Test Booklet Code & Serial No. **A**
प्रश्नपत्रिका कोड व क्रमांक

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 - 32220

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

Number of Pages in this Booklet : **28** 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. Unit vector perpendicular to $\overline{\mathrm{A}} = 2\hat{i} - \hat{j} + \hat{k}$ and $\overline{\mathrm{B}} = 3\hat{i} + 4\hat{j} - \hat{k}$ is :

(A) $\dfrac{-3\hat{i} + 5\hat{j} + 11\hat{k}}{\sqrt{155}}$

(B) $\dfrac{\hat{i} - \hat{j} + 2\hat{k}}{\sqrt{6}}$

(C) $\dfrac{4\hat{i} - \hat{j} - 5\hat{k}}{\sqrt{42}}$

(D) $\dfrac{\hat{i} + 2\hat{j} - 4\hat{k}}{\sqrt{21}}$

2. If S is a closed surface enclosing a volume V and $\hat{n}$ is the unit vector normal to the surface and $\overline{r}$ is the position vector, then the value of the integral $\iint\limits_{\mathrm{S}} \hat{n}\, d\mathrm{S}$ is :

(A) V

(B) 2V

(C) 0

(D) 3V

3. A particle passes through a medium and is deflected by a small angle $\pm\, \delta_0$ upon each collision within the medium with equal probability in any direction. The mean square angular scattering after N such collision, $\overline{\delta^2}$ is :

(A) 0

(B) $\mathrm{N}\delta_0^2$

(C) $\dfrac{\delta_0^2}{\mathrm{N}}$

(D) $\mathrm{N}^2\delta_0^2$

4. When a complex number Z is multiplied by i, the resulting vector iz, in the z plane, is obtained by rotating the vector z through :

(A) π

(B) $-\pi/2$

(C) $3\pi/2$

(D) $\pi/2$

5. The residue of the function $\dfrac{z^2}{z^2 + a^2}$ at $z = ia$ is :

(A) $\dfrac{ia}{2}$

(B) $-a^2$

(C) ia

(D) ∞

6. If $y = e^{zt}$ is a solution of $y'' - 5y' + ky = 0$, then k is equal to :

(A) 1

(B) 4

(C) 5

(D) 6

7. Solution of the differential equation $x\dfrac{dy}{dx} + y = x^4$ with the boundary condition that $y = 1$ at $x = 1$ is :

(A) $y = 5x^4 - 4$

(B) $y = \dfrac{x^4}{5} + \dfrac{4x}{5}$

(C) $y = \dfrac{4x^4}{5} + \dfrac{1}{5x}$

(D) $y = \dfrac{x^4}{5} + \dfrac{4}{5x}$

8. The matrices $\bar{A} = \begin{bmatrix} a & b \\ -b & a \end{bmatrix}$ and $B = \begin{bmatrix} c & d \\ -d & c \end{bmatrix}$, for some values of a, b, c, d :

(A) have no commutation relation between them

(B) Commute for all values of a, b, c, d

(C) Commute if and only if a, b, c, d are real numbers

(D) Anticommute for all values of a, b, c, d

9. For any operator A, $i\,(A^+ - A)$ is :

(A) Hermitian

(B) Anti-Hermitian

(C) Unitary

(D) Orthogonal

10. The complex Fourier transform of $e^{-|x|}$ is :

(A) $\frac{2}{1+n^2}$

(B) $\frac{1}{1+n^2}$

(C) $\frac{4}{1+n^2}$

(D) $\frac{\pi}{1+n^2}$

11. A mouse of mass m jumps on a freely rotating disc of moment of inertia I and radius R. If ω_0 and ω are the angular velocities of the disc before and after mouse jumps, then the ratio ω/ω_0 is :

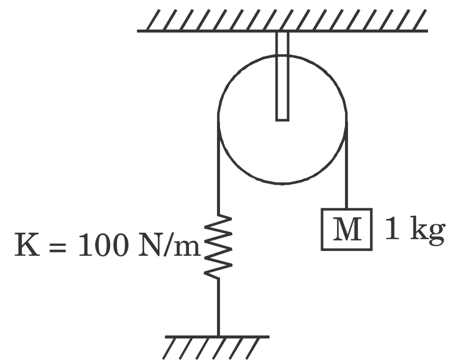
(A) I/mR^2

(B) $I/I - mR^2$

(C) $I/I + mR^2$

(D) $(I - mR^2)/I$

12.



