Test Booklet Code & Serial No.
प्रश्नपत्रिका कोड व क्रमांक

A

Paper-II
PHYSICAL SCIENCE

Signature and Name of Invigilator

1. (Signature) ....

(Name) ....

2. (Signature) ....

(Name) ....

Seat No. | | | | | | |

(In figures as in Admit Card)

Seat No. ....

(In words)

OMR Sheet No. | | | | | | |

(To be filled by the Candidate)

JUN - 32219

Time Allowed : 2 Hours] **[Maximum Marks : 200**

Number of Pages in this Booklet : **32** Number of Questions in this Booklet : **100**

Instructions for the Candidates

1. Write your Seat No. and OMR Sheet No. in the space provided on the top of this page.
2. This paper consists of **100** objective type questions. Each question will carry *two* marks. *All* questions of Paper II will be compulsory.
3. At the commencement of examination, the question booklet will be given to the student. In the first 5 minutes, you are requested to open the booklet and compulsorily examine it as follows :
   (*i*) To have access to the Question Booklet, tear off the paper seal on the edge of this cover page. Do not accept a booklet without sticker-seal or open booklet.
   (*ii*) Tally the number of pages and number of questions in the booklet with the information printed on the cover page. Faulty booklets due to missing pages/questions or questions repeated or not in serial order or any other discrepancy should not be accepted and correct booklet should be obtained from the invigilator within the period of 5 minutes. Afterwards, neither the Question Booklet will be replaced nor any extra time will be given. The same may please be noted.
   (*iii*) After this verification is over, the OMR Sheet Number should be entered on this Test Booklet.
4. Each question has four alternative responses marked (A), (B), (C) and (D). You have to darken the circle as indicated below on the correct response against each item.
   Example : where (C) is the correct response.
   (A) (B) ● (D)
5. Your responses to the items are to be indicated in the **OMR Sheet given inside the Booklet only.** If you mark at any place other than in the circle in the OMR Sheet, it will not be evaluated.
6. Read instructions given inside carefully.
7. Rough Work is to be done at the end of this booklet.
8. If you write your Name, Seat Number, Phone Number or put any mark on any part of the OMR Sheet, except for the space allotted for the relevant entries, which may disclose your identity, or use abusive language or employ any other unfair means, you will render yourself liable to disqualification.
9. You have to return original OMR Sheet to the invigilator at the end of the examination compulsorily and must not carry it with you outside the Examination Hall. You are, however, allowed to carry the Test Booklet and duplicate copy of OMR Sheet on conclusion of examination.
10. Use only Blue/Black Ball point pen.
11. Use of any calculator or log table, etc., is prohibited.
12. There is no negative marking for incorrect answers.

