2\pi t - \frac{\pi}{3}\right)$

(D) $10\pi\,Cos\left(2\pi t - \frac{\pi}{3}\right)$

37. The differential equation describing the motion of a damped harmonic oscillator of mass m is given as :

$\left(m\frac{d^2x}{dt^2} + c\frac{dx}{dt} + kx = 0\right)$, where c is damping coefficient and k the spring constant. The condition for critically damped oscillations is :

(A) $c^2 - 2mk < 0$

(B) $c^2 - 2mk = 0$

(C) $c^2 - 4mk < 0$

(D) $c^2 - 4mk = 0$

38. The divergence of the function : $\vec{v}=\frac{\hat{r}}{r^2}$ is equal to :

(A) 1

(B) 0

(C) 3

(D) –1

39. A parallel plate capacitor, immersed in a liquid of resistivity ρ, permittivity ε and permeability μ, is driven by a voltage $V_0 Cos(2\pi f t)$. The ratio of the amplitudes of conduction current to displacement current is equal to :

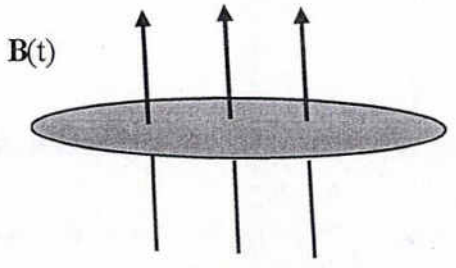
(A) $\frac{1}{2\pi\varepsilon\rho}$

(B) $\frac{1}{2\pi f\varepsilon\mu\rho}$

(C) $\frac{1}{2\pi f\varepsilon\rho}$

(D) $\frac{1}{2\pi f\varepsilon\mu}$

40. A uniform magnetic field B(t), pointing straight up, fills the shaded circular region of the figure given below. If B is increasing with time, the induced electric field



(A) runs anticlockwise as seen from above

(B) runs clockwise as seen from above

(C) runs parallel to the direction of **B**

(D) runs antiparallel to the direction of **B**

41. In which of the following thermodynamic processes, heat is neither absorbed nor released by the system ?

(A) Isothermal process

(B) Isobaric process

(C) Adiabatic process

(D) Isochoric process

42. Which of the following statements is not correct ?

(A) The second law of thermodynamics states that the total entropy of an isolated system can never decrease over time; it can only remain constant or increase

(B) During solidification the entropy of the system (the substance undergoing solidification) decreases

(C) The decrease in entropy during solidification appears to violate the second law of thermodynamics

(D) The entropy released into the surroundings due to the heat transfer during solidification outweighs the decrease in entropy within the system itself

43. Fraunhofer diffraction pattern from a single narrow slit of width 'd' has an intensity distribution which is given by :

(A) $I=I_0\frac{\sin^2\alpha}{\alpha^2}$

(B) $I=I_0\frac{\sin\alpha}{\alpha}$

(C) $I=I_0\alpha^2\sin^2\alpha$

(D) $I=I_0\frac{\sin^2\alpha}{\alpha}$

where $\alpha=\pi d\frac{\sin\theta}{\lambda}$

44. A given Zone-plate has radii, $r_n = 0.1\sqrt{n}$. For a light of wavelength 5×10^{-5} cm, the position of most intense focal point will be at distance :

(A) 100 cm

(B) 200 cm

(C) 150 cm

(D) 300 cm

45. To resolve D_1 and D_2 of sodium ($\Delta\lambda = 6\,A^\circ$) in the first order, a diffraction grating is used. The total number of lines on the grating must be at least:

(A) 1000

(B) 400

(C) 600

(D) 800

46. As one goes away from the centre of an atom, the electron density :

(A) Decreases like a Gaussian

(B) Decreases exponentially

(C) Oscillates with slowly decreasing amplitude

(D) Decreases linearly

47. A beam of neutral atoms passes through a Stern-Gerlach apparatus. Five equally spaced lines are observed. The total angular momentum of the atom is :