A mass of 1 kg is connected to a spring at one end using a massless, rigid string. Initially the spring is in unstretched state. If the mass falls through a distance h before stopping (now the spring is in stretched condition), then the distance h is given as :

(A) 0.196 m

(B) 1.96 m

(C) 0.14 m

(D) 1.4 m

13. The mutual potential energy V of two particles is function of their mutual distance r, given as :

$$V(r) = \frac{a}{r^2} - \frac{b}{r}, \ a > 0, \ b > 0$$

If the particles are in static equilibrium, then the separation (r) is :

(A) $2b/a$

(B) $b/2a$

(C) a/b

(D) $2a/b$

14. A particle of mass m moves in an ellipitical orbit under the action of inverse square central force. If α is the ratio of maximum angular velocity to the minimum angular velocity, then the eccentricity of the ellipse is given as :

(A) $\alpha/(\alpha + 1)$

(B) $(\alpha + 1)/\alpha$

(C) $(\alpha - 1)/\alpha$

(D) $(\alpha - 1)/(\alpha + 1)$

15. The number of degrees of freedom for an astronaut constrained to move on surface of a spherical spaceship freely moving in space, is :

(A) 5

(B) 6

(C) 4

(D) 3

16. A particle falls vertically under the action of gravity and a frictional force obtainable from dissipation function $G(v) = \frac{1}{2}kv^2$, k is constant. The Lagrange's equation of motion is :

(A) $m\ddot{y} + k\dot{y} + mg = 0$

(B) $m\ddot{y} - k\dot{y} - mg = 0$

(C) $m\ddot{y} - k\dot{y} + mg = 0$

(D) $m\ddot{y} + mg = 0$

17. Suppose a system has holonomic and conservative part, and also some part of forces acting on the system are not conservative. Let the typical non-conservative force acting on jth particle is denoted as Q_i. The Hamilton's equations of motion modify to :

(A) $\dot{q}_i = \dfrac{\partial H}{\partial p_i}, \ \dot{p}_i = \dfrac{\partial H}{\partial q_i} + Q_i$

(B) $\dot{q}_i = \dfrac{\partial H}{\partial p_i}, \ \dot{p}_i = \dfrac{-\partial H}{\partial q_i} + Q_i$

(C) $\dot{q}_i = \dfrac{\partial H}{\partial p_i}, \ \dot{p}_i = \dfrac{\partial H}{\partial q_i} - Q_i$

(D) $\dot{q}_i = \dfrac{\partial H}{\partial p_i}, \ \dot{p}_i = \dfrac{-\partial H}{\partial q_i} - Q_i$

18. A rigid body, whose two of the principal moments of inertia are equal and the third is zero, is called as :

(A) Asymmetrical top

(B) Rotor

(C) Spherical top

(D) Symmetrical top

19. A frame of reference S′ is rotating with constant angular velocity ω with respect to a stationary frame of reference S. Both the frames of reference have common origin. The time derivative of vector $\bar{A}$ in S′ is :

(A) $\dfrac{d'\bar{A}}{dt} = \bar{\omega} \times \bar{A}$

(B) $\dfrac{d'\bar{A}}{dt} = \bar{\omega} \times \bar{A} + \dfrac{d\bar{A}}{dt}$

(C) $\dfrac{d'\bar{A}}{dt} = -\bar{\omega} \times \bar{A} + \dfrac{d\bar{A}}{dt}$

(D) $\dfrac{d'A}{dt} = \dfrac{d\bar{A}}{dt}$

20. A particle as observed in certain frame of reference has a total energy of 13 GeV and a momentum of 5 GeV/c. Its rest mass is :

(A) 12 GeV/c^2

(B) 12 MeV/c^2

(C) 1.2 MeV/c^2

(D) 1.2 GeV/c^2

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, 1, 4) and B(–6, 1, 4). The ratio of magnitudes of $\bar{B}$ at point A to that at point B is ....

(A) $\frac{1}{3}$

(B) 3

(C) 1

(D) $\mu_0 I$

22. A charged particle is released from rest in a region where both uniform constant electric field and uniform constant magnetic field are present. If these fields are perpendicular to each other, then the trajectory of the particle is a ....

(A) Straight line

(B) Circle

(C) Cycloid

(D) Circular helix

23. The SI unit of magnetic dipole moment is ....

(A) Cm

(B) Cm^2

(C) Cm/s

(D) Cm^2/s

24. A solid sphere of radius R with its center at origin has a volume charge density $\rho = A\sqrt{r}$, where A is a constant. The magnitude of electric field, $\bar{E}$, at $r < R$, varies with r as ....

(A) $E \propto r^{-\frac{1}{2}}$

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

(C) $E \propto r^{\frac{3}{2}}$

(D) $E \propto r^{-2}$

25. Three point charges q, q and $-2q$ are located at (0, –1, 1), (0, 1, 1) and (0, 0, –1) respectively. The magnitude of electric dipole moment of this charge distribution is :

(A) zero

(B) q

(C) $2q$

(D) $4q$

26. The electrostatic potential is given by $\phi = k(x^2 + y^2 + z^2)$, where k is a constant. The volume charge density giving rise to the above potential is ....

