

# June 2019 Paper-II

1. If  $\vec{A} = x\hat{e}_x + y\hat{e}_y + z\hat{e}_z$ , then  $\nabla^2 \vec{A}$  will be :

(a) 1 (b) 3

(c) 0 (d) -3

2. If a vector field  $\vec{F} = x\hat{i} + 2y\hat{j} + 3z\hat{k}$ , then  $\vec{\nabla} \times (\vec{\nabla} \times \vec{F})$  is :

(a) Zero (b)  $\hat{j}$

(c)  $2\hat{j}$  (d)  $3\hat{k}$

3. A gas molecule moves equal distances  $\lambda$  between successive collisions with equal probability in any direction. After a total of  $N$  such collisions, the mean square displacement of the molecule  $\bar{d}^2$  will be :

(a)  $N\lambda$  (b)  $N\lambda^2$

(c)  $N^2\lambda^2$  (d)  $N^2\lambda$

4. At the origin, the function  $f(z) = \sqrt{|xy|}$  is not analytic because :

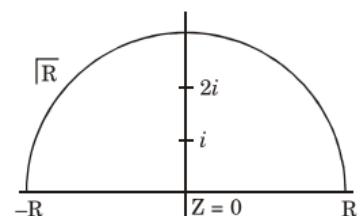
(a) The Cauchy-Riemann (C-R) conditions are not satisfied at origin.

(b)  $f'(0) \neq 0$  and the C – R conditions are satisfied at origin.

(c)  $f'(0) = 0$  though the C-R conditions are satisfied at origin.

(d)  $f'(0) = 0$  and the C – R conditions are not satisfied at origin.

5.  $I = \int_c \frac{z^2 dz}{(z^2+1)(z^2+4)}$ , in the  $z$ -plane. Here  $c$  is a contour as shown :



then :

(a)  $I = \pi/6$

(b)  $I = -\pi/3$

(c)  $I = 0$

(d)  $I = \pi/3$

6. Consider a differential equation

$$\frac{d^2x}{dt^2} + 2\frac{dx}{dt} + x = 0$$

At time  $t = 0$ , it is given that  $x = 1$  and  $\frac{dx}{dt} = 0$ .

At  $t = 1$ , the value of  $x$  is :

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

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

7. The solution of the differential equation  $\frac{d^2y}{dt^2} - y = 0$ , subject to the boundary conditions  $y(0) = 1, y(\infty) = 0$  is :

(a)  $\cos t + \sin t$  (b)  $\cosh t + \sinh t$

(c)  $\cos t - \sin t$  (d)  $\cosh t - \sinh t$

8. A matrix is said to be of rank zero if and only if :

(a) All the elements are non-zero, but the determinant is zero.

(b) It is equal to its own inverse.

(c) All its diagonal elements are zero.

(d) All its elements are zero.

9. The following Pauli spin matrices

$$\sigma_x = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} \text{ and } \sigma_y = \begin{bmatrix} 0 & -i \\ i & 0 \end{bmatrix}$$

(a) Commute

(b) Anti-commute

(c) Do not possess commutation relation

(d) Are inverses of each other.

10. Fourier series for the function

$$f(\theta) = \begin{cases} +1 & 0 < \theta < \pi \\ -1 & \pi < \theta < 2\pi \end{cases}$$

there are :

(a) Even cosine terms only

(b) Both odd sine and cosine terms

(c) Sine terms only

(d) Odd sine terms only

11 A circular hoop of mass 'M' and radius 'a' rolls without slipping with constant angular speed  $\omega$  along horizontal x-axis in the x - y plane. When the center of hoop is at a distance  $d = \sqrt{2} - a$  from the origin, the magnitude of total angular momentum of the hoop about the origin is :

(a)  $Ma^2\omega$

(b)  $\sqrt{2} \cdot Ma^2\omega$

(c)  $2Ma^2\omega$

(d)  $3Ma^2\omega$

12 A projectile is fired with initial velocity  $v_0$  making an angle  $\alpha$  with the horizontal axis. The range (R) of the projectile is proportional to, (Neglect the air resistance) :

(a)  $v_0$  and  $\sin 2\alpha$

(b)  $v_0$  and  $\sin \alpha$

(c)  $v_0^2$  and  $\sin \alpha$

(d)  $v_0^2$  and  $\sin 2\alpha$

13 An artificial satellite revolves about the earth at height H ( $H \ll R$ ,  $R$  = radius of earth). The orbital period, for which a man in the satellite will be in state of weightlessness is given as :

(a)  $2\pi\sqrt{\frac{g}{R}}$

(b)  $2\pi\sqrt{\frac{R}{g}}$

(c)  $\frac{1}{2\pi}\sqrt{\frac{g}{R}}$

(d)  $\frac{1}{2\pi}\sqrt{\frac{R}{g}}$

14 For repulsive inverse square force, the shape of the orbit is :

(a) Circular

(b) Parabolic

(c) Hyperbolic

(d) Elliptical

15 A unit charge q moving with initial velocity ( $\vec{v} = v_x \hat{i}$ ) is subjected to external electric field

( $\vec{E} = E_y \hat{j}$ ). The number of degrees of freedom is :

(a) 1

(b) 2

(c) Zero

(d) 3

16 For a Lagrangian  $L(q, \dot{q}, \ddot{q}, t)$ , the equation of motion is of the form :

(a)  $\frac{d^2}{dt^2} \left( \frac{\partial L}{\partial \ddot{q}} \right) - \frac{\partial L}{\partial q} = 0$