विद्यार्थ्यांसाठी महत्त्वाच्या सूचना

1. परिक्षार्थींनी आपला आसन क्रमांक या पृष्ठावरील वरच्या कोपऱ्यात लिहावा. तसेच आपणांस दिलेल्या उत्तरपत्रिकेचा क्रमांक त्याखाली लिहावा.
2. सदर प्रश्नपत्रिकेत 100 बहुपर्यायी प्रश्न आहेत. प्रत्येक प्रश्नास **दोन** गुण आहेत. या प्रश्नपत्रिकेतील **सर्व** प्रश्न सोडविणे अनिवार्य आहे.
3. परीक्षा सुरू झाल्यावर विद्यार्थ्याला प्रश्नपत्रिका दिली जाईल. सुरुवातीच्या 5 मिनीटांमध्ये आपण सदर प्रश्नपत्रिका उघडून खालील बाबी अवश्य तपासून पहाव्यात.
   (*i*) प्रश्नपत्रिका उघडण्यासाठी प्रश्नपत्रिकेवर लावलेले सील उघडावे. सील नसलेली किंवा सील उघडलेली प्रश्नपत्रिका स्विकारू नये.
   (*ii*) पहिल्या पृष्ठावर नमूद केल्याप्रमाणे प्रश्नपत्रिकेची एकूण पृष्ठे तसेच प्रश्नपत्रिकेतील एकूण प्रश्नांची संख्या पडताळून पहावी. पृष्ठे कमी असलेली/कमी प्रश्न असलेली/प्रश्नांचा चुकीचा क्रम असलेली किंवा इतर त्रुटी असलेली सदोष प्रश्नपत्रिका सुरुवातीच्या 5 मिनिटातच पर्यवेक्षकाला परत देऊन दुसरी प्रश्नपत्रिका मागवून घ्यावी. त्यानंतर प्रश्नपत्रिका बदलून मिळणार नाही तसेच वेळही वाढवून मिळणार नाही याची कृपया विद्यार्थ्यांनी नोंद घ्यावी.
   (*iii*) वरीलप्रमाणे सर्व पडताळून पाहिल्यानंतरच प्रश्नपत्रिकेवर ओ.एम.आर. उत्तरपत्रिकेचा नंबर लिहावा.
4. प्रत्येक प्रश्नासाठी (A), (B), (C) आणि (D) अशी चार विकल्प उत्तरे दिली आहेत. त्यातील योग्य उत्तराचा रकाना खाली दर्शविल्याप्रमाणे ठळकपणे काळा/निळा करावा.
   उदा. : जर (C) हे योग्य उत्तर असेल तर.
   (A) (B) ● (D)
5. या प्रश्नपत्रिकेतील प्रश्नांची उत्तरे **ओ.एम.आर. उत्तरपत्रिकेतच दर्शवावीत.** इतर ठिकाणी लिहिलेली उत्तरे तपासली जाणार नाहीत.
6. आत दिलेल्या सूचना काळजीपूर्वक वाचाव्यात.
7. प्रश्नपत्रिकेच्या शेवटी जोडलेल्या कोऱ्या पानावरच कच्चे काम करावे.
8. जर आपण ओ.एम.आर. वर नमूद केलेल्या ठिकाणा व्यतिरीक्त इतर कोठेही नाव, आसन क्रमांक, फोन नंबर किंवा ओळख पटेल अशी कोणतीही खूण केलेली आढळून आल्यास अथवा असभ्य भाषेचा वापर किंवा इतर गैरमार्गांचा अवलंब केल्यास विद्यार्थ्याला परीक्षेस अपात्र ठरविण्यात येईल.
9. परीक्षा संपल्यानंतर विद्यार्थ्याने मूळ ओ.एम.आर. उत्तरपत्रिका पर्यवेक्षकांकडे परत करणे आवश्यक आहे. तथापि, प्रश्नपत्रिका व ओ.एम.आर. उत्तरपत्रिकेची द्वितीय प्रत आपल्याबरोबर नेण्यास विद्यार्थ्यांना परवानगी आहे.
10. फक्त निळ्या किंवा काळ्या बॉल पेनचाच वापर करावा.
11. कॅलक्युलेटर किंवा लॉग टेबल वापरण्यास परवानगी नाही.
12. चुकीच्या उत्तरासाठी गुण कपात केली जाणार नाही.

Physical Science

Paper II

Time Allowed : 120 Minutes] **[Maximum Marks : 200**

Note : This Paper contains **Hundred (100)** multiple choice questions. Each question carrying **Two (2)** marks. Attempt *All* questions.

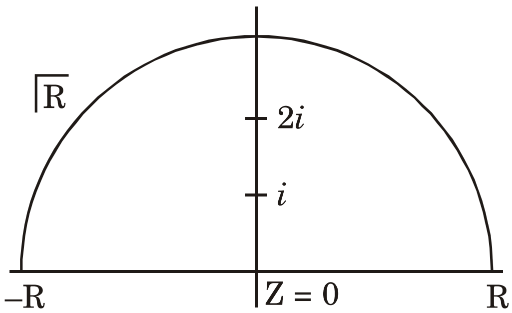
1. If $\overline{A} = x\hat{e}_x + y\hat{e}_y + z\hat{e}_j$, then $\nabla^2\overline{A}$ will be :
   (A) 1
   (B) 3
   (C) 0
   (D) – 3

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

3. A gas molecule moves equal distances λ between successive collisions with equal probability in any direction. After a total of N such collisions, the mean square displacement of the molecule $\overline{d}^2$ 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) $1/e$

(B) $2/e$

(C) 1

(D) $3/e$

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 ω 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) $\sqrt{2}.Ma^2\omega$