(A) $6 \in_0 k$

(B) $-6 \in_0 k$

(C) $2 \in_0 k$

(D) $-2 \in_0 k$

27. What is the magnitude of the Poynting vector at the surface of a long cylindrical wire of radius R, length L, carrying current I, when its ends are kept at a potential difference V ?

(A) zero

(B) $\dfrac{\mathrm{VI}}{2\pi \mathrm{R}^2 + 2\pi \mathrm{RL}}$

(C) $\dfrac{\mathrm{VI}}{\pi \mathrm{R}^2 \mathrm{L}}$

(D) $\dfrac{\mathrm{VI}}{2\pi \mathrm{RL}}$

28. Velocity of light in air is 3×10^8 m/s. Velocity of light in a medium having relative permittivity 3 and relative permeability 2 is ....

(A) $\sqrt{\dfrac{3}{2}} \times 10^8$ m/s

(B) $\dfrac{\sqrt{3}}{4} \times 10^8$ m/s

(C) $\sqrt{2} \times 10^8$ m/s

(D) $\dfrac{\sqrt{3}}{2} \times 10^8$ m/s

29. Which of the following volume charge densities $\bar{J}(\bar{r})$ generates the magnetic vector potential $\bar{A}(\bar{r}) = y^2\hat{x} + x^2\hat{y}$?

(A) $\frac{2}{\mu_0}(\hat{x} + \hat{y})$

(B) $\frac{-2}{\mu_0}(\hat{x} + \hat{y})$

(C) $\frac{2}{\mu_0}(x\hat{x} + y\hat{y})$

(D) $\frac{-2}{\mu_0}(x\hat{x} + y\hat{y})$

30. A square wave guide with perfect conductor boundaries is of cross-sectional area l^2. The wave guide is placed in vacuum. The minimum frequency of the electromagnetic waves that can propagate through this wave guide is ....

(A) $\frac{c}{l}$

(B) $\frac{2c}{l}$

(C) $\frac{\pi c}{l}$

(D) $\sqrt{2}\,\frac{\pi c}{l}$

31. Out of the following particles, all having the same kinetic energy, which has the longest wavelength ?

(A) An α-particle

(B) An electron

(C) A proton

(D) A neutron

32. If quantum mechanical operators of two observables of a system do not commute, then :

(A) the total energy of the system must be negative

(B) the parity of the wave function of the system must be odd

(C) the observables corresponding to these operators must be time-independent

(D) it is impossible to know the precise values of the observables simultaneously

33. Given the operators $\hat{A} = i\left(xp_y - yp_x\right)$ and $\hat{B} = \left(yp_z + zp_y\right)$ the commutator $\left[\hat{A}, \hat{B}\right]$ is :

(A) $-\hbar\left(xp_z - p_x z\right)$

(B) $-\hbar\left(xp_z + p_x z\right)$

(C) $\hbar\left(xp_z + p_x z\right)$

(D) $\hbar\left(xp_z - p_x z\right)$

34. A particle in one-dimension is moving under the potential described by :

$$V(x) = \begin{cases} \infty & \text{for} \quad x < 0 \\ -V_0 & \text{for} \quad 0 \le x \le a, V_0 > 0 \\ 0 & \text{for} \quad x > a \end{cases}$$

The minimum depth of the potential for at least one bound state is :

(A) $\dfrac{\hbar^2 \pi^2}{2ma^2}$

(B) $\dfrac{\hbar^2 \pi^2}{8ma^2}$

(C) $\dfrac{\hbar^2 \pi^2}{ma^2}$

(D) $\dfrac{2\hbar^2 \pi^2}{ma^2}$

35. Given 10 > and 11 > are the ground and first excited state for a one-dimensional harmonic oscillator, the uncertainty in position Δx for a particle in the state given by $\frac{1}{\sqrt{2}}(10 > + 11 >)$ is :

$\left(\text{Given } \hat{x} = \sqrt{\dfrac{\hbar}{2m\omega}} \left(\hat{a} + \hat{a}^{+}\right)\right)$

(A) $\Delta x = \sqrt{\left(\dfrac{\hbar}{2m\omega}\right)}$

(B) $\Delta x = \sqrt{\left(\dfrac{\hbar}{m\omega}\right)}$

(C) $\Delta x = \sqrt{\left(\dfrac{2\hbar}{m\omega}\right)}$

(D) $\Delta x = \sqrt{\left(\dfrac{4\hbar}{m\omega}\right)}$

36. A muonic atom is formed by a muon (μ^-) and a proton. The longest wavelength of spectral line (in Balmer series) of such an atom is approximately ($h = 6.6 \times 10^{-34}$ Js)