(b)  $\frac{d^2}{dt^2} \left( \frac{\partial L}{\partial \ddot{q}} \right) - \frac{d}{dt} \left( \frac{\partial L}{\partial \dot{q}} \right) + \frac{\partial L}{\partial q} = 0$

(c)  $\frac{d^2}{dt^2} \left( \frac{\partial L}{\partial \ddot{q}} \right) + \frac{d}{dt} \left( \frac{\partial L}{\partial \dot{q}} \right) + \frac{\partial L}{\partial q} = 0$

(d)  $\frac{d^2}{dt^2} \left( \frac{\partial L}{\partial \ddot{q}} \right) - \frac{d}{dt} \left( \frac{\partial L}{\partial \dot{q}} \right) - \frac{\partial L}{\partial q} = 0$

17 The radius of gyration of a rigid body of mass M and moment of inertia I is :

(a)  $(I/M)^2$

(b)  $(M/I)^2$

(c)  $(I/M)^{1/2}$

(d)  $(M/I)^{1/2}$

18 The period of oscillation of the plane of Foucault's pendulum is : ( $\phi$  is the latitude)

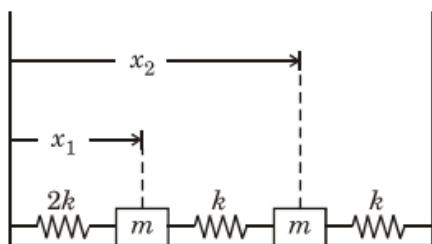
(a) Directly proportional to the latitude ( $\phi$ )

(b) Inversally proportional to  $\sin \phi$

(c) Inversally proportional to  $\cos \phi$

(d) Directly proportional to  $\sin \phi$

19 Two masses are connected by springs (as shown in the figure). The potential energy matrix is :



- (a)  $\begin{pmatrix} 2k & k \\ k & 2k \end{pmatrix}$  (b)  $\begin{pmatrix} 2k & -k \\ -k & 2k \end{pmatrix}$   
 (c)  $\begin{pmatrix} 3k & -k \\ -k & 3k \end{pmatrix}$  (d)  $\begin{pmatrix} 3k & k \\ k & 3k \end{pmatrix}$

20 A space ship is moving away from earth with velocity  $0.4c$ . It fires a rocket (away from earth) whose velocity is  $0.5c$  with respect to the space ship. The velocity of the rocket as observed from the earth is :

- (a)  $0.75c$  (b)  $0.80c$   
 (c)  $0.60c$  (d)  $0.90c$

21 Current  $I$  is flowing through an infinitely long wire placed along the  $x$ -axis. The Cartesian coordinates of the points A and B are  $A(2,3,-4)$  and  $B = (-8,4,-3)$ . The ratio of magnitudes of  $\vec{B}$  at point A to that at point B is :

- (a)  $\mu_0 I$  (b)  $\frac{1}{4}$   
 (c)  $\frac{4}{1}$  (d)  $1$

22 There is a space region where  $\vec{E} = E_0 \hat{z}$  and  $\vec{B} = B_0 \hat{x}$  are both present. A charged particle with velocity  $\left(\frac{E_0}{B_0}\right) \hat{y}$  enters this region. The trajectory of the particle in this region is a :

- (a) Straight line (b) Circle  
 (c) Cycloid (d) Circular helix

23 The magnetic dipole moment of a circular loop of radius  $R$ , carrying current  $I$ , is  $\vec{m}$ . If radius is doubled and current is halved, then the magnetic

dipole moment becomes :

- (a)  $4m$  (b)  $\frac{m}{4}$   
 (c)  $\frac{m}{2}$  (d)  $2m$

24 A rectangle of cross-sectional area ' $A$ ' is placed in a uniform constant electric field  $\vec{E}$ . The plane of the rectangle makes an angle of  $30^\circ$  with the direction of the electric field. The electric flux through the rectangle is :

- (a)  $AE$  (b)  $\frac{AE}{2}$

- (c)  $AE \frac{\sqrt{3}}{2}$  (d) Zero

25 The magnitude of magnetic vector potential at a distance  $r$  from an ideal magnetic quadrupole is proportional to :

- (a)  $r^{-1}$  (b)  $r^{-2}$   
 (c)  $r^{-3}$  (d)  $r^{-4}$

26 ABCD is a square and 'O' is the point of intersection of the diagonals. Charge  $Q$  is placed at corner A and charge  $-Q$  is placed at corner C. If electric potential at corner D is  $1\text{ V}$ , then the electric potential at point 'O' is :

- (a) Zero V (b)  $1\text{ V}$   
 (c)  $\frac{1}{\sqrt{2}}\text{ V}$  (d)  $\left(1 + \frac{1}{\sqrt{2}}\right)\text{ V}$

27 A constant current  $I$  is flowing through a cylindrical conductor. The direction of Poynting vector on the curved surface is :

- (a)  $\hat{z}$  (b)  $\hat{\phi}$   
 (c)  $\hat{r}$  (d)  $-\hat{r}$

28 Vector potential  $\vec{A}(\vec{r}, t)$  is such that

$$\vec{r} \cdot \vec{A} = \frac{-\mu_0 Q}{4\pi r^2}.$$

The corresponding electric potential  $V(\vec{r}, t)$ ,

under Lorentz gauge condition is :

(a)  $\frac{Q}{4\pi\epsilon_0 r}$  (b)  $\frac{Q}{4\pi\epsilon_0 r^2}$

(c)  $\frac{Qt}{4\pi\epsilon_0 r}$  (d)  $\frac{Qt}{4\pi\epsilon_0 r^2}$

29 If an electromagnetic wave is propagating in a medium with permittivity  $\epsilon$  and permeability  $\mu$ , then  $\sqrt{\frac{\mu}{\epsilon}}$  is :

- (a) The refractive index of the medium.  
(b) The square root of the refractive index of the medium.  
(c) The intrinsic impedance of the medium.  
(d) The energy density of the wave in the medium.