(C) $2Ma^2\omega$

(D) $3Ma^2\omega$

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

(A) v_0 and sin 2α

(B) v_0 and sin α

(C) v_0^2 and sin α

(D) v_0^2 and sin 2α

13. An artificial satellite revolves about the earth at height H (H << 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

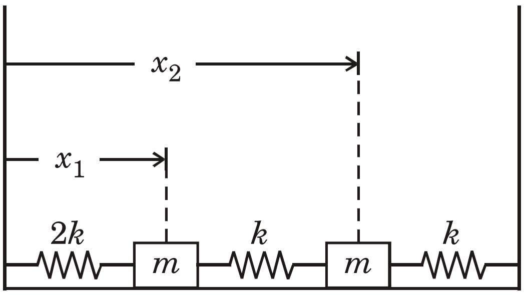
15. A unit charge q moving with initial velocity $(\overline{v} = v_x\hat{i})$ is subjected to external electric field $(\overline{\mathrm{E}} = \mathrm{E}_y\overline{j})$. The number of degrees of freedom is :
    (A) 1
    (B) 2
    (C) Zero
    (D) 3

16. For a Lagrangian $\mathrm{L}(q, \dot{q}, \ddot{q}, t)$, the equation motion is of the form :
    (A) $\frac{d^2}{dt^2}\left(\frac{\partial \mathrm{L}}{\partial \ddot{q}}\right) - \frac{\partial \mathrm{L}}{\partial q} = 0$
    (B) $\frac{d^2}{dt^2}\left(\frac{\partial \mathrm{L}}{\partial \ddot{q}}\right) - \frac{d}{dt}\left(\frac{\partial \mathrm{L}}{\partial \dot{q}}\right) + \frac{\partial \mathrm{L}}{\partial q} = 0$
    (C) $\frac{d^2}{dt^2}\left(\frac{\partial \mathrm{L}}{\partial \ddot{q}}\right) + \frac{d}{dt}\left(\frac{\partial \mathrm{L}}{\partial \dot{q}}\right) + \frac{\partial \mathrm{L}}{\partial q} = 0$
    (D) $\frac{d^2}{dt^2}\left(\frac{\partial \mathrm{L}}{\partial \ddot{q}}\right) - \frac{d}{dt}\left(\frac{\partial \mathrm{L}}{\partial \dot{q}}\right) - \frac{\partial \mathrm{L}}{\partial q} = 0$

17. The radius of gyration of a rigid body of mass M and moment of inertia I is :
    (A) $(\mathrm{I/M})^2$
    (B) $(\mathrm{M/I})^2$
    (C) $(\mathrm{I/M})^{1/2}$
    (D) $(\mathrm{M/I})^{1/2}$

18. The period of oscillation of the plane of Foucault's pendulum is :
    (ϕ is the latitude)
    (A) Directly proportional to the latitude (ϕ)
    (B) Inversally proportional to sin ϕ
    (C) Inversally proportional to cos ϕ
    (D) Directly proportional to sin ϕ

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

(A) 0.75 c

(B) 0.80 c

(C) 0.60 c

(D) 0.90 c

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 $\overline{B}$ 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 $\overline{E} = E_0\hat{z}$ and $\overline{B} = B_0\hat{x}$ 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 $\overline{m}$. 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 $\overline{\text{E}}$. The plane of the rectangle makes an angle of 30° with the direction of the electric field. The electric flux through the rectangle is :

(A) AE

(B) $\frac{\text{AE}}{2}$

(C) $\text{AE}\frac{\sqrt{3}}{2}$

(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 V, then the electric potential at point 'θ' is :

(A) Zero V

(B) 1 V

(C) $\frac{1}{\sqrt{2}}$ V

(D) $\left(1+\frac{1}{\sqrt{2}}\right)$ 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 $\overline{A}(\overline{r}, t)$ is such that $\overline{r}.\overline{A} = \frac{-\mu_0}{4\pi}\frac{Q}{r^2}$. The corresponding electric potential $V(\overline{r}, t)$, under Lorentz gauge condition is :

(A) $\frac{Q}{4\pi\varepsilon_0 r}$

(B) $\frac{Q}{4\pi\varepsilon_0 r^2}$

(C) $\frac{Qt}{4\pi\varepsilon_0 r}$

(D) $\frac{Qt}{4\pi\varepsilon_0 r^2}$

29. If an electromagnetic wave is propagating in a medium with permittivity ε and permeability μ, then $\sqrt{\frac{\mu}{\varepsilon}}$ 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 π. The phase difference between $\overline{E}$ and $\overline{B}$ associated with the wave is :