(A) 20.5 Å

(B) 2.05 Å

(C) 205 Å

(D) 10.25 Å

37. A particle in a one-dimensional infinite potential well of width L is acted on by a perturbation

$$H' = b(L - x) \qquad 0 \le x \le L$$
$$= 0 \qquad \text{otherwise}$$

First order correction to the first excited state is :

(A) $\frac{bL}{2}$

(B) $\frac{bL}{\sqrt{2}}$

(C) $2bL$

(D) bL

38. Minimum energy of a collection of six non-interacting electrons of spin $\frac{1}{2}$ and mass m, placed in a one-dimensional infinite potential well of width L is :

(A) $\frac{3\pi^2 \hbar^2}{mL^2}$

(B) $\frac{14\pi^2 \hbar^2}{mL^2}$

(C) $\frac{7\pi^2 \hbar^2}{mL^2}$

(D) $\frac{91\pi^2 \hbar^2}{mL^2}$

39. In the Born approximation, scattering amplitude $f(\theta)$ for Yukawa potential $V(r) = \frac{\beta e^{-\mu r}}{r}$ is given by

(Given data : $b = 2k \sin\frac{\theta}{2}, E = \frac{\hbar^2 k^2}{2m}$)

(A) $-\frac{2m\beta}{\hbar^2\left(\mu^2 + b^2\right)}$

(B) $-\frac{2m\beta}{\hbar^2\left(\mu^2 + b^2\right)^3}$

(C) $-\frac{2m\beta}{\hbar^2\left(\mu^2 + b^2\right)^2}$

(D) $-\frac{2m\beta}{\hbar^2\sqrt{\mu^2 + b^2}}$

40. Which one of the following given below represents the bound state eigen function of the operator $-\frac{d^2}{dx^2}$ in the region $0 \le x \le \infty$ with eigen value -4 ?

(A) $A_0 \, e^{2x}$

(B) $A_0 \, e^{-2x}$

(C) $A_0 \cosh 2x$

(D) $A_0 \sinh 2x$

41. Density and specific heat at constant volume 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 to the surroundings. If the process is carried at temperature T the change in the entropy of the universe would be :
   (A) $\frac{CV^2}{8T}$
   (B) $\frac{CV^2}{T}$
   (C) $\frac{CV^2}{2T}$
   (D) $\frac{CV^2}{4T}$

43. A three-dimensional classical Harmonic Oscillator is in thermal equilibrium with a heat reservoir at temperature T. Its average total energy would be :
   (A) 6 $k_B T$
   (B) 3/2 $k_B T$
   (C) $k_B T$
   (D) 3 $k_B T$

44. A system at temperature 30 K is so large that its temperature does not change if 10^7 J of heat is added. The factor by which the number of accessible states increase is ($k_B = 1.3807 \times 10^{-23}$ JK^{-1})
   (A) 2.4×10^{14}
   (B) $e^{2.4 \times 10^{14}}$
   (C) 10^7
   (D) 30×10^7

45. Consider a system with only two energy levels with energies $E_0 = 0$ and $E_1 = 1.3806 \times 10^{-23}$ J. The level E_0 has degeneracy 2 and the level E_1 has degeneracy 3. The partition function at T = 1 K is ($K_B = 1.3806 \times 10^{-23}$ JK^{-1}) :

(A) $z = 2e^0 + 3e^{-1}$

(B) $z = 6e^{-3}$

(C) $z = 6(e^0 + e^{-1})$

(D) $z = 6e^{-1}$

46. Fermi level in a solid is a direct measure of :

(A) Electronic current

(B) Temperature of solid

(C) Resistivity of solid

(D) Chemical potential of electrons

47. The number of distinct ways in which 7 identical Fermions can be distributed in 3 energy levels is :

(A) $\frac{7!}{4!3!}$

(B) 3^7

(C) 0

(D) 210

48. One block at temperature T_1 and another identical block at temperature T_2 are placed in thermal contact and come to an equilibrium, the system being isolated from surroundings. If the heat capacities at constant volume C depend on temperature as $C = aT$, the entropy change of the system would be :

(A) $a\left[2\left(\frac{T_1^2 + T_2^2}{2}\right)^{1/2} - T_1 - T_2\right]$

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

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

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

49. An ideal gas at temperature T expands in an isothermal process from volume V_1 to volume V_2. The work done in the process is :

