

MH SET 2011 PHYSICS PAPER 2 AUGUST 2011 QUESTION PAPER
Physics
Paper II

Time Allowed : 75 Minutes]

[Maximum Marks : 100

Note : This Paper contains **Fifty (50)** multiple choice questions. Each question carries **Two (2)** marks. Attempt **All** questions.

1. Spherical Bessel function of order n

is a product of $\sqrt{\frac{\pi}{2x}}$ with :

(A) Bessel function of order $n + \frac{1}{2}$

(B) Bessel function of order $n - \frac{1}{2}$

(C) Bessel function transformed in polar coordinates

(D) Spherical harmonic of order n

2. The angle between vector $\hat{i} + \hat{j}$ and $\hat{j} + \hat{k}$ is (in radian) :

(A) π

(B) $\pi/2$

(C) $\pi/6$

(D) $\pi/4$

3. The cube roots of unity $1, \omega, \omega^2$ form :

(A) a cyclic group of order 3

(B) a permutation group

(C) SU3 group

(D) SU2 $\times$ U group

4. The value of

$$1 + \frac{1}{1 + \frac{1}{1 + \frac{1}{1 + \dots}}}$$

is :

(A) $\sqrt{2}$

(B) 1.6

(C) $\sqrt{3}$

(D) 0.8

AUG-32211/II

5. The real matrix $A = \begin{bmatrix} a & f & g \\ -f & a & -h \\ -g & h & a \end{bmatrix}$ is

skew symmetric when :

(A) $a = 0$

(B) $f = 0$

(C) $g = h$

(D) $f = g$

6. The eigenvalues of the matrix

$\begin{pmatrix} 1 & \omega \\ \omega & 1 \end{pmatrix}$ are :

(A) 1

(B) $\pm \omega$

(C) $\pm \omega^2$

(D) $\pm i$

7. A complex function $f(z)$ is given by :

$$f(z) = \sqrt{z} + \frac{1}{z-a} + \exp(z)$$

The singularities of $f(z)$ are :

(A) simple pole at $z = a$

(B) branch point at $z = 0$

(C) essential singularity at $z \rightarrow \infty$

(D) all of the three above

8. The determinant of a 3×3 real symmetric matrix is 36. If two of its eigenvalues are 2 and 3, then the sum of the eigenvalues is :

(A) 30

(B) 10

(C) 11

(D) 31

9. A harmonic oscillator in one dimension is perturbed by the potential αx^3 . The ground state energy of the oscillator to a first order in perturbation is :

(A) $\frac{\hbar\omega}{2} + \alpha$

(B) $\frac{3}{2} \hbar\omega + \alpha$

(C) $\frac{\hbar\omega}{2} + \alpha^3$

(D) $\frac{\hbar\omega}{2}$

10. A particle moves in one-dimensional potential $V(x)$. At $x = a$, if V has a finite discontinuity (jump), then which of the following is true for its wave function ϕ and its first derivative ϕ' at $x = a$?

- (A) ϕ is continuous and ϕ' must be discontinuous
- (B) ϕ is discontinuous and ϕ' must be continuous
- (C) both ϕ and ϕ' are discontinuous
- (D) both ϕ and ϕ' are continuous

11. In quantum mechanics, three dimensional wave function $\psi(\vec{r})$ of a particle :

- (A) has dimension of (energy $\times$ time)
- (B) has dimension of (length)^{-3/2}
- (C) has dimension of energy
- (D) is dimensionless

12. A system is known to be in a state described by the wave function :

$$\psi(\theta, \phi) = \frac{1}{\sqrt{30}} \{5Y_4^0 + Y_6^0 + 2Y_6^3\}$$

where $Y_l^m(\theta, \phi)$ are spherical harmonics. The probability of finding the system in a state with $m = 0$ is :

- (A) zero
- (B) $6/\sqrt{30}$
- (C) $6/30$
- (D) $13/15$

13. What is the degeneracy of the third excited state for a particle in 3-dimensional isotropic Harmonic oscillator potential ?

(Note : ground state is not an excited state)

- (A) 10
- (B) 6
- (C) 4
- (D) 3

AUG-32211/II

14. The parity of wave function ψ is associated with which of the following transformation ?

- (A) Space translation
- (B) Space rotation
- (C) Space inversion
- (D) Space exchange of two particles

15. Which of the following processes involves tunnelling through a potential barrier ?

- (A) Pair production
- (B) α -decay
- (C) β -decay
- (D) γ -decay

16. The variational method in perturbation theory, when applied to obtain the value of the ground state energy :

- (A) gives energy value higher than or equal to the exact ground state energy
- (B) always gives exact ground state energy
- (C) gives energy value lower than the exact ground state energy
- (D) gives energy value which is sometimes higher than or sometimes lower than the exact ground state energy

