Test Booklet Code & Serial No.
प्रश्नपत्रिका कोड व क्रमांक

C

Paper-III
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)

APR - 32317

Time Allowed : 2½ Hours] **[Maximum Marks : 150**

Number of Pages in this Booklet : **28**

Number of Questions in this Booklet : **75**

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 **75** objective type questions. Each question will carry *two* marks. *All* questions of Paper-III will be compulsory, covering entire syllabus (including all electives, without options).
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.

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 **75** बहुपर्यायी प्रश्न आहेत. प्रत्येक प्रश्नास **दोन** गुण आहेत. या प्रश्नपत्रिकेतील **सर्व** प्रश्न सोडविणे अनिवार्य आहे. सदरचे प्रश्न हे या विषयाच्या संपूर्ण अभ्यासक्रमावर आधारित आहेत.
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 चूकीचा 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 पहिल्यानंतरच 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.

5. या प्रश्नपत्रिकेतील प्रश्नांची उत्तरे **ओ.एम.आर. उत्तरपत्रिकेतच दर्शवावीत.** इतर ठिकाणी लिहीलेली 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 गैरमार्गाचा अवलंब केल्यास विद्यार्थ्याला परीक्षेस अपात्र ठरविण्यात येईल.
9. परीक्षा संपल्यानंतर विद्यार्थ्याने मूळ ओ.एम.आर. उत्तरपत्रिका पर्यवेक्षकांकडे परत करणे आवश्यक आहे. तथापी, 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 III

Time Allowed : 2½ Hours] **[Maximum Marks : 150**

Note : This Paper contains **Seventy Five (75)** multiple choice questions, each question carrying **Two (2)** marks. Attempt *All* questions.

1. Consider a crystal of N atoms with spin quantum numbers $s = \frac{1}{2}$ and $m_s = \pm\frac{1}{2}$. The magnetic moment of the ith atom is $\vec{\mu}_i = g\mu_B \vec{s}_i$, where g is the Lande g-factor and μ_B is Bohr magneton. Assuming that the atoms do not interact appreciably but are in equilibrium at temperature T and are placed in an external magnetic field $\vec{H} = H\hat{z}$, the partition function is :

(A) $2N\cosh\left(\frac{g\mu_B H}{2kT}\right)$

(B) $\left(2\cosh\left(\frac{g\mu_B H}{2kT}\right)\right)^N$

(C) $2\cosh\left(\frac{Ng\mu_B H}{2kT}\right)$

(D) $\left(2\sinh\left(\frac{g\mu_B H}{2kT}\right)\right)^N$

2. A BCC crystal is used to measure the wavelength of X-rays. The Bragg diffraction from (110) planes is obtained at $2\theta = 40.4°$. The lattice parameter of the crystal is 3.15 Å. The wavelength of X-ray is estimated to be closed to :

(Given $\sin 20.2° = 0.34$, $\sin 40.4° = 0.643$)

(A) 1.75 Å

(B) 0.70 Å

(C) 1.54 Å

(D) 0.50 Å

3. In Thomson's Experiment for measuring $\frac{e}{m}$ value, an electron is accelerated from rest through a potential difference of V volts so that the velocity of electron $v = 4 \times 10^7$ m/s. If the electron enters a magnetic field having a strength of 0.02 T acting at right angle to its path. The radius of the resulting orbit will be :

(Given $e/m = 1.7 \times 10^{11}$ c/kg)

(A) 0.12 cm

(B) 0.012 cm

(C) 12.00 cm

(D) 1.2 cm

4. The molecular density at vacuum of 10^{-12} Torr is of the order of :

(A) 10^{16} cm^{-3}

(B) 10^{19} cm^{-3}

(C) 10^{4} cm^{-3}

(D) 10^{6} cm^{-3}

5. In a certain experiment of β-particle detection, the counter measures 10,000 counts in 10 minutes. What is the percentage error in measurement ?