(A) $RT\ln\left(\frac{(V_1V_2)^{\frac{1}{2}}}{V_1 + V_2}\right)$

(B) $RT\ln\left(\frac{V_1}{V_2}\right)$

(C) $RT\ln\left(\frac{V_1 + V_2}{(V_1V_2)^{\frac{1}{2}}}\right)$

(D) $RT\ln\left(\frac{V_2}{V_1}\right)$

50. According to Weiss molecular theory near the critical point the isothermal susceptibility of the magnetic system behaves as :

(A) $\chi_T \propto |T - T_C|$

(B) $\chi_T \propto |T - T_C|^{-1}$

(C) $\chi_T \propto |T - T_C|^{1/2}$

(D) $\chi_T \propto |T - T_C|^{-1/2}$

51. In a critically damped series LCR circuit :

(A) $R^2 = 4L/C$

(B) $R^2 = 2L/C$

(C) $R = \sqrt{L/C}$

(D) $R^2 = 4L^2C^2$

52. Johnson Noise in resistor R is given by :

(A) $\bar{v}_{rms} = (4KTR\Delta f)^{1/2}$

(B) $\bar{v}_{rms} = (2qI\Delta f)^{1/2}\ R$

(C) $\bar{v}_{rms} = A/f^2$

(D) $\bar{v}_{rms} = A/f$

53. A 50 Hz noise signal of 1 mV peak value is introduced at the input of an op-amp based integrator (RC = 1 s). The output will be :

(A) 3.2 nV

(B) 3.2 μV

(C) 3.2 mV

(D) 3.2 V

54. In Millikan's oil drop experiment the electronic charge e could be written as $K\eta^{1.5}$, where K was a function of other experimental parameters with negligible error, while the viscosity of air η assumed was 0.4% too low. What was the error in e ?

(A) 1.5%

(B) 0.7%

(C) 0.6%

(D) 0.4%

55. Which of the following experiments provides verification of charge quantization ?

(A) Millikan's oil drop E

(B) Franck-Hertz

(C) Davisson and Germer

(D) Zeeman Effect

56. In X-ray diffraction pattern the positions of the peaks depend on :

(A) size of the crystal

(B) shape of the crystal

(C) texture of the crystal

(D) lattice constants of the planes of the crystals

57. For NMR spectra of proton nuclei, the commonly used reference is :

(A) Ethyl alcohol

(B) Carbon tetrachloride

(C) Methyl alcohol

(D) Tetramethylsilame (TMS)

58. To measure temperature of more than 3000°C, the most suitable thermometer is :

(A) Platinum resistance thermometer

(B) Thermocouple

(C) Radiation pyrometer

(D) Gas thermometer

59. What is the temporal coherence length of a mercury vapour lamp emitting in the green portion of the spectrum at wavelength of 546.1 nm with an emission bandwidth of $\Delta\nu = 6 \times 10^8$ Hz :

(A) 0.5 m

(B) 2 m

(C) 0.25 m

(D) 1 m

60. Best vacuum that can be attained with a rotary pump is :

(A) 10^{-3} Torr

(B) 1 Torr

(C) 10^{-6} Torr

(D) 10^{-10} Torr

61. **Symbols :**

I_D = Drain Current, V_{SD} = Source to Drain Voltage, V_{GS} = Gate to Source Voltage.

In the operation of JFET, the pinch-off region has the following characteristics :

(A) The current I_D increases with the increase in the V_{SD} when V_{GS} is negative, reverse biased

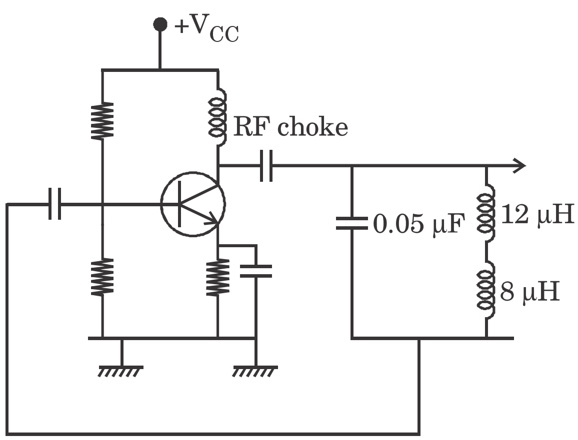
(B) The current I_D is constant when the V_{GS} is positive, forward biased and the V_{SD} is near break down region

(C) The current I_D is constant and relatively independent of V_{SD} but the gate is reverse biased, V_{GS} negative

(D) The current I_D is constant and relatively independent of V_{SD} but the V_{GS} is zero

62. In p-n junction photodiode, the reversing biasing :
(A) Lowers the carrier transit period through the depletion layer and reduces the depletion capacitance
(B) Increases the carrier transit period through depletion region and also the depletion capacitance
(C) Reduces the concentration of n-type impurity and increases the photoabsorption efficiency
(D) Increases the concentration of p-type impurity and photo-absorption efficiency