17. In a scintillation detector, the height of the output pulse is proportional to :

- (A) Energy of the incident photon
- (B) Intensity of the incident photon
- (C) Energy and intensity of the photon
- (D) Does not depend either on intensity or energy

18. If 'N' number of gadgets are connected to a power supply with a capacity of 'X' amperes without overloading then :

- (A) Total current drawn by all the gadgets should be equal to $\frac{X}{2}$ ampere
- (B) Total current drawn by all the gadgets should be equal to N.X ampere
- (C) Total current drawn by all the gadgets should be equal to X
- (D) Total current drawn by all the gadgets should be equal to $\frac{X}{4}$

19. If a square wave from a function generator is coupled to an oscilloscope in a.c. mode, what would be observed on the oscilloscope ?

- (A) A perfect square wave
- (B) Distorted square wave
- (C) A sawtooth wave
- (D) A perfect square wave with change in repetition rate

20. If a oscilloscope is operated in a d.c. mode, one can faithfully measure :

- (A) only a.c. voltage
- (B) only d.c. voltage
- (C) both a.c. and d.c. voltage
- (D) only low frequency a.c. voltage

21. In recording a powder X-ray diffraction pattern :

- (A) the specimen and detector are both rotated
- (B) the specimen alone is rotated
- (C) the detector alone is rotated
- (D) the specimen and the source are both rotated

22. In a Michelson Interferometer, the mirror M_2 is moved such that 800 fringes are counted. The wavelength of the source used was $6000 \text{ \AA}$. Through what distance the mirror M_2 must have been moved ?

- (A) 0.24 mm
- (B) 0.48 mm
- (C) 0.36 mm
- (D) 0.60 mm

23. For the measurement of pressure in a chamber evacuated by a diffusion pump and a rotary mechanical pump, one would require the following combination of gauges :

- (A) Thermocouple/Pirani
- (B) Penning-Pirani
- (C) Thermocouple/Mercury Manometer
- (D) Pirani/Mercury Manometer

24. The vapour diffusion pump works in the following region of air flow :

- (A) Molecular flow
- (B) Turbulent flow
- (C) Lamellar flow
- (D) Viscous flow

25. A cork is submerged in a pail of water by a spring attached to the bottom of the pail. The pail is held by a child in an elevator. During the initial acceleration as the elevator travels to the next lower floor, will the displacement of the spring :

- (A) increase
- (B) decrease
- (C) remain the same
- (D) indeterminate

26. A satellite is launched into a circular orbit of radius R . A second satellite is launched into an orbit of radius $1.01 R$. Then, the period of the second satellite is :

- (A) larger by 1.5%
- (B) smaller by 1%
- (C) larger by 2%
- (D) smaller by 2%

27. A sphere of radius R is released in a liquid of viscosity η , so that by Stokes' law its drag is $6 \eta \pi R v$. Simultaneously, a second sphere of identical mass but with radius $2R$ is released. Then the ratio of their terminal velocities is :

(A) $\frac{V_R}{V_{2R}} = 1$

(B) $\frac{V_R}{V_{2R}} = \frac{3}{2}$

(C) $\frac{V_R}{V_{2R}} = 2$

(D) $\frac{V_R}{V_{2R}} = \frac{2}{3}$

28. What would be the approximate length of a day if the earth spun so fast that bodies floated on the equator ? Take the radius of the earth = 6×10^6 m and $g = 9.8 \text{ m/sec}^2$.