(A) 0.1%

(B) 1.0%

(C) 10.0%

(D) 0.01%

6. A 10 stage photomultiplier tube has stage gain of 4 secondary electrons per incident primary electron. The overall amplification of the tube is :

(A) 10

(B) 10^3

(C) 10^4

(D) 10^6

7. What is the minimum resolving power required to resolve the sodium doublet ?

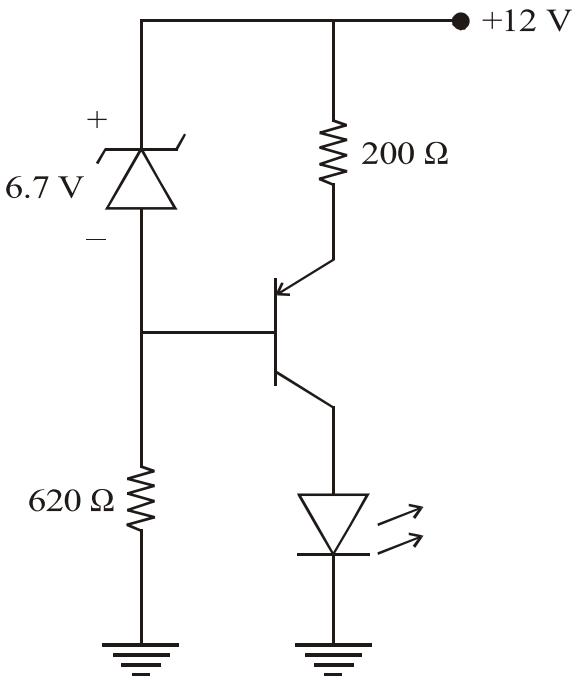
(A) 1000

(B) 500

(C) 50

(D) 10

8. What is LED current in the following circuit ?



(A) 27.9 mA

(B) 30.0 mA

(C) 25.5 mA

(D) 60.0 mA

9. The Binary to Gray conversion for the value 1011 is :

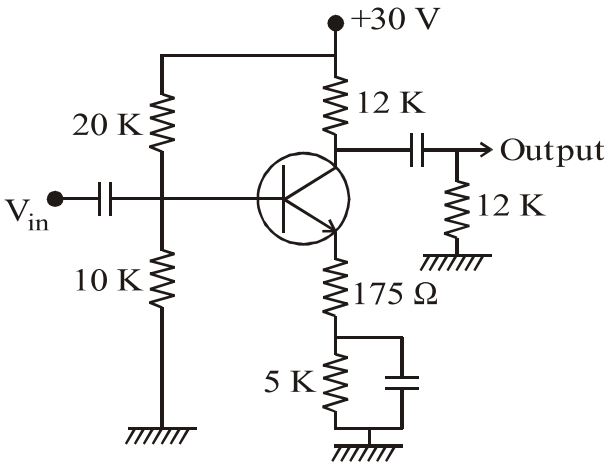
(A) 0011

(B) 1101

(C) 1100

(D) 1110

10. In the following transistor amplifier circuit, if the value of the a.c. emitter resistance r_e' is 25 Ω, then the a.c. voltage gain will be :



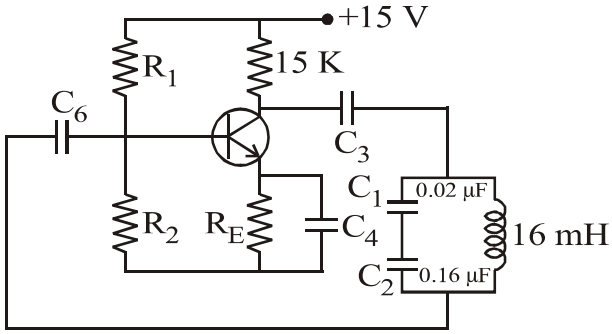
(A) 20

(B) 25

(C) 30

(D) 40

11. In the following Colpitt's oscillator :



The minimum gain required to sustain oscillator is :

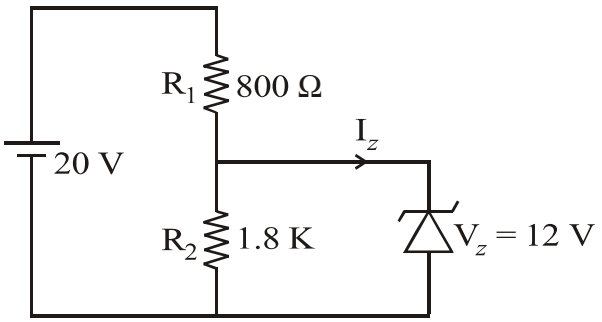
(A) 6

(B) 8

(C) 10

(D) 12

12. In the following electronic circuit a Zener diode of 12 V is connected across the resistance R_2 of 1.8 K :



The current flowing through the Zener diode is :