30 A plane electromagnetic wave is propagating through a perfect dielectric medium with dielectric constant equal to  $\pi$ . The phase difference between  $\vec{E}$  and  $\vec{B}$  associated with the wave is :

- (a) Zero (b)  $\frac{\pi}{4}$   
(c)  $\frac{\pi}{2}$  (d)  $\pi$

31 A boy of mass 60 kg is running with a velocity 12 km/hr. The de Broglie wavelength associated with him is approximately ( $h = 6.626 \times 10^{-34}$  Js)

- (a)  $3 \times 10^{-32}$  m (b)  $3 \times 10^{-34}$  m  
(c)  $3 \times 10^{-30}$  m (d)  $3 \times 10^{-31}$  m

32 Which of the following functions can be an acceptable solution for Schrödinger equation for all values of  $x$  ?

- (a)  $\psi(x) = Ae^{-\alpha x^2}$  (b)  $\psi(x) = Ae^{\alpha x^2}$   
(c)  $\psi(x) = A \tan x$  (d)  $\psi(x) = A \sec x$

33 The Hamiltonian

$$H = \frac{-\hbar^2}{2m} \frac{d^2}{dx^2} - \alpha \delta(x)$$

is given for a particle. Using the trial wave function  $\psi_{\text{trial}}(x) = Ae^{-bx^2}$  (with  $b$  as the variational parameter), the bound on the ground state energy is :

(Given :  $\int_{-\infty}^{\infty} x^{2n} e^{-\alpha x^2} dx = \Gamma(n + 1/2)/\alpha^{n+1/2}$ )

- (a)  $-\alpha^2/2\hbar^2$  (b)  $-2\alpha^2/\pi\hbar^2$   
(c)  $-\alpha^2/\pi\hbar^2$  (d)  $\alpha^2/\pi\hbar^2$

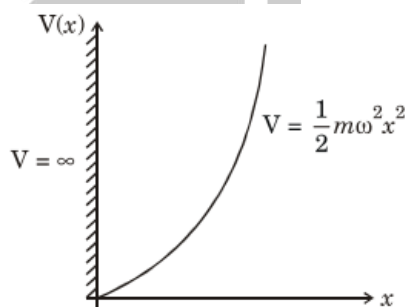
34 A particle is moving in a one-dimensional infinite potential well of width  $a$ . Using a normalized trial wave function

$$\psi(x) = \frac{\sqrt{15}}{5} (a^2 - x^2)$$

, variational calculation estimate for  $4a^{\frac{5}{2}}$  the ground state energy is :

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

35 A particle is constrained to move in a truncated harmonic potential well (as shown below). Which one of the following statements is correct ?



- (a) The parity of the first excited state is even.  
(b) The parity of the ground state is even.  
(c) The ground state energy is  $\frac{1}{2}\hbar\omega$   
(d) The energy of the first excited state is  $\frac{7}{2}\hbar\omega$

- 36 The wave function for an electron in a hydrogen atom is given by

$$\psi(\vec{r}) = \psi_{200}(\vec{r}) + 2\psi_{211} + 3\psi_{210} + \sqrt{2}\psi_{21-1}$$

where  $\psi_{n_l m_l}(\vec{r})$  is the wave function for an electron in the eigenstate  $(n_l m_l)$ . The expectation value of z-component of angular momentum,  $\langle L_z \rangle$  in the state  $\psi(\vec{r})$  is :

- (a)  $3\hbar/8$  (b)  $\hbar/8$   
(c)  $11\hbar/16$  (d)  $15\hbar/16$

- 37 A system described by the Hamiltonian  $H =$

$$\begin{pmatrix} 5 & 2 & 0 \\ 2 & 5 & 0 \\ 0 & 0 & 2 \end{pmatrix} \text{ is perturbed by } H' = \varepsilon \begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & -1 \\ 1 & -1 & 1 \end{pmatrix}$$

where  $(\varepsilon \ll 1)$ . A pair of eigenvalues of the perturbed system is :

- (a)  $3 + 2\varepsilon, 2 + \varepsilon$  (b)  $3, 2 + 2\varepsilon$   
(c)  $3, 7 + 2\varepsilon$  (d)  $3 + 2\varepsilon, 7 + 2\varepsilon$

- 38 An electron is in a state  $\chi = \begin{pmatrix} \frac{1+i}{\sqrt{6}} \\ \frac{1}{\sqrt{2}/\sqrt{3}} \end{pmatrix}$  where the

basis functions are  $\begin{pmatrix} 1 \\ 0 \end{pmatrix}$  and  $\begin{pmatrix} 0 \\ 1 \end{pmatrix}$ . The respective probabilities that a measurement of  $S_z$  yields values  $+\hbar/2$  and  $-\hbar/2$  are :

- (a)  $\frac{1}{2}$  and  $\frac{1}{2}$  (b)  $\frac{2}{3}$  and  $\frac{1}{3}$   
(c)  $\frac{1}{4}$  and  $\frac{3}{4}$  (d)  $\frac{1}{3}$  and  $\frac{2}{3}$