(A) Zero

(B) $\frac{\pi}{4}$

(C) $\frac{\pi}{2}$

(D) π

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 × 10^{-34} Js) :

(A) 3×10^{-32} m

(B) 3×10^{-34} m

(C) 3×10^{-30} m

(D) 3×10^{-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) $-m\alpha^2/2\hbar^2$

(B) $-2m\alpha^2/\pi\hbar^2$

(C) $-m\alpha^2/\pi\hbar^2$

(D) $m\alpha^2/\pi\hbar^2$

34. A particle is moving in a one-dimensional infinite potential well of width a. Using a normalized trial wave function $\psi(x) = \frac{\sqrt{15}}{4a^{5/2}}(a^2 - x^2)$, variational calculation estimate for $4a^{5/2}$ the ground state energy is :

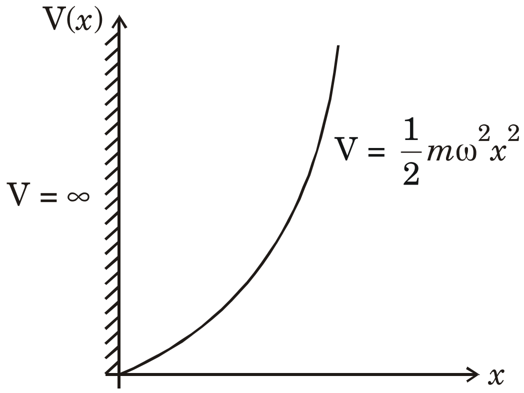
(A) $\frac{5\hbar^2}{4ma^2}$

(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 $H = \begin{pmatrix} 5 & 2 & 0 \\ 2 & 5 & 0 \\ 0 & 0 & 2 \end{pmatrix}$ is perturbed by $H' = \varepsilon \begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & -1 \\ 1 & -1 & 1 \end{pmatrix}$ where ($\varepsilon << 1$). 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 $\chi = \begin{pmatrix} \frac{1+i}{\sqrt{6}} \\ \sqrt{2}/\sqrt{3} \end{pmatrix}$ 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

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

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

(A) π

(B) 2π

(C) 3π

(D) $2n\pi$, where n = 0, 1, 2, ...

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 20 eV. 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 $S = \frac{4}{3}\sigma V^{1/4}U^{3/4}$ where σ is a constant V is the volume and U is internal energy of the system. The temperature of the radiation is :

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

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

(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. $E_1 = \varepsilon$ and $E_2 = 2\varepsilon$. If the particles satisfy Boltzmann statistics, the partition functions would be $\left(\beta=\frac{1}{k_B T}\right)$:

(A) $z=e^{-3\varepsilon\beta}$

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

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

(D) $z=2(e^{-\beta\varepsilon}+e^{-2\beta\varepsilon})$

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

(A) $T_F = 380$ K

(B) $T_F = 3800$ K

(C) $T_F = 38000$ K

(D) $T_F = 38$ 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*) $\frac{7\,!}{4\,!}$ and (*ii*) $\frac{7\,!}{4\,!\,3\,!}$

(B) (*i*) 4^7 and (*ii*) 210

(C) (*i*) 7 ! 4 ! and (*ii*) $\frac{7\,!}{4\,!\,3\,!}$

(D) (*i*) 7^4 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) $C\ln\left[\frac{T_1T_2}{|T_2-T_1|}\right]$

(B) $C\ln\left[\frac{(T_1+T_2)}{2T_1T_2}\right]$

(C) $C\ln\left[\frac{(T_1+T_2)^2}{4T_1T_2}\right]$

(D) $C\ln\left[\frac{2T_1T_2}{T_1+T_2}\right]$

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

(A) 150 K

(B) 37.5 K

(C) 2400 K

(D) 75 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) Thermister

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 W/cm^2 falls on a perfectly reflecting plane mirror for an hour. The area of the mirror is 5 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 mm a shift of 200 fringes is observed ? The wavelength of light used in Å 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 2 Amp flows through it. The bulk resistance of the diode is :