(A) 2.3 mA

(B) 2.8 mA

(C) 3.2 mA

(D) 3.8 mA

13. The resolution in percentage of a 9-bit D to A converter which uses a ladder network is approximately around :

(A) 0.2%

(B) 0.4%

(C) 0.6%

(D) 0.8%

14. For a frequency modulation network (F.M.), the highest modulation frequency is 18 kHz. If the modulation index is 8, then the approximate band width of the F.M. signal will be :

(A) 284 kHz

(B) 304 kHz

(C) 324 kHz

(D) 424 kHz

15. In the Gunn diode when the electric field is increased above a certain critical value, the conduction electrons are shifted :

(A) from a state of high mobility to a state of low mobility

(B) from a state of low mobility to a state of high mobility

(C) from conduction band to valence band

(D) from valence band to conduction band

16. The final result of the following Boolean equation :

$$\left(A + B\right)\left(A + \bar{B}\right)\left(\bar{A} + C\right)$$

is :

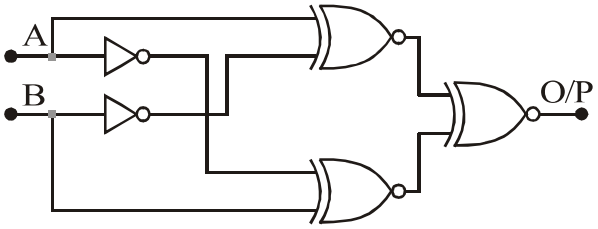
(A) AB

(B) $\bar{B}C$

(C) AC

(D) $\bar{A}\bar{B}$

17. For any values of 'A' and 'B', the output of logic circuit shown in the following is equal to :



(A) 0

(B) 1

(C) $AB + A\overline{B}$

(D) $(A \oplus B) \oplus (A \oplus B)$

18. With which type of spectroscopy would one observe the pure rotational spectrum of H_2 ?

(A) Infrared spectroscopy

(B) Microwave spectroscopy

(C) Raman spectroscopy

(D) UV-visible absorption spectroscopy

19. Consider two energy levels E_0 and E_1. The ratio of coefficient of spontaneous emission A_{10} (from E_1 to E_0) to the coefficient of stimulated emission B_{10} is ....., the wavelength of the radiation emitted is :

(A) directly proportional to λ

(B) inversely proportional to λ

(C) directly proportional to λ^3

(D) inversely proportional to λ^3

20. Which of the vibrational modes of CO_2 molecule are degenerate ?

(A) Symmetric stretching mode

(B) Asymmetric stretching mode

(C) Both Symmetric as well as Asymmetric stretching mode

(D) Bending mode

21. According to Moseley's law, the frequency of a spectral line in X-ray spectrum varies as .....

(A) atomic number of the element

(B) square of the atomic number of the element

(C) atomic weight of the element

(D) square of the atomic weight of the element

22. The 'normal' and 'anomalous' Zeeman effect are observed when : (*Note* : s' is the total spin angular momentum due to the coupling of individual spin angular momentum)

(A) $s' = 0$ and $s' \neq 0$ respectively

(B) $s' = 0$ and $s' = 0$ respectively

(C) $s' \neq 0$ and $s' = 0$ respectively

(D) $s' \neq 0$ and $s' \neq 0$ respectively

23. Consider a homonuclear diatomic molecule M-M. To which vibrational state will the electromagnetic radiation couple ?

(A) the two atoms vibrating in the same sense : symmetric vibration

(B) the two atoms vibrating against each other antisymmetric vibration

(C) the two atoms vibrating at right angles to each other

(D) the two atoms are vibrating randomly

24. A two level (2-level) system of N atoms is at a negative temperature 'T'. N_1 is the number of atoms in lower energy level E_1 and N_2 is the number of atoms in higher level E_2 :

(A) $N_1 = N_2$

(B) $N_1 > N_2$

(C) $N_2 > N_1$

(D) N_1 N_2 random

25. The rotational constant 'B' of a molecule, is related to the interatomic separation r_0 by :

(A) $B \propto r_0$

(B) $B \propto \frac{1}{r_0}$

(C) $B \propto \frac{1}{r_0^2}$

(D) $B \propto r_0^2$

26. The successive rotational levels, in case of a simple diatomic molecule with permanent electric dipole moment, are separated in energy by :