- 39 The differential scattering cross section for a Gaussian potential  $V(r) = V_0 e^{-r^2/a^2}$ , using Born approximation is given by

$$\sigma(\theta) = C e^{D \sin^2(\theta/2)}$$

where C and D are constants and  $(C \text{ and } D > 0)$   $\sigma(\theta)$  is maximum for  $\theta =$

- (a)  $\pi$  (b)  $2\pi$   
(c)  $3\pi$  (d)  $2n\pi$ , where  $n = 0, 1, 2, \dots$

- 40 A particle is in the normalized state  $|\psi\rangle$ .  $|\psi\rangle$  is a

superposition of energy eigen states  $|E_0 = 10\text{eV}\rangle$  and  $|E_1 = 30\text{eV}\rangle$ . The average value of energy of the particle in the state  $|\psi\rangle$  is 20eV. The state  $|\psi\rangle$  is :

- (a)  $\frac{1}{2}|E_0 = 10\text{eV}\rangle + \frac{\sqrt{3}}{4}|E_1 = 30\text{eV}\rangle$   
(b)  $\frac{1}{\sqrt{3}}|E_0 = 10\text{eV}\rangle + \sqrt{\frac{2}{3}}|E_1 = 30\text{eV}\rangle$   
(c)  $\frac{1}{2}|E_0 = 10\text{eV}\rangle - \frac{\sqrt{3}}{4}|E_1 = 30\text{eV}\rangle$   
(d)  $\frac{1}{\sqrt{2}}|E_0 = 10\text{eV}\rangle - \frac{1}{\sqrt{2}}|E_1 = 30\text{eV}\rangle$

- 41 Viscosity and surface tension are :

- (a) Both intensive variables  
(b) Both extensive variables  
(c) Intensive and extensive variables respectively  
(d) Extensive and intensive variables respectively

- 42 A capacitor of capacitance C farads is charged from a battery of emf V volts. Out of the work done by the battery an amount  $\frac{1}{2}CV^2$  is stored in the capacitor and the rest is released as heat. The released heat is :

- (a) Zero (b)  $CV^2$

- (c)  $\frac{CV^2}{8}$  (d)  $\frac{CV^2}{2}$

- 43 van der Waals equation for one mole of gas is

$\left(p + \frac{a}{V^2}\right)(V - b) = RT$ . The equation for n moles would be :

- (a)  $\left(p + \frac{an}{V^2}\right)(V - nb) = nRT$   
(b)  $\left(p + \frac{a}{V^2}\right)(V - b) = nRT$

$$(c) \left( p + \frac{an^2}{V^2} \right) (V - nb) = nRT$$

$$(d) \left( p + \frac{an}{V^2} \right) (V - b) = nRT$$

44 The entropy of black-body radiation is given by

$$S = \frac{4}{3} \sigma V^{\frac{1}{4}} U^{\frac{3}{4}}$$

where  $\sigma$  is a constant  $V$  is the volume and  $U$  is internal energy of the system. The temperature of the radiation is :

$$(a) T = \frac{U^{\frac{1}{4}}}{\sigma V^{\frac{1}{4}}}$$

$$(b) T = \frac{U^{\frac{1}{4}}}{\sigma}$$

$$(c) T = \frac{1}{\sigma^4} \left( \frac{U}{V} \right)$$

$$(d) T = \sigma \left( \frac{V}{U} \right)^{1/4}$$

45 A system consists of two identical particles. Each particle can occupy only two energy levels.  $E_1 = \epsilon$  and  $E_2 = 2\epsilon$ . If the particles satisfy Boltzmann statistics, the partition functions would be

$$\left( \beta = \frac{1}{k_B T} \right):$$

$$(a) z = e^{-3\epsilon\beta}$$

$$(b) z = \frac{1}{2} (e^{-\beta\epsilon} + e^{-2\beta\epsilon})^2$$

$$(c) z = e^{-2\beta\epsilon} + e^{-3\beta\epsilon} + e^{-4\beta\epsilon}$$

$$(d) z = 2(e^{-\beta\epsilon} + e^{-2\beta\epsilon})$$

46 Crystalline sodium has 2 conduction electrons per unit cell with lattice constant (cube edge)  $4.28 \text{ \AA}$ . In the free-electron model the Fermi temperature is ( $h = 6.62 \times 10^{-27} \text{ ergs}$ ,  $c = 3 \times 10^{10} \text{ cm/s}$ ,  $m_e = 9.1 \times 10^{-27} \text{ gm}$ ):

$$(a) T_F = 380 \text{ K}$$

$$(b) T_F = 3800 \text{ K}$$

$$(c) T_F = 38000 \text{ K}$$

$$(d) T_F = 38 \text{ K}$$

47 The number of distinct ways in which 4 particles can be distributed in 7 energy levels if (i) they are distinguishable and (ii) if they are

indistinguishable bosons respectively is :

$$(a) (i) \frac{7!}{4!} \text{ and } (ii) \frac{7!}{4!3!}$$

$$(b) (i) 4^7 \text{ and } (ii) 210$$

$$(c) (i) 7!4! \text{ and } (ii) \frac{7!}{4!3!}$$

$$(d) (i) 7^4 \text{ and } (ii) 210$$

48 One block of certain metal is at temperature  $T_1$  and a second identical block is at a temperature  $T_2$ . These blocks are brought in contact and the system is thermally isolated from the surroundings. Assume that the heat capacity at constant volume  $C$  of each block is independent of temperature  $T$ . The increase in the entropy of the universe, when the system comes to an equilibrium is :