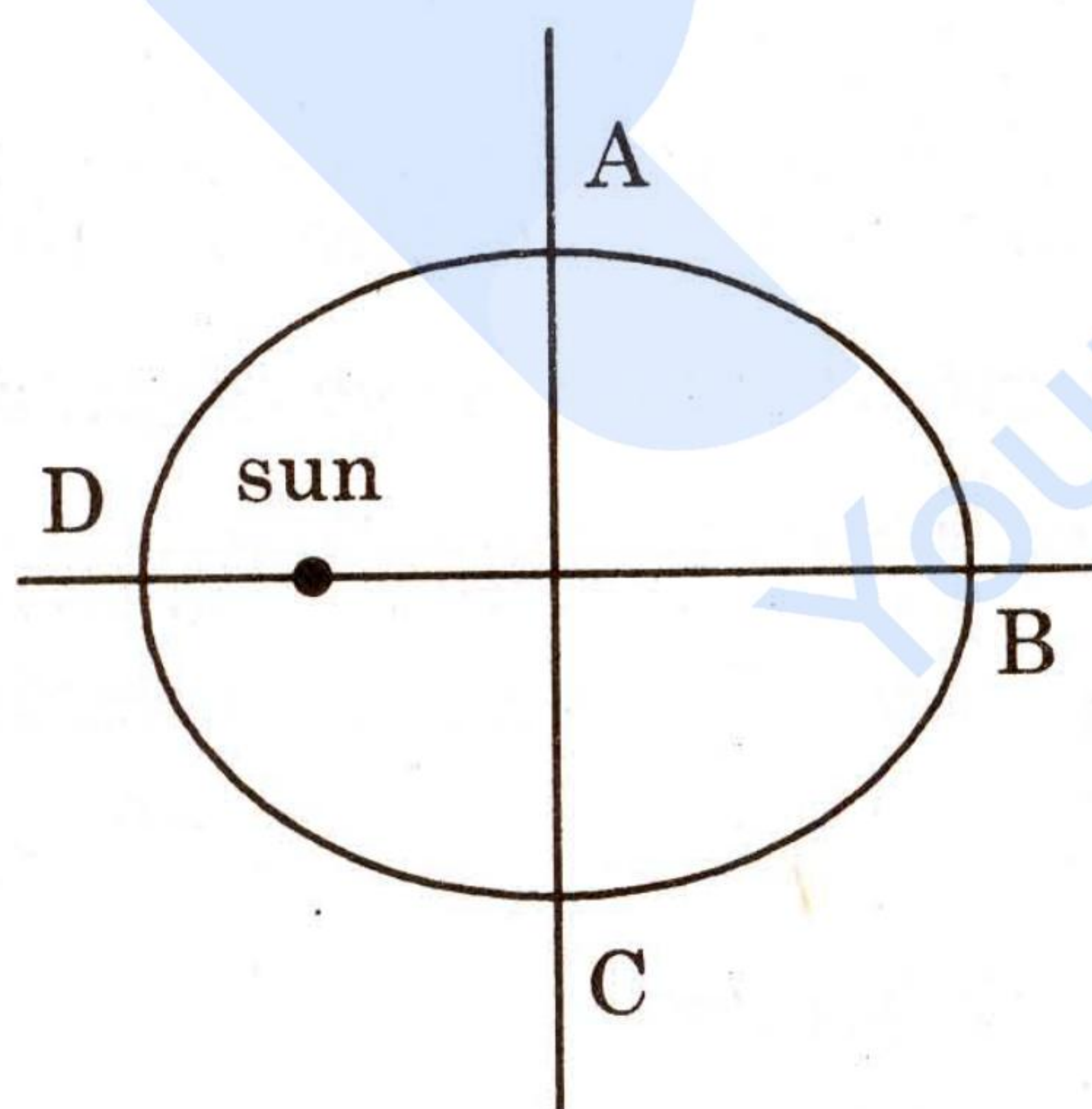
- (A) 12 hrs
- (B) 6 hrs
- (C) 3 hrs
- (D) 1.5 hrs

AUG-32211/II

29. An example of a scleronomic, holonomic, conservative and unilateral constraint is :

- (A) simple pendulum with rigid support
- (B) simple pendulum with variable length
- (C) a spherical container of fixed radius filled with gas
- (D) an expanding or contracting spherical container of gas

30. A planet has elliptical orbit with sun at the focus as shown in the figure. Which position of the orbit the planet has the highest speed ?



- (A) A
- (B) B
- (C) C
- (D) D

31. If the Lagrangian of the system is :

$$L(\rho, \theta, \dot{\rho}, \dot{\theta}) = \frac{m}{2}(\dot{\rho}^2 + \rho^2 \dot{\theta}^2) - mg \rho \cot \alpha$$

then conserved quantities are :

- (A) p_ρ
- (B) p_ρ and p_θ
- (C) p_θ
- (D) none of the above

32. Example of a non-central force is :

- (A) Gravitational force $-\frac{Gm_1m_2}{r^2}\hat{r}$
- (B) Coulomb force $\frac{z_1z_2}{r^2}\hat{r}$
- (C) Hooke law $k\vec{r}$
- (D) dipole-dipole interaction $\frac{\vec{p} \cdot \vec{r}}{r^3}$

where $\vec{p}$ is the dipole moment

AUG-32211/II

33. An infinitely long line-charge has a uniform linear charge density λ . If r denotes the distance of a point from the wire, then magnitude of the electric field at the point is :

- (A) proportional to $\frac{1}{r}$
- (B) proportional to $\frac{1}{r^2}$
- (C) proportional to $\frac{1}{r^3}$
- (D) independent of r

34. The dispersion relation for electromagnetic waves in a certain medium is $\omega^2 = \alpha k$, where α is constant, ω the angular frequency and k the magnitude of the wave vector. The velocity of the energy propagation by electromagnetic waves in this medium is :

- (A) $\frac{\alpha}{\omega}$
- (B) $\frac{2\alpha}{\omega}$
- (C) $\frac{\alpha}{2\omega}$
- (D) $\frac{\alpha}{4\omega}$

35. The dispersion relation for electromagnetic waves in a certain medium is $\omega^2 = \alpha k^2$, where α is constant, ω the angular frequency and k the magnitude of the wave vector. Which of the following statements is *correct* ?