(*Note* : Rotational quantum number $r = 0, 1, 2, 3, ...$)

(A) $\frac{r\hbar^2}{I}$

(B) $\frac{r\hbar^2}{2I}$

(C) $\frac{2r\hbar^2}{I}$

(D) $\frac{3r\hbar^2}{I}$

27. Packing efficiency of a diamond structure is :

(A) 34%

(B) 52%

(C) 68%

(D) 74%

28. The total number of $(Na^+ + Cl^-)$ ions per unit cell is :

(A) 2

(B) 4

(C) 6

(D) 8

29. If the lattice parameter of a 2D square lattice increases to three times the original value. The original Debye frequency ω_D will change to :

(A) $\frac{\omega_D}{9}$

(B) $\frac{\omega_D}{3}$

(C) $3\omega_D$

(D) $9\omega_D$

30. The Helmholtz free energy F of phonon mode of frequency ω in a crystal at temperature T is :

(A) $kT\, e^{-\hbar\omega}$

(B) $kT\left[\frac{\hbar\omega}{2kT} + \ln\left(1 - e^{-\hbar\omega/kT}\right)\right]$

(C) $kT \ln\left(1 - e^{-\hbar\omega/kT}\right)$

(D) $\frac{3\hbar\omega}{kT}$

31. Silicon crystal is lightly doped with boron. The silicon therefore becomes :

(A) metallic

(B) insulator

(C) *n*-type semiconductor

(D) *p*-type semiconductor

32. The Fermi energy of an intrinsic semiconductor lies :

(A) approximately at the middle of band gap

(B) closer to the bottom of conduction band

(C) inside the conduction band

(D) closer to the top of the valence band

33. The frequency dependence of the electronic polarizability of an electron having the resonance frequency ω_0 is given by :

(A) $\frac{e^2/m}{\omega_0^2 - \omega^2}$

(B) $\frac{e^2/m}{\omega_0^2 + \omega^2}$

(C) $\frac{e^2/m}{\omega_0 + \omega}$

(D) $\frac{e^2/m}{\omega_0 - \omega}$

34. The effective magneton number for $C_e^{3+}\left(4f^1\ 5s^1\ p^6\right)$ is :

(A) 1

(B) 1.5

(C) 2.0

(D) 2.5

35. In a long wavelength regime, the dispersion relation for magnons in a ferromagnet in one dimension with nearest neighbor interaction yields :

(A) ω proportional to k

(B) ω proportional to k^2

(C) ω proportional to k^3

(D) ω is independent of k

36. Transition temperature T_C and critical field H_C for a superconductor are related to :

(A) $H_C = H_0(T_C - 1)$

(B) $H_C = H_0(T_C + 1)$

(C) $T_C = T_0\left[1 - \left(\frac{H_0}{H_C}\right)^2\right]$

(D) $H_C = H_0\left[1 - \left(\frac{T}{T_0}\right)^2\right]$

37. The stable nucleus that has a radius which is 1/3 that of ^{189}Os is :

(A) ^{7}Li

(B) ^{16}O

(C) ^{4}He

(D) ^{14}N

38. The reaction $e^+e^- \rightarrow Y$ (Gamma-Ray) is forbidden because the :

(A) lepton number is not conserved

(B) linear momentum is not conserved

(C) angular momentum is not conserved

(D) charge is not conserved

39. Neutrons are bombarded on a Fluorine target to induce the following nuclear reaction :

$$^{19}_{9}F + ^{1}_{0}n \rightarrow ^{19}_{8}O + ^{1}_{1}H + Q$$

Masses are given below in a.m.u. :

1 a.m.u. = 931.494 MeV

^{19}F = 18.998405 : ^{19}O = 19.003577

n = 1.008665 : H = 1.007825

The estimated threshold energy for the nuclear reaction is about :

(A) 4.24 MeV

(B) 5.03 MeV

(C) 8.42 MeV

(D) 6.11 MeV

40. A radioactive ^{28}Al nuclei decays to ^{28}Si through the following nuclear process :

$^{28}Al \rightarrow {}^{28}Si + \beta^- + Y + \bar{\nu}_e$

(Antineutrino)

The masses given below are in a.m.u. : 1 a.m.u. = 931.494 MeV ^{28}Al = 27.981908 : ^{28}Si = 27.976929 : β^- = 0.0005485799.