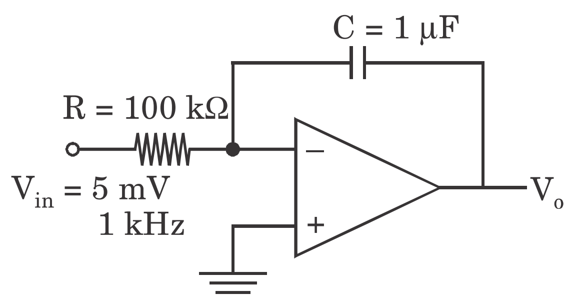
63. The frequency of the following Hartley oscillator



is nearly equal to :
(A) 139 kHz
(B) 159 kHz
(C) 179 kHz
(D) 279 kHz

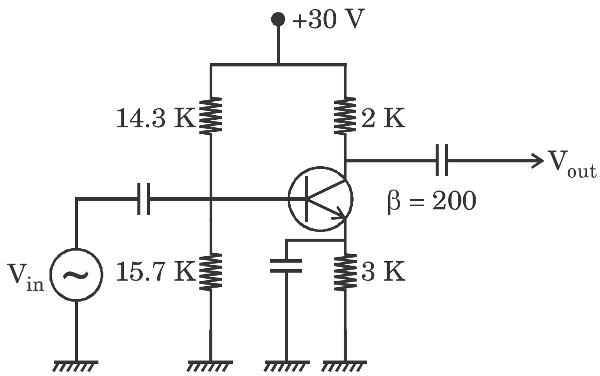
64. A full wave rectifier supplies DC voltage to a load resistance of 2 kΩ. The AC voltage applied to the diodes is 300-0-300 Volts rms. If the diode voltage drop is neglected, the average DC voltage across the load is nearly :
(A) 300 Volts
(B) 270 Volts
(C) 150 Volts
(D) 100 Volts

65. A 5 mV, 1 kHz sinusoidal signal is applied to the input of an op-amp circuit shown below. Find the output voltage :



(A) $\frac{1}{20\pi}(\cos 2000\pi t - 1)$ mV
(B) $\frac{1}{40\pi}(\cos 2000\pi t - 1)$ mV
(C) $\frac{1}{60\pi}(\cos 2000\pi t - 1)$ mV
(D) $\frac{1}{80\pi}(\cos 2000\pi t - 1)$ mV

66. The AC Gain of the following transistor amplifier



is nearly equal to :

(A) 200

(B) 300

(C) 400

(D) 500

67. 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

68. The most suitable gates to check whether the number of ones in a digital word is even or odd is :

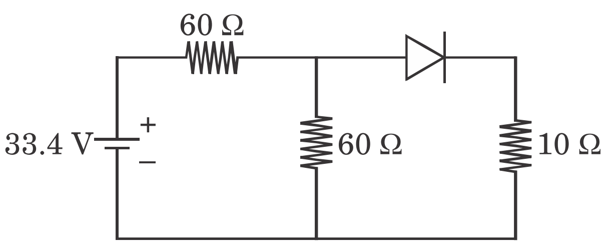
(A) EX-OR

(B) NAND

(C) NOR

(D) AND and OR

69. In the following circuit, the diode current flows through the resistance 10 Ω :



If the voltage drop across the diode is 0.7 Volt, then the diode used should have minimum power rating nearly :

(A) 180 mW

(B) 240 mW

(C) 280 mW

(D) 350 mW

70. A pulse train with a frequency of 1 MHz is counted using a modulo 1024 ripple counter built with J-K flip-flop. For proper operations of the counter the maximum permissible propagation delay per flip-flop stage is :

(A) 10 nsec

(B) 20 nsec

(C) 50 nsec

(D) 100 nsec

71. The Bohr radius of the hydrogen atom and the Compton wavelength of electron are given by :

(A) $a \propto \dfrac{\hbar^2}{me^2}$ and $\lambda_c \propto \dfrac{h}{m_0 c}$

(B) $a \propto \dfrac{h^2}{me^2}$ and $\lambda_c \propto \dfrac{\hbar^2}{m_0 c}$

(C) $a \propto \dfrac{h}{me}$ and $\lambda_c \propto \dfrac{\hbar}{m_0 c^2}$

(D) $a \propto \dfrac{\hbar^2}{mc^2}$ and $\lambda_c \propto \dfrac{h}{m_0 c^2}$

72. For a singlet state of electronic system the Landé splitting factor will be :

(A) 1

(B) 3/2

(C) 1/2

(D) 5/2

73. T_e^{2+} ion has two d electrons in its outermost shell. With the aid of Hund's rule the ground term for the d^2 system will be :