(A) 0.6 Ω

(B) 0.9 Ω

(C) 1.2 Ω

(D) 2.5 Ω

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

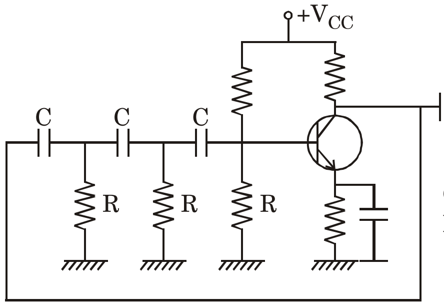
(A) Pure crystals of silicon and germanium

(B) Thin waters of SiC and GaN

(C) $GaAs_{1-y}$ Py and GaP by deposition

(D) ZnSe, CdS and ZnTe in powder

63. The frequency of the following phase shift oscillator :



C = 13 × 10^{-9} F
R = 1 kΩ

is nearly equal to :

(A) 2 kHz

(B) 5 kHz

(C) 8 kHz

(D) 10 kHz

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 kΩ. The D.C. current through the load resistance of 5 kΩ is nearly :

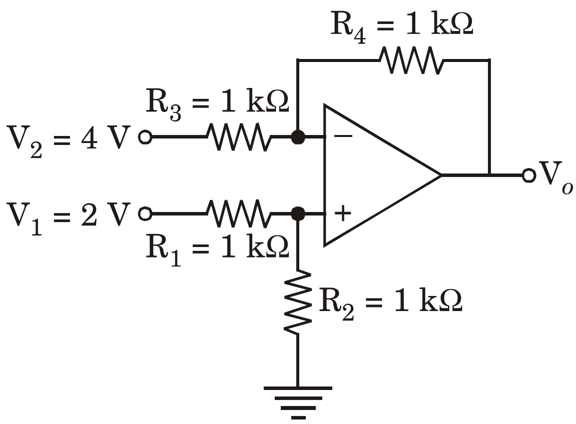
(A) 15 mA

(B) 18 mA

(C) 21 mA

(D) 25 mA

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



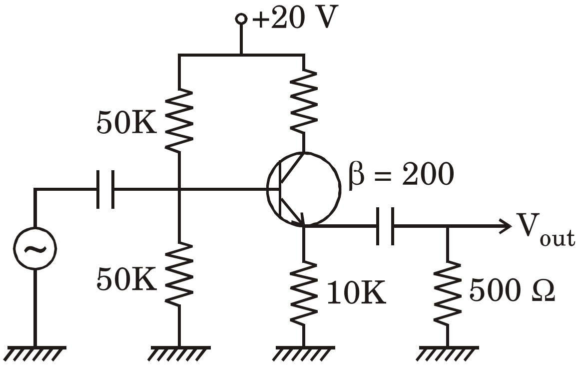
(A) + 2

(B) – 2

(C) + 4

(D) – 4

66. 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 :

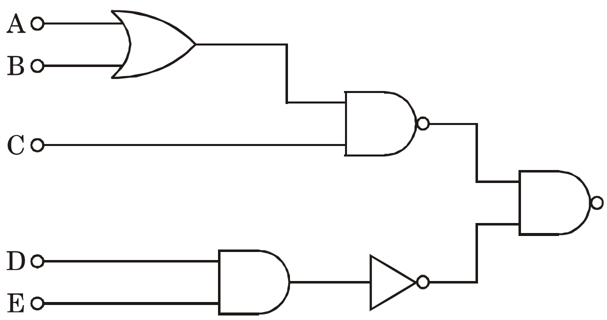
(A) Increase the input and output impedance

(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 :



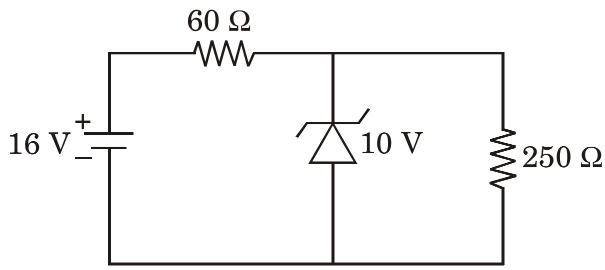
(A) AB + C(D + E)