$$(a) C \ln \left[ \frac{T_1 T_2}{|T_2 - T_1|} \right]$$

$$(b) C \ln \left[ \frac{(T_1 + T_2)}{2 T_1 T_2} \right]$$

$$(c) C \ln \left[ \frac{(T_1 + T_2)^2}{4 T_1 T_2} \right]$$

$$(d) C \ln \left[ \frac{2 T_1 T_2}{T_1 + T_2} \right]$$

49 An ideal monoatomic gas at temperature  $300 \text{ K}$  is adiabatically decompressed so that the final volume is 8 times the original. The final temperature is :

$$(a) 150 \text{ K}$$

$$(b) 37.5 \text{ K}$$

$$(c) 2400 \text{ K}$$

$$(d) 75 \text{ K}$$

50 For one mole the van der Waals equation is

$$\left( p + \frac{a}{V^2} \right) (V - b) = RT$$

At the critical point the pressure is :

$$(a) P_c = \frac{a}{27b^2}$$

$$(b) P_c = \frac{a}{27b}$$

$$(c) P_c = \frac{a}{b}$$

$$(d) P_c = \frac{a}{3b}$$

- 51 To measure the temperature below the liquid Nitrogen temperature, we need to use :  
 (a) Thermocouple  
 (b) Semiconductor diode  
 (c) Transistor  
 (d) Thermistor
- 52 In an experiment, the acceleration due to gravity is determined by measuring the time period of a simple pendulum. If there is an error of 1% in the measurement of time period, the error in the value of  $g$  is :  
 (a) 2% (b) 1%  
 (c) 0.5% (d) no error
- 53 A laser beam of intensity  $50 \text{ W/cm}^2$  falls on a perfectly reflecting plane mirror for an hour. The area of the mirror is  $5 \text{ cm}^2$ . The average force acting on the mirror is few :  
 (a) Newtons (b) Milli Newtons  
 (c) Micro Newtons (d) Nano Newtons
- 54 When the movable mirror of Michelson interferometer is shifted through  $0.0589 \text{ mm}$  a shift of 200 fringes is observed ? The wavelength of light used in  $\text{\AA}$  is :  
 (a) 5885 (b) 5890  
 (c) 5895 (d) 6000
- 55 Photomultiplier can detect a feeble optical signal because of :  
 (a) The shape of its photocathode  
 (b) Multiplication of the output pulse  
 (c) Multiplication of secondary electrons  
 (d) Multiplication of photons
- 56 Which of the following gauges can measure the pressure in the range of  $10^{-10}$  to  $10^{-3}$  Torr ?  
 (a) McLeod gauge (b) Pirani gauge  
 (c) Penning gauge (d) Ionization gauge
- 57 A 10 stage photomultiplier tube has a stage gain of 4 secondary electrons. The overall amplification of the tube is :  
 (a)  $10^3$  (b)  $10^4$   
 (c) 10 (d)  $10^6$
- 58 In oil rotary pump for low vacuum, the oil primarily serves :  
 (a) As a lubricant  
 (b) To isolate rotating and stationary members of the group  
 (c) To discharge the exhaust against atmospheric pressure  
 (d) To prevent air from leaking into the pump side
- 59 For a typical laboratory sizes and specification which of the following has better resolving power ?  
 (a) Prism spectrometer  
 (b) Grating spectrometer  
 (c) Fabry-Perrot etalon  
 (d) Constant deviation spectrometer
- 60 In which of the following wavelength region, the sources are comparatively weak and detectors insensitive requiring Fourier Transform methods  
 (a) UV (b) VISIBLE  
 (c) Infrared (d) X-rays

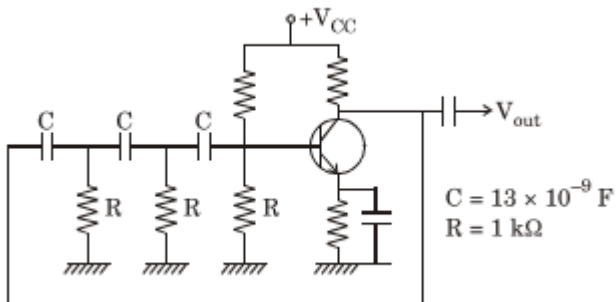
61 A silicon diode dissipates 5 W of power when the dc current of 2Amp flows through it. The bulk resistance of the diode is :

- (a)  $0.6\Omega$  (b)  $0.9\Omega$   
(c)  $1.2\Omega$  (d)  $2.5\Omega$

62 For fabrication of light emitting diodes, the commonly used semiconductor materials are :

- (a) Pure crystals of silicon and germanium  
(b) Thin waters of SiC and GaN  
(c)  $\text{GaAs}_{1-y}\text{Py}$  and GaP by deposition  
(d) ZnSe, CdS and ZnTe in powder

63 The frequency of the following phase shift oscillator :



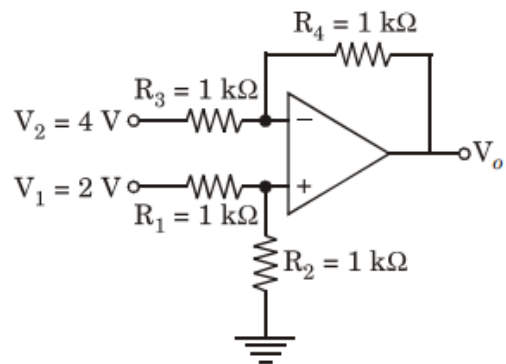
is nearly equal to :