If the β^- particle is emitted with an end point energy of 2.86 MeV, then the energy of the excited state is the ^{28}Si daughter nuclei from which gamma-ray is emitted will be around :

(A) 3.02 MeV

(B) 1.78 MeV

(C) 4.98 MeV

(D) 2.58 MeV

41. Given that the range of nuclear force is about 1.93×10^{-15} meter, the mass of the Yukawa particle estimated using uncertainty principle in the unit of electron mass m_e is about :

(m_e = 0.511 MeV)

(A) 450 m_e

(B) 200 m_e

(C) 50 m_e

(D) 300 m_e

42. About 200 MeV energy is produced in fission of one ^{235}U nucleus. The amount of energy produced by complete fission of 0.1 kg of ^{235}U is about :

[1 MeV = 1.6×10^{-13} Watt-sec]

(A) 0.1 Mega-Watt-Day

(B) 10 Mega-Watt-Day

(C) 500 Mega-Watt-Day

(D) 100 Mega-Watt-Day

43. The following nuclear reaction :

$$\Xi^{\circ} + P \rightarrow \Sigma^{+} + n$$

is examined on the basis of the conservation laws of charge, Baryon number, strangeness and third component of Isospin. It is observed that the above reaction cannot be induced due to non-conservation of :

(A) Strangeness and third component of Isospin

(B) Charge and Baryon number

(C) Strangeness and Charge

(D) Baryon number and third component of Isospin

44. An excited nucleus decayed from an energy level having spin and parity values of 2^+ to another energy level having spin and parity values of O^+, by emitting a gamma-ray.

For the emission of gamma-ray, the predominant decay mode can be classified as :

(A) Electric Dipole E_1

(B) Electric Quadrupole E_2

(C) Magnetic Dipole M_1

(D) Magnetic Quadrupole M_2

45. In the nuclear shell model, the nuclear spin-orbit coupling splits a nuclear energy level which is identified by the spins and orbital angular momentum l into $j = l \pm s$, where s is spin, having value 1/2. The positions of the splitted energy levels are :

(A) $j = l - 1/2$ lies higher in energy and $j = l + 1/2$ lies lower in energy

(B) $j = l - 1/2$ lies lower in energy and $j = l + 1/2$ lies higher in energy

(C) $j = l - 1/2$ has the same energy level as that of $j = l + 1/2$ because neutron has no charge

(D) $j = 2l - 1/2$ lies lower in energy and $j = 2l + 1/2$ lies higher in energy

46. $f(x)$ represents electromotive force in an electric circuit and is given to be a periodic square wave. Which of the following represents a Fourier series for $f(x)$?

(A) $\frac{2}{\pi}\left(\cos x + \frac{1}{2}\cos 2x + \frac{1}{3}\cos 3x + \frac{1}{4}\cos 4x + ...\right)$

(B) $\frac{4}{\pi}\left(\cos x + \frac{1}{3}\cos 3x + \frac{1}{5}\cos 5x + ...\right)$

(C) $\frac{2}{\pi}\left[\cos x + \sin x + \frac{1}{3}(\cos 3x + \sin 3x) + \frac{1}{5}(\cos 5x + \sin 5x) + ...\right]$

(D) $\frac{4}{\pi}\left(\sin x + \frac{1}{3}\sin 3x + \frac{1}{5}\sin 5x + ...\right)$