(B) (A + B)C + DE

(C) (A + B)C + D + E

(D) (AB + C).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 Å) :

(A) 0.529 Å

(B) 0.26 Å

(C) 8.4 Å

(D) 13.25 Å

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 vibration-rotational spectrum for CO molecule shows $\Delta\bar{v}$ = 55 cm^{-1}. The associated value of rotational constant B is (Given; Boltzmann const. k = 1.38 × 10^{-23} J/K, T = 300, h = 6.6 × 10^{-34} J-s) :

(A) 1.8 cm^{-1}

(B) 1.6 cm^{-1}

(C) 2.0 cm^{-1}

(D) 1.4 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) Millicon oil drop experiment

(D) Frank-Hertz experiment

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

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

(A) 1200 cm^{-1}

(B) 409 cm^{-1}

(C) 803 cm^{-1}

(D) 606 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 – BCl_3

(B) sp-linear – CO_2

(C) sp^3-square planar – $PtCl_4^{2-}$

(D) sp^3-Tetrahedral – CH_4

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

(A) 2*p*, 3*s*, 3*p*, 3*d* & 3*s*, 3*p*, 3*d*, 4*s*

(B) 3*s*, 3*p*, 3*d*, 4*s* & 4*s*, 5*s*, 6*s*, 7*s*

(C) 3*s*, 3*p*, 4*s*, 3*d* & 5*s*, 3*d*, 4*f*, 4*p*

(D) 3*p*, 4*s*, 3*d*, 4*p* & 2*p*, 3*s*, 3*p*, 4*s*

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 Å, a positive edge dislocation 1 mm long climbs down by 1 μm. The number of vacancies created or lost in the crystal is :

(A) 1.10×10^{10}

(B) 5.00×10^{12}

(C) 5.00×10^{14}

(D) 8.00×10^{15}

83. The Debye temperature of diamond is 2230 K. The molar heat capacity of diamond at 10 K is :

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

(A) 0.025 $Jkmol^{-1}K^{-1}$

(B) 0.175 $Jkmol^{-1}K^{-1}$

(C) 0.235 $Jkmol^{-1}K^{-1}$

(D) 0.350 $Jkmol^{-1}K^{-1}$

84. In an MX molecule, suppose M atom has an ionization potential energy 5 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 Å is :

(A) 0.50 eV

(B) – 2.88 eV

(C) – 1.88 eV

(D) – 4.20 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/4B

(B) $(2B/A)^{1/6}$

(C) $A^2/4B$

(D) $4B^2/A$

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 : $10^{17}/cm^3$) is heated from 100°C to 200°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 4*f* unpaired electrons in this ion is :

(A) 2

(B) 3

(C) 4

(D) 5

90. A flux quantum (fluxoid) is approximately equal to 2×10^{-7} gauss-cm^2. 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 Å

(B) 100 Å

(C) 1000 Å

(D) 1200 Å

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

(A) 7 F

(B) 9 F

(C) 11 F

(D) 13 F

92. The nuclear density of a ^{197}Au nucleus is nearly :

[Mass of ^{197}Au = 3.2707×10^{-25} kg, $r_0 = 1.2 \times 10^{-15}$ m]

(A) 3.96×10^{17} kg/m^3

(B) 5.80×10^{17} kg/m^3

(C) 6.54×10^{17} kg/m^3

(D) 8.38×10^{17} kg/m^3

93. Nuclear forces are :

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

(B) Spin dependent and have a non-central part

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

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

94. Given : Masses of $^{80}_{35}$Br and $^{80}_{34}$Se are respectively 79.918528 amu and 79.916520 amu. Use 1 amu = 931.5 MeV Nucleus $^{80}_{35}$Br decays to $^{80}_{34}$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. $_1H^3$ nuclei undergoes beta decay at a rate of 1.27×10^{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 ionised and therefore the energy information is lost.

(D) All the atoms of the gas are ionised 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}C target.

$$^{13}C + n \rightarrow {}^{10}Be + {}^{4}He$$

If the R value of this reaction is – 3.835 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

$K^+, K^-, \pi^+, \pi^0, \pi^-, K^0$

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) U*d*S and *d*SS

(C) UUS and USS

(D) UU*d* and U*dd*

ROUGH WORK

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