- (a) 2kHz (b) 5kHz  
(c) 8kHz (d) 10kHz

64 In a power supply circuit, the a.c. voltage of 100-0-100 Volts r.m.s. is applied to diodes of the full wave rectifier circuit. The output of the diodes is connected to a load of  $5\text{k}\Omega$ . The D.C. current through the load resistance of  $5\text{k}\Omega$  is nearly :

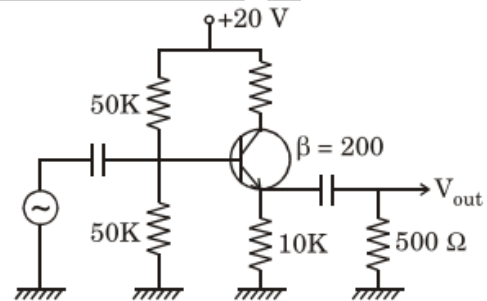
- (a) 15 Ma (b) 18 mA  
(c) 21 mA (d) 25 mA

65 The output voltage ( $V_o$ ) of the following Op-amp circuit is :



- (a) +2 (b) -2  
(c) +4 (d) -4

65 The voltage gain for the following amplifier circuit



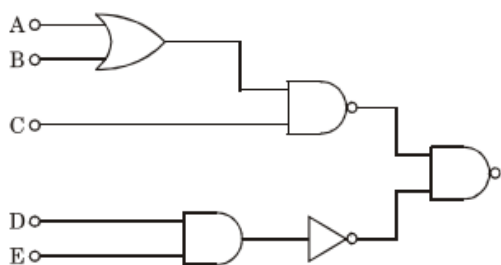
is nearly equal to :

- (a) 0.5 (b) 1.0  
(c) 1.5 (d) 2.0

67 Negative feedback for an operational amplifier leads to :

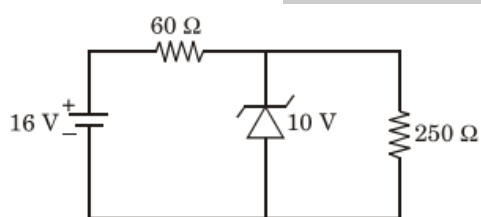
- (a) Increase the input and output impedance  
(b) Increase the input impedance and the bandwidth  
(c) Decrease the output impedance and bandwidth  
(d) Does not affect impedance or bandwidth

68 The output of the following logic circuit is :



- (a)  $AB + C(D + E)$       (b)  $(A + B)C + DE$   
 (c)  $(A + B)C + D + E$       (d)  $(AB + C) \cdot DE$

69 In the following Zener diode circuit



the current flowing through the Zener diode is :

- (a) 40 mA      (b) 60 mA  
 (c) 80 mA      (d) 100 mA

70 Among the following A to D converter, the slowest one is the :

- (a) Parallel comparator type  
 (b) Successive approximation type  
 (c) Integrating type  
 (d) Counting type

71 Value of radius for fifth orbital of hydrogen is (first orbital radius is  $0.53\text{\AA}$ ) :

- (a)  $0.529\text{\AA}$       (b)  $0.26\text{\AA}$   
 (c)  $8.4\text{\AA}$       (d)  $13.25\text{\AA}$

72 The S, L and J values that correspond to each of the following states  $^1S_0$ ,  $^3P_2$  are :

- (a)  $S = 0, L = 0, J = 0$  and  $S = 1, L = 1, J = 2$

(b)  $S = 1, L = 0, J = 0$  and  $S = 2, L = 1, J = 2$

(c)  $S = 0, L = 1, J = 1$  and  $S = 1, L = 0, J = 2$

(d)  $S = 1, L = 1, J = 2$  and  $S = 2, L = 0, J = 2$

73 In many electron atoms which of the following statements is not correct ?

- (a) In heavier atoms LS coupling is dominant  
 (b) In lighter atoms jj coupling is dominant

(c) LS coupling occurs irrespective of atomic size

(d) Electrostatic forces couple the  $l_i$  vectors into single L vector and  $S_i$  into another vector S

74 A typical PR contour for vibrational rotational spectrum for CO molecule shows  $\Delta\bar{\nu} = 55\text{ cm}^{-1}$ .

The associated value of rotational constant B is (Given; Boltzmann const.  $k = 1.38 \times 10^{-23}\text{ J/K}$ ,  $T = 300$ ,  $h = 6.6 \times 10^{-34}\text{ J-s}$ ) :

- (a)  $1.8\text{ cm}^{-1}$       (b)  $1.6\text{ cm}^{-1}$   
 (c)  $2.0\text{ cm}^{-1}$       (d)  $1.4\text{ cm}^{-1}$

75 Which of the following is not correct (for number of fundamental modes of vibration)?

- (a) Non-linear molecule has  $3N - 6$  modes  
 (b) Non-linear molecule has  $3N - 3$  modes  
 (c) Linear molecule has  $3N - 5$  modes

(d) Spherical top molecule has  $3N - 6$  modes

76 Direct confirmation about the quantization of internal energy states of an atom was first obtained from :

- (a) Stern-Gerlach experiments  
 (b) Compton scattering experiment

(c) Mill icon oil drop experiment

(d) Frank-Hertz experiment

77 When excited with mercury line at 435.8 nm, Benzene shows first Raman shift at  $606\text{ cm}^{-1}$ . What will be the Raman shift if excited by He-Ne Laser ( $632.8\text{ nm}$ ).