47. The value of $\int_0^\infty e^{-ax}\cos \lambda x \, dx$, $a > 0$, is :

(A) $\frac{a}{a^2 + \lambda^2}$

(B) $\frac{a^2 + \lambda^2}{a}$

(C) $a\left(a^2 + \lambda^2\right)$

(D) $a\left(a^2 - \lambda^2\right)$

48. The dimension of the vector space of $n \times n$ symmetric matrices is :

(A) $n^2 - n$

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

(C) $n^2/2$

(D) $n(n-1)/2$

49. The value of $\int_0^{\infty} \frac{dx}{1+x^2}$ is :

(A) Infinity

(B) π

(C) 2π

(D) $\pi/2$

50. The equation $\frac{d^2y}{dt^2} - y + y^2 = 0$ has :

(A) no critical points

(B) has only one critical point

(C) has two critical points

(D) has infinite number of critical points

51. The probability density for a random variable is Ae^{-x} for $x \geq 0$. Then :

(A) A = 1

(B) A = $\frac{1}{\sqrt{\pi}}$

(C) A = $\frac{1}{\pi}$

(D) A = π

52. Consider the vector space of polynomials of degree less than or equal to 5. This vector space has dimension :

(A) 5

(B) 6

(C) Infinity

(D) 4

53. The equation of motion of a particle can be expressed as :

(A) $d/dt(m\mathrm{T}) = f \cdot p$

(B) $d/dt(\mathrm{T}/2m) = f \cdot p$

(C) $d/dt(2m\mathrm{T}) = f \cdot p$

(D) $d/dt(m\mathrm{T}/2) = f \cdot p$

54. A mass m_1 elastically collides with another mass m_2 initially at rest. After collision the masses m_1 and m_2 travel at angles θ and $-\theta$ respectively with respect to the initial direction of m_1. If $m_1 = m_2$ then :

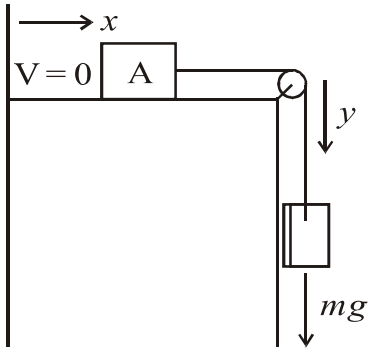
(A) $\theta = \pi/4$

(B) $\theta = \pi/2$

(C) $\theta = \pi$

(D) $\theta = 3\pi/2$

55. Two blocks of equal masses (m) are connected by inextensible massless string of length l. The block 'A' moves without friction. The Lagrangian L for the given system is :



(A) $m\dot{y}^2 - mgy$

(B) $\frac{1}{2}m\dot{y}^2 - mgy$

(C) $\frac{1}{2}m\dot{y}^2 - mg(y - x)$

(D) $m\dot{y}^2 - mg(y - x)$

56. For a system with n degrees of freedom, the Poisson's bracket $[x_i, L_j]$ is :

(A) $\varepsilon_{ijk}\ x_k$

(B) $\varepsilon_{ijk}\ p_k$

(C) $\varepsilon_{ijk}\ x_k p_k$

(D) Zero

57. A simple harmonic oscillator is oscillating with a frequency ω_0 around the origin. When a perfect reflector is introduced at the origin, the frequency of oscillation becomes ω_1 given by :

(A) $2\omega_0$

(B) $\omega_0/2$

(C) ω_0

(D) $3\omega_0/2$

58. The motion of a one-dimensional free particle in phase space is represented by :

(A) A circle

(B) A parabola

(C) A straight line parallel to x-axis

(D) A straight line parallel to p-axis

59. Two charges $-q$ and $2q$ are located on the x-axis at $x = a$ and $x = 2a$ respectively. There is an infinite grounded conducting plane at $x = a/2$. The net induced charge on the plane is :

(A) q

(B) $-q$

(C) $-q/2$

(D) $-5q/2$

60. A point charge q is placed at the origin. The electric flux through the triangle with vertices at (1, 0, 0), (0, 1, 0) and (0, 0, 1) is ..... .

(coordinates are Cartesian)

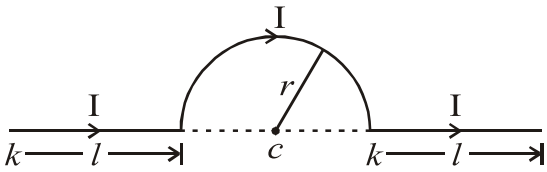
(A) $\frac{q\sqrt{6}}{\epsilon_0}$

(B) $\left(\frac{\sqrt{3}}{2}\right)\frac{q}{\epsilon_0}$

(C) $\frac{q}{\epsilon_0}$

(D) $\frac{q}{8\,\epsilon_0}$

61. Consider the figure. A current I flows through the long wire which has a semi-circular loop of radius 'r' centred at 'c'. The magnetic induction at 'c' due to the entire wire is .....



(A) $\mu_0 I/4\pi r$

(B) $\mu_0 I/4r^2$

(C) $\mu_0 I/4\pi r^2$

(D) $\mu_0 I/4r$

62. A plane electromagnetic wave is incident from rarer medium to denser medium at an angle of incidence equal to the Brewster's angle. Which of the following statements is *incorrect* ?