(A) $M_L = 2$, $M_S = 1/2$, Term = ^2D

(B) $M_L = 3$, $M_S = 1$, Term = ^3F

(C) $M_L = 2$, $M_S = 2$, Term = ^5D

(D) $M_L = 2$, $M_S = -1/2$, Term = ^2D

74. The wavelength of hydrogen spectrum known as Balmer series is given by :

(A) $\frac{1}{\lambda} = \left(\frac{1}{4^2} - \frac{1}{n^2}\right)R_H \; n = 5, 6, 7 \,.....$

(B) $\frac{1}{\lambda} = \left(\frac{1}{3^2} - \frac{1}{n^2}\right)R_H \; n = 4, 5, 6 \,.....$

(C) $\frac{1}{\lambda} = \left(\frac{1}{2^2} - \frac{1}{n^2}\right)R_H \; n = 3, 4, 5 \,.....$

(D) $\frac{1}{\lambda} = \left(\frac{1}{1} - \frac{1}{n^2}\right)R_H \; n = 2, 3, 4 \,.....$

75. The rotational spectrum of $^{12}C^{16}O$ and $^{13}C^{16}O$ provide the values of rotational constants B and B′ respectively. If B is 1.92 cm^{-1}, what is the value of B′ ?

(h = 6.6 × 10^{-34} Js)

(A) B′ = 2.12 cm^{-1}

(B) B′ = 1.83 cm^{-1}

(C) B′ = 1.06 cm^{-1}

(D) B′ = 4.24 cm^{-1}

76. For proton (^{1}H), placed in a magnetic field of 2.3 Tesla, the resonant frequency observed in an NMR spectrometer is (Given : $g_N = 5.58$, $\beta_N = 5.05 \times 10^{-27}$ JT^{-1} and $h = 6.6 \times 10^{-34}$ Js)

(A) 100 kHz

(B) 1 MHz

(C) 1000 MHz

(D) 100 MHz

77. In CO_2 Laser it is possible to obtain laser radiations at wavelengths of 9.6 μm and 10.6 μm. The energy levels corresponding to the two transitions are :

(A) (10°0) → (02°0) and (02°0) → (01′0)

(B) (00°1) → (10°0) and (00°1) → (02°0)

(C) (02°0) → (01′0) and (01′0) → (00°0)

(D) (00°1) → (02°0) and (00°1) → (10°0)

78. Which of the following molecules give no infrared or microwave spectra but Rotational Raman spectra ?

(A) HCl, HCN

(B) CO_2, CH_4

(C) O_2, H_2

(D) CO, H_2O

79. Auger electron emission cannot be obtained from :

(A) Nickel

(B) Carbon

(C) Oxygen

(D) Hydrogen

80. The *correct* order of increasing "first ionization potential" is :

(A) Li, Na, K, Rb

(B) Li, Be, B, C

(C) Be, Mg, Ca, Sr

(D) B, Al, Ga, In

81. In a powder diffraction pattern recorded from a face centered cubic sample using X-rays, the first peak appears at 30°. The second peak will appear at :

(A) 32.8°

(B) 33.7°

(C) 34.8°

(D) 35.3°

82. A single crystal of copper contains a low angle tilt boundary on (001) plane with a tilt axis parallel to [010]. The tilt angle, if the spacing of the dislocation in the boundary is 3×10^{-6} m and their Burgers vector is 0.4×10^{-9} m, is :

(A) 2.00×10^{-4} rad

(B) 2.60×10^{-4} rad

(C) 0.50×10^{-4} rad

(D) 1.33×10^{-4} rad

83. Atomic weight and density of gold are 197 and 1.9×10^4 kg/m^3 respectively. If the velocity of sound in it is 2100 m/s, the Debye temperature for gold will be :

(A) 200 K

(B) 240 K

(C) 300 K

(D) 370 K

84. If there are p atoms in the primitive cell, the phonon dispersion relation will have :

(A) 3 optical phonon branches

(B) $3p$-3 optical phonon branches

(C) $3p$-1 optical phonon branches

(D) $3p$ optical phonon branches

85. The kinetic energy of a free electron at a corner of the first Brillouin zone of a two-dimensional square lattice is larger than that of an electron at the midpoint of a side of the zone by a factor b. The value of b is :

(A) $b = \sqrt{2}$

(B) $b = 2$

(C) $b = 4$

(D) $b = 8$

86. In a p-type semiconductor, the Fermi level lies 0.4 eV above the valence band. If the concentration of the acceptor atoms is trippled and kT = 0.03 eV, the new position of the Fermi level will be :

(A) 0.250 eV

(B) 0.100 eV

(C) 0.525 eV

(D) 0.367 eV

87. In a dielectric, the power loss is proportional to :

(A) ω

(B) ω^2

(C) $1/\omega$

(D) $1/\omega^2$

where ω is the angular frequency of applied electric field.