(A) $\frac{h}{2\pi}\sqrt{8}$

(B) $\frac{h}{2\pi}\sqrt{10}$

(C) $\frac{h}{2\pi}\sqrt{6}$

(D) $\frac{h}{2\pi}\sqrt{2}$

48. To penetrate the Coulomb barrier of a light nucleus, a proton must have a minimum energy of the order of :

(A) 1 G eV

(B) 1 T eV

(C) 1 K eV

(D) 1 M eV

49. The quark composition of neutrons and protons is respectively:

(A) uud and udd

(B) udd and uud

(C) $uu\bar{d}$ and $ud\bar{d}$

(D) $ud\bar{d}$ and $uu\bar{d}$

50. In a photoelectric experiment the photoelectrons stopping potential depends on:

(A) The frequency of incident light and the nature of the cathode material

(B) The intensity of the incident light

(C) Only the frequency of the incident light

(D) Nature of cathode material

51. According to Heisenberg's principle involving position and momentum, the minimum uncertainty in momentum of an electron, if uncertainty in its position is 50 pm (picometers), is:

(A) 5.27×10^{-25} kgms^{-1}

(B) 5.27×10^{-25} gms^{-1}

(C) 1.054×10^{-25} kgms^{-1}

(D) 1.054×10^{-25} gms^{-1}

52. A body is vibrating simultaneously in two perpendicular directions with simple harmonic motions of equal frequency. If the phase angle is equal to $\pi/2$, then the path traced by the body is :

(A) An ellipse

(B) A straight line

(C) A Circle

(D) None of the above

53. A string of length 'L' is stretched between two ends. The wavelength, λ_n of standing waves on the string satisfy the following relation:

(A) $L=\frac{n\lambda_n}{2}$

(B) $nL=\frac{\lambda_n}{2}$

(C) $L=\frac{n^2\lambda_n}{2}$

(D) $n^2L=\frac{\lambda_n}{2}$

54. If the co-ordinates of the displacement of a particle of mass m are given by :

$$x = 10\ \text{Cos}(\omega t)$$

$$y = 10\ \text{Sin}(\omega t),$$

then the particle follows :

(A) An elliptical path

(B) A circular path

(C) A straight line

(D) A parabolic path

55. The magnitude of typical h_{ie}-parameter for the small-signal transistor equivalent circuit in the region of operation for the common-emitter configuration is of the order of :

(A) 1 Ω

(B) 1 kΩ

(C) 1 MΩ

(D) 100 kΩ

56. How many RC networks capable of generating a 90° phase shift can be cascaded and linked to a Common Emitter amplifier to create an oscillator circuit ?

(A) 6

(B) 3

(C) 2

(D) 4

57. In a pn-junction diode, if the p-side of the junction is connected to the negative terminal and the n-side to the positive terminal of a battery then :

(A) The junction is said to be reverse biased, and the width of the depletion region is increased

(B) The junction is said to be forward biased, and the width of the depletion region is increased

(C) The junction is said to be reverse biased, and the width of the depletion region is decreased

(D) The junction is said to be forward biased, and the width of the depletion region is decreased

58. For an intrinsic semiconductor, the electrical conductivity is given by :

(A) $\sigma_i = q(\mu_n + \mu_n)\, n_i^2$

(B) $\sigma_i = q^2(\mu_n + \mu_n)\, n_i^2$

(C) $\sigma_i = q(\mu_n + \mu_n)\, n_i$

(D) $\sigma_i = q(\mu_n + \mu_n)^2 n_i$

where μ_n and μ_p denote the electron and hole mobilities, respectively, and n_i is the intrinsic carrier density.

59. Which of the following is not correct about the application of a transistor ?

(A) It can be used as an amplifier

(B) It can be used as a rectifier in conventional applications

(C) It can be used as an electronic switch

(D) It can be used as an oscillator

60. The capacitance of two concentric spherical metal shells, with radii r_1 and r_2 is equal to :

(A) $C=4\pi\epsilon_0\frac{r_1}{r_2}$

(B) $C=4\pi\epsilon_0\left(\frac{r_1}{r_2}-\frac{r_2}{r_1}\right)$

(C) $C=4\pi\epsilon_0\left(\frac{r_1}{r_2}-\frac{r_2}{r_1}\right)^2$

(D) $C=4\pi\epsilon_0\left(\frac{r_2r_1}{r_2-r_1}\right)$