(Given :  $n = 6.6 \times 10^{-34}\text{ Js}$ ) :

(a)  $1200\text{ cm}^{-1}$  (b)  $409\text{ cm}^{-1}$

(c)  $803\text{ cm}^{-1}$  (d)  $606\text{ cm}^{-1}$

78 Nuclear Magnetic Resonance (NMR) spectrometer normally operates at :

(a) Radio frequency region

(b) Microwave frequency region

(c) Audio frequency region

(d) Ultraviolet frequency region

79 Which of the following identity is not correct as regards the hybridization of atomic orbitals to form MO :

(a)  $sp^2$ -Trigonal –  $\text{BCl}_3$

(b)  $sp$ -linear –  $\text{CO}_2$

(c)  $sp^3$ -square planar –  $\text{PtCl}_4^{2-}$

(d)  $sp^3$ -Tetrahedral –  $\text{CH}_4$

80 Which of the both sequences represent an increasing order of orbital energy?

(a)  $2p, 3s, 3p, 3d \& 3s, 3p, 3d, 4s$

(b)  $3s, 3p, 3d, 4s \& 4s, 5s, 6s, 7s$

(c)  $3s, 3p, 4s, 3d \& 5s, 3d, 4f, 4p$

(d)  $3p, 4s, 3d, 4p \& 2p, 3s, 3p, 4s$

81 The primitive translational vectors of the body centered lattice are given by

$$\vec{a} = \frac{a}{2}(\hat{i} + \hat{j} - \hat{k}), \vec{b} = \frac{a}{2}(-\hat{i} + \hat{j} + \hat{k})$$

$$\vec{c} = \frac{a}{2}(\hat{i} - \hat{j} + \hat{k}),$$

where  $a$  is the side of the conventional unit cube and  $\hat{i}, \hat{j}, \hat{k}$  are orthogonal unit vectors parallel to the cube edges. The volume of the reciprocal lattice of bcc cell is :

(a)  $\frac{1}{2}a^3$  (b)  $2(2\pi/a)^3$

(c)  $(\pi/a)^3$  (d)  $(2\pi/3a)^3$

82 In a simple cubic crystal of lattice spacing  $a = 3\text{ \AA}$ , a positive edge dislocation  $1\text{ mm}$  long climbs down by  $1\mu\text{m}$ . The number of vacancies created or lost in the crystal is :

(a)  $1.10 \times 10^{10}$  (b)  $5.00 \times 10^{12}$

(c)  $5.00 \times 10^{14}$  (d)  $8.00 \times 10^{15}$

83 The Debye temperature of diamond is  $2230\text{ K}$ . The molar heat capacity of diamond at  $10\text{ K}$  is :

( $R = 8.314\text{ Jmol}^{-1}\text{ K}^{-1}$ )

(a)  $0.025\text{ Jkmol}^{-1}\text{ K}^{-1}$  (b)  $0.175\text{ Jkmol}^{-1}\text{ K}^{-1}$

(c)  $0.235\text{ Jkmol}^{-1}\text{ K}^{-1}$  (d)  $0.350\text{ Jkmol}^{-1}\text{ K}^{-1}$

84 In an MX molecule, suppose M atom has an ionization potential energy  $5\text{ eV}$  and X atom has an electron affinity. The amount of energy required to transfer an electron from M to X when they are at a distance of  $5\text{ \AA}$  is :

(a)  $0.50\text{ eV}$  (b)  $-2.88\text{ eV}$

(c)  $-1.88\text{ eV}$  (d)  $-4.20\text{ eV}$

85 A linear diatomic lattice of lattice constant  $a$  with masses  $M$  and  $m$  ( $M > m$ ) are coupled by a force constant  $C$ . The dispersion relation is given by

$$\omega^2 = C \left( \frac{1}{M} + \frac{1}{m} \right) \pm \left[ C^2 \left( \frac{1}{M} + \frac{1}{m} \right)^2 - \frac{4C^2}{Mm} \sin^2 ka \right]^{1/2}$$

Which one of the following statements is incorrect?

- (a) The atoms vibrating in transverse mode correspond to the optical branch
- (b) The maximum frequency of the acoustic branch depends on the mass of the lighter atom m
- (c) The dispersion of frequency in the optical branch is smaller than that in the acoustic branch
- (d) No normal modes exist in the acoustic branch for any frequency greater than the maximum frequency at  $k = \pi/a$

86 If the interatomic potential energy function can be expressed as

$$U(R) = -\frac{A}{R^6} + \frac{B}{R^{12}}$$

where A and B are constants, the atomic spacing  $R_0$  for which the potential energy is a minimum is given by :

- (a)  $A/4 B$
- (b)  $(2 B/A)^{1/6}$
- (c)  $A^2/4 B$
- (d)  $4 B^2/A$

87 For an ideal Fermi gas in Three dimensions, the electron velocity  $v_F$  at the Fermi surface is related to electron concentration n as :

- (a)  $v_F \propto n^{2/3}$
- (b)  $v_F \propto n$
- (c)  $v_F \propto n^{1/2}$
- (d)  $v_F \propto n^{1/3}$

88 A phosphorous doped silicon semiconductor (doping density :  $10^{17}/\text{cm}^3$ ) is heated from  $100^\circ\text{C}$  to  $200^\circ\text{C}$ . Which one of the following statements is correct?