- (A) The phase velocity in the medium is α
- (B) The group velocity in the medium is α
- (C) The medium is dispersive
- (D) The medium is non-dispersive

36. The interaction energy of an electric dipole $\vec{p}$ in an external electric field $\vec{E}$ is :

- (A) $\vec{p} \cdot \vec{E}$
- (B) $-\vec{p} \cdot \vec{E}$
- (C) $|\vec{p} \times \vec{E}|$
- (D) $-|\vec{p} \times \vec{E}|$

37. In the Young's double slit experiment, the intensity of central maximum is I_2 . If either of the slits is closed, the intensity at the same location is I_1 . The relation between I_1 and I_2 is :

- (A) $I_2 = 4I_1$
- (B) $I_2 = 2I_1$
- (C) $I_2 = I_1$
- (D) $I_1 = 2I_2$

38. Maxwell introduced an additional term in :

- (A) Gauss's law
- (B) Faraday's law
- (C) Ampere's law
- (D) Coulomb's law

39. The skin depth δ of a good metal, for the microwave frequency ω follows the relation :

- (A) $\delta \propto \omega$
- (B) $\delta \propto \frac{1}{\omega}$
- (C) $\delta \propto \sqrt{\omega}$
- (D) $\delta \propto \frac{1}{\sqrt{\omega}}$

40. For a certain material $\frac{g}{\epsilon W} \ll 1$, where g and ϵ are conductivity and permittivity of the medium. For a radiation of frequency ω , this material is :

- (A) a good conductor
- (B) a good insulator
- (C) partially insulating
- (D) a semiconductor

41. The entropy of an ideal gas at absolute zero is :

- (A) ∞
- (B) 0
- (C) Nk_B
- (D) can not be calculated

42. For a system of N non-interacting fermions enclosed in a volume ' V ' at constant temperature T , the average occupation number of the ' r th' energy level is given by :

(A) $\bar{n}_r = \frac{1}{e^{\beta(\epsilon_r - \mu)} + 1}$

(B) $\bar{n}_r = \frac{1}{(e^{\beta(\epsilon_r - \mu)} - 1)}$

(C) $\bar{n}_r = e^{-\beta(\epsilon_r - \mu)}$

(D) $\bar{n}_r = (e^{\beta(\epsilon_r - \mu)} + 1)$

43. A first order phase transition is characterised by :

(A) a divergence of the specific heat at T_C , the critical temperature

(B) A cusp in the average energy at T_C

(C) The constancy of entropy in the transition

(D) A latent heat is involved in the transition process

44. A gas of molecules, each of mass ' m ' is in thermal equilibrium at an absolute temperature ' T '. If v_x, v_y, v_z are the components of the velocity ' $\vec{v}$ ' of each molecule, then the mean value of v^2 :

(A) 0

(B) $\frac{1}{2}k_B T$

(C) $\frac{3}{m}k_B T$

(D) $Nk_B T$

45. The Fermi energy of a free electron gas at absolute zero is of the order of :

(A) electron-volts

(B) MeV

(C) keV

(D) ergs

46. Consider an ideal gas of N molecules enclosed in a volume ' V ' maintained at a temperature ' T '. The correct expression for the entropy of the system is :

- (A) $S = Nk_B \left[\ln V + \frac{3}{2} \ln T + \sigma \right]$
- (B) $S = Nk_B \left[\ln \left(\frac{V}{N} \right) + \frac{3}{2} \ln T + \sigma \right]$
- (C) $S = k_B \left[\ln V + \frac{3}{2} \ln T + \sigma \right]$
- (D) $S = k_B \left(\frac{N}{V} \right) \left[\ln \left(\frac{V}{N} \right) + \frac{3}{2} \ln T + \sigma \right]$

47. If the temperature of a black body is increased by a factor of 2, the amount of energy/volume radiated increases by a factor of :

- (A) 2
- (B) 4
- (C) 8
- (D) 16

48. If the temperature of a free electron gas is increased by a factor of 2, its specific heat increases by a factor of :

- (A) 2
- (B) 4
- (C) 8
- (D) 16

49. In Laue X-ray diffraction experiment in the study of single crystal structure, the following X-ray source is used :

- (A) Monochromatic
- (B) Non-monochromatic
- (C) Pulsed Monochromatic
- (D) Bychromatic

50. 5 boys and 3 girls are to stand in a straight line such that no two girls are adjacent. The number of ways in which this can be done is :

- (A) 5 !
- (B) 3 !
- (C) 5 ! $\times$ 3 !
- (D) 5 ! $\times$ 5 !