(A) Reflected ray is plane polarized

(B) Reflected ray is perpendicular to transmitted ray

(C) Angle of reflection is greater than $\pi/4$

(D) Angle of reflection is less than $\pi/4$

63. A radiation of frequency $\nu = 7.5$ GHz is introduced in a rectangular wave guide of dimensions 2.5 cm × 1.5 cm. Which of the following modes can exist inside the wave guide ?

(A) Only TE_{10}

(B) Only TM_{10}

(C) TE_{10} and TM_{10}

(D) TE_{10} and TE_{01}

64. A tiny oscillating magnetic dipole is formed by circulating sinusoidal current through a circular loop. Consider this dipole as a perfect dipole. If peak value of current flowing is doubled, then time averaged power radiated by this dipole becomes ..... times the initial power.

(A) 4

(B) 1/4

(C) 16

(D) 1/16

65. Which of the following operators commutes with Hamiltonian of one-dimensional oscillator. x, p_x are position and momentum operators, a and a^+ are annihilation and creation operators, respectively ?

(A) a^+a

(B) p_x

(C) a

(D) x

66. For a quantum mechanical system which is in one of the eigenstates of L_z, with eigenvalue $m\hbar$, the expectation value of L_x is :

(A) $m\hbar$

(B) $-m\hbar$

(C) Zero

(D) Cannot be determined

67. The number of bound states that a quantum mechanical one-dimensional finite square well admits :

(A) depends only on the depth of potential well V_0

(B) depends only on the width of the potential well a

(C) is independent of the depth V_0 and width a of the potential

(D) depends on both the depth V_0 and width a of the potential well

68. For a 1-dimensional quantum mechanical system the Heisenberg uncertainty product Δx, Δp is maximum when the system state is :

(A) Lorentzian function

(B) Gaussian function

(C) Plane wave function

(D) Exponential function

69. Consider two spin ½ particles having spin angular momentum operators $\vec{s}_1$ and $\vec{s}_2$. The expectation value of the product $\vec{s}_1 \cdot \vec{s}_2$ in $|\uparrow\uparrow\rangle$ state is :

(A) $\frac{3}{4}\hbar^2$

(B) $\frac{1}{4}\hbar^2$

(C) $0\hbar^2$

(D) $\frac{-3}{4}\hbar^2$

70. The second order perturbative correction to ground state energy eigenvalue of a one-dimensional quantum mechanical system is :

(A) always positive

(B) always negative

(C) always zero

(D) always greater than first order correction

71. The number of ways of distributing 7 undistinguishable bosons in 5 energy levels is :

(A) 7^5

(B) 5^7

(C) $\frac{11!}{7!4!}$

(D) $\frac{12!}{7!5!}$

72. A gas of N spinless Bose particle of mass m is enclosed in a volume V at a temperature T. The density of state is :

(A) $\frac{2\pi V}{h^3}(2m)^{3/2} \in^{1/2}$

(B) $\frac{2\pi V}{h^3}(2m)^{3/2} \in^{-1/2}$

(C) $\frac{2\pi}{h^3}(2m)^{3/2} \in^{1/2}$

(D) $\frac{2\pi}{h^3}(2m)^{3/2} \in^{-1/2}$

73. If the quantum correction to the compressibility of ideal bosons and fermions are given by ΔK_T^B and ΔK_T^F respectively, which of the following statements is *true* ?

(A) $\Delta K_T^B > 0$ and $\Delta K_T^F > 0$

(B) $\Delta K_T^B > 0$ and $\Delta K_T^F < 0$

(C) $\Delta K_T^B < 0$ and $\Delta K_T^F > 0$

(D) $\Delta K_T^B < 0$ and $\Delta K_T^F < 0$

74. The partition function of a system with Hamiltonian given by :

$$\frac{1}{\sqrt{2}}\begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$$

is :

(A) $2 \sinh \beta$

(B) $2 \cosh \beta$

(C) $1 + 2 \sinh \beta$

(D) $1 + 2 \cosh \beta$

75. For Na metal there are approximately 2.6×10^{22} conduction electrons/cm^3, which behave approximately as a free electron gas. The Fermi energy of Na approximately is :

(Given $\hbar = 6.58 \times 10^{-16}$ eV, mass of electron = $0.511 \frac{MeV}{c^2}$)

(A) 320 eV

(B) 3.2 eV

(C) 32 eV

(D) 0.32 eV

ROUGH WORK

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