- (a) Position of Fermi level moves towards conduction band

(b) Position of dopant level moves towards conduction band

(c) Position of Fermi level moves towards middle of the energy gap

(d) Position of dopant level moves towards the middle of the energy gap

89 For a rare earth ion the ground state energy level is characterized by the term value  $^4I_{9/2}$ . The number of 4f unpaired electrons in this ion is :

- (a) 2
- (b) 3
- (c) 4
- (d) 5

90 A flux quantum (fluxoid) is approximately equal to  $2 \times 10^{-7}$  gauss-cm<sup>2</sup>. A type II superconductor is placed in a small magnetic field, which is then slowly increased till the field starts penetrating the superconductor. The strength of the field at this point is  $(2/\pi) \times 10^5$  gauss. The penetration depth of this superconductor is :

- (a)  $10\text{\AA}$
- (b)  $100\text{\AA}$
- (c)  $1000\text{\AA}$
- (d)  $1200\text{\AA}$

91 The wavelength of 10MeV proton is nearly equal to : ( $1 \text{ F} = 10^{-15} \text{ meter}$ )

- (a) 7 F
- (b) 9 F
- (c) 11 F
- (d) 13 F

92 The nuclear density of a  $^{197}\text{Au}$  nucleus is nearly : [Mass of  $^{197}\text{Au} = 3.2707 \times 10^{-25} \text{ kg}$ ,  $r_0 = 1.2 \times 10^{-15} \text{ m}$ ]

- (a)  $3.96 \times 10^{17} \text{ kg/m}^3$
- (b)  $5.80 \times 10^{17} \text{ kg/m}^3$
- (c)  $6.54 \times 10^{17} \text{ kg/m}^3$
- (d)  $8.38 \times 10^{17} \text{ kg/m}^3$

93 Nuclear forces are :

- (a) Spin dependent and have no non-central part

(b) Spin dependent and have a noncentral part

(c) Spin independent and have no non-central part

(d) Spin independent and have a non-central part

94 Given : Masses of  $^{80}_{35}\text{Br}$  and  $^{80}_{34}\text{Se}$  are respectively 79.918528 amu and 79.916520 amu. Use 1 amu = 931.5 MeV Nucleus  $^{80}_{35}\text{Br}$  decays to  $^{80}_{34}\text{Se}$  by emitting a positron. The end point energy of the emitted positron is nearly :

(a) 0.511 MeV

(b) 0.84 MeV

(c) 1.84 MeV

(d) 1.022 MeV

95  $^1_1\text{H}^3$  nuclei undergoes beta decay at a rate of  $1.27 \times 10^{17}$  particles/hour and produce 21 calories of heat per hour in a medium. The average energy of the beta particle emitted is :

(a) 10.2 KeV

(b) 8.5 KeV

(c) 6.4 KeV

(d) 4.3 KeV

96 A gamma-ray of 3.43 MeV energy undergoes pair production. The electron and positron formed move with equal kinetic energy in opposite direction to each other. The kinetic energy of the positron is nearly :

(a) 0.511 MeV

(b) 1.022 MeV

(c) 1.20 MeV

(d) 1.40 MeV

97 A gas filled G.M. counter cannot be used to measure energy of radiation because :

(a) The electrons and ions produced in the counter recombine and therefore energy information is lost.

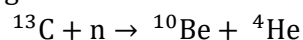
(b) The window of the G.M. counter is thick and therefore a large fraction of the energy of radiation is lost while entering the counter.

(c) Only a fraction of the gas atoms of the G.M.

counter are ionized and therefore the energy information is lost.

(d) All the atoms of the gas are ionized irrespective of the energy of incident radiation. The information about the energy of the radiation is lost.

98 The following nuclear reaction is induced by bombarding neutrons on the  $^{13}\text{C}$  target.



If the R value of this reaction is  $-3.835\text{MeV}$ , the minimum neutron energy required to induce the reaction is nearly :

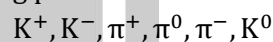
(a) 2.13 MeV

(b) 4.13 MeV

(c) 4.835 MeV

(d) 5.835 MeV

99 The following particles



are broadly classified as :

(a) Leptons

(b) Quarks

(c) Baryons

(d) Mesons

100 Considering U, d, S Quarks, the quark content of proton and neutron are respectively :

(a) UUS and dd S

(b) Ud S and dSS

(c) UUS and USS

(d) UUd and Udd

Answer Key				
1. c	2. a	3. b	4. b	5. d
6. b	7. d	8. d	9. b	10. d
11. c	12. d	13. b	14. c	15. b
16. b	17. c	18. b	19. *	20. a
21. d	22. a	23. d	24. c	25. c
26.	27. d	28.	29. c	30. a
31. *	32. a	33. c	34. *	35. d
36. b	37.	38. d	39. d	40. d
41. a	42. d	43. c	44. a	45. b
46.	47. d	48. c	49. d	50. a
51. b	52. a	53.	54. b	55. c
56. d	57.	58. a	59. c	60. c
61. b	62. c	63. b	64. b	65. b
66.	67. b	68. b	69. b	70. c
71. d	72. a	73. abc	74. a	75. b
76. d	77.	78. a	79. c	80. d
81. b	82.	83. b	84.	85. b
86. b	87. d	88. c	89.	90. b
91. b	92. *	93. b	94. b	95. d
96. c	97. d	98. b	99. d	100. d