88. If the static dielectric constant of NaCl is 5.6 and its optical refractive index is 1.5, the ratio of its electric polarizability to its total polarizability is :

(A) 0.5

(B) 0.6

(C) 0.8

(D) 0.9

89. The ground state of an alkali metal is a $^2S_{1/2}$ state. The difference in energy levels arising in the presence of a weak magnetic field B, given in terms of Bohr magneton μ_B is :

(A) $\mu_B B$

(B) $2\mu_B B$

(C) $4\mu_B B$

(D) $6\mu_B B$

90. Considering the BCS theory of superconductivity, which one of the following statements is *not* correct ?

(A) Presence of energy gap at temperature below the critical temperature

(B) Different critical temperatures are possible for isotopes

(C) Presence of Meissner effect can be observed

(D) Quantization of magnetic flux in superconducting ring in the units of (h/e)

91. As per the nuclear stability rule, the following nuclear decay :

$$^5_3\text{Li} \rightarrow \,^4_2\text{He} + \text{P}$$

can be possible because :

(A) The mass of ^{5}Li is smaller than the sum of the masses of ^{4}He and P

(B) The spin of ^{5}Li is less than the sum of the spins of ^{4}He and P

(C) The mass of ^{5}Li is greater than the sum of the masses of ^{4}He and P

(D) The spin of ^{5}Li is greater than the sum of the spins of ^{4}He and P

92. The binding energy per nucleon for $^{107}Ag_{47}$ nuclei is nearly :

[Given :

Mass of proton = 1.007825 amu

Mass of neutron = 1.008665 amu

Mass of silver = 106.905091 amu

1 amu = 931.5 MeV]

(A) 8.10 MeV/nucleon

(B) 8.54 MeV/nucleon

(C) 8.95 MeV/nucleon

(D) 9.25 MeV/nucleon

93. The violation of CP invariance theorem was observed in the :

(A) Decay of beta particles

(B) Decay of alpha particles

(C) Decay of heavy ions

(D) Decay of K° meson

94. A nucleus decays from its spin state $5^{-}/2$ to spin state $3^{-}/2$ by emission of gamma-ray. The gamma-ray decay mode can be classified as :

(A) E1, M2, E3, M4

(B) M1, E2, M3, E4

(C) E2, M3, E4, M5

(D) E3, M4, E5, M6

95. The beta particles emitted by a radioactive source have continuous energy spectrum, with end point energy E_{max}. This is due to sharing of disintegration energy by :

(A) Emitting nucleus and the beta particle in the form of recoil energy

(B) Neutrino and gamma-ray

(C) Beta particle and neutron in the nucleus

(D) Beta particle and neutrino

96. A gamma-ray of 1 MeV energy is scattered by the process Compton scattering. If the angle of scattering is 180°, the energy of the scattered gamma-ray will approach to :

(A) 0.511 MeV

(B) 0.551 MeV

(C) 0.352 MeV

(D) 0.255 MeV

97. A comparison between HPGe and NaI(Tl) detectors for recording spectrum of gamma-rays, it is observed that in general :
(A) the energy resolution and efficiency of HPGe detector are higher as compared to those of NaI(Tl) detector
(B) the energy resolution and efficiency of HPGe detector are almost the same as those of NaI(Tl) detector
(C) for HPGe detector, the energy resolution is high and efficiency is low as compared to those of NaI(Tl) detector
(D) for HPGe detector the energy resolution is low and efficiency is high as compared to those of NaI(Tl) detector

98. After absorbing a thermal neutron by ^{235}U nucleus, the following fission reaction is induced :

$$^{235}_{92}\text{U} + n \rightarrow \, ^{90}_{36}\text{Kr} + \text{X} + 2n$$

The fission fragment X is :
(A) ^{145}La
(B) ^{144}Ce
(C) ^{145}Cs
(D) ^{144}Ba

99. The following nuclear reaction

$$\text{P} + \text{P} \rightarrow \text{K}^{+} + \Sigma^{+}$$

is not allowed due to non-conservation of :
(A) Baryon number and isospin
(B) Strangeness and baryon number
(C) Charge and strangeness
(D) Isospin and charge

100. To obtain splitting in the nuclear energy levels, the concept of spin-orbit interaction was used in the nuclear :
(A) Liquid drop model
(B) Collective model
(C) Optical model
(D) Shell model

ROUGH WORK

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