Roll No. ☐☐☐☐☐☐☐

(Write Roll Number from left side
exactly as in the Admit Card)

Signature of Invigilators

1. _____

2. _____

Question Booklet Series ☒ **X**

1617

PAPER–III

Question Booklet No.

(Identical with OMR
Answer Sheet Number)

Subject Code : 16

PHYSICAL SCIENCES

Time : 2 Hours 30 Minutes   *Maximum Marks: 150*

Instructions for the Candidates

1. Write your Roll Number in the space provided on the top of this page as well as on the OMR Sheet provided.
2. At the commencement of the examination, the question booklet will be given to you. In the first 5 minutes, you are requested to open the booklet and verify it:
    (i) To have access to the Question Booklet, tear off the paper seal on the edge of this cover page.
   (ii) Faulty booklet, if detected, should be get replaced immediately by a correct booklet from the invigilator within the period of 5 minutes. Afterwards, neither the Question Booklet will be replaced nor any extra time will be given.
  (iii) Verify whether the Question Booklet No. is identical with OMR Answer Sheet No.; if not, the full set to be replaced.
  (iv) After this verification is over, the Question Booklet Series and Question Booklet Number should be entered on the OMR Sheet.
3. This paper consists of seventy-five (75) multiple-choice type questions. All the questions are compulsory. Each question carries *two* marks.

4. Each Question has four alternative responses marked: Ⓐ Ⓑ Ⓒ Ⓓ. You have to darken the circle as indicate below on the correct response against each question.

   Example: Ⓐ Ⓑ ● Ⓓ , where Ⓒ is the correct response.

5. Your responses to the questions are to be indicated correctly in the OMR Sheet. If you mark your response at any place other than in the circle in the OMR Sheet, it will not be evaluated.
6. Rough work is to be done at the end of this booklet.
7. If you write your Name, Roll Number, Phone Number or put any mark on any part of the OMR Sheet, except the space allotted for the relevant entries, which may disclose your identity, or use abusive language or employ any other unfair means, such as change of response by scratching or using white fluid, you will render yourself liable to disqualification.
8. Do not tamper or fold the OMR Sheet in any way. If you do so, your OMR Sheet will not be evaluated.
9. You have to return the 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 question booklet and duplicate copy of OMR Sheet after completion of examination.
10. **Use only Black Ball point pen.**
11. **Use of any calculator or mobile phone etc. is strictly prohibited.**
12. **There are no negative marks for incorrect answers.**

[Please Turn Over]

PHYSICAL SCIENCES

PAPER III

1. Which law of thermodynamics corresponds to the conservation of energy?

    (A) Zeroth law

    (B) First law

    (C) Second law

    (D) Third law

2. Which of the following statements is true for blackbody radiation?

    (A) As temperature increases, peak of energy distribution curve decreases in height and shifts to longer wavelength.

    (B) As temperature increases, peak of energy distribution curve increases in height and shifts to lower wavelength.

    (C) As temperature increases, peak of energy distribution curve increases in height and shifts to longer wavelength.

    (D) As temperature increases, peak of energy distribution curve decreases in height and shifts to lower wavelength.

3. A system is in contact with a reservoir at constant temperature and pressure. If its external parameters are excited so that it can do work on the reservoir, then the state of equilibrium situation is characterized by the condition:

    (A) Gibbs free energy is maximum.

    (B) Helmholtz free energy is maximum.

    (C) Gibbs free energy is minimum.

    (D) Helmholtz free energy is minimum.

4. A spin-$\frac{1}{2}$ particle is placed in a magnetic field $\vec{H} = H\hat{k}$. The probability of finding it in $S = -\frac{1}{2}$ is (where $\beta = \frac{1}{k_B T}$)

    (A) $\dfrac{e^{\beta H/2}}{\left(e^{\beta H/2} + e^{-\beta H/2}\right)}$

    (B) $\dfrac{e^{-\beta H/2}}{\left(e^{\beta H/2} + e^{-\beta H/2}\right)}$

    (C) $\sinh\dfrac{\beta H}{2}$

    (D) $\tanh\dfrac{\beta H}{2}$

5. Mean square fluctuation in the energy E of a system in the canonical ensemble is

    (A) $k_B^2 T^2 C_V$

    (B) $k_B T^2 C_V$

    (C) $k_B T C_V$

    (D) $k_B T^2 C_V^{\,2}$

6. In Bose-Einstein condensation there is

    (A) an upper limit for the number of particles in the excited state and this limit decreases with decreasing temperature.

    (B) an upper limit for the number of particles in the excited state and this limit decreases with increasing temperature.

    (C) an upper limit for the number of particles in the excited state and this limit is independent of temperature.

    (D) no upper limit for the number of particles in the excited state.

7. N non-interacting spin ½ particles each of magnetic moment μ are placed in a uniform magnetic field H and at finite temperature T. Helmholtz free energy of the system is

(A) $Nk_BT \ln\{2cosh(\mu H / k_BT)\}$

(B) $-Nk_BT \ln\{2cosh(\mu H / k_BT)\}$

(C) $-Nk_BT \ln\{cosh(\mu H / k_BT)\}$

(D) $Nk_BT \ln\{cosh(\mu H / k_BT)\}$

8. The Lorentz transformation matrix between two inertial frames S and S' is given by

$$\wedge = \begin{pmatrix} 5 & 0 & 0 & -2\sqrt{6} \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -2\sqrt{6} & 0 & 0 & 5 \end{pmatrix}$$

If a proton of rest mass $1 GeV/c^2$ is at rest in S', its energy in S will be

(A) $\frac{1}{5}GeV$

(B) $5GeV$

(C) $2\sqrt{6}\,GeV$

(D) $\frac{7}{5}GeV$

9. Our nearest star is 4·2 light years away. A spaceship which leaves the earth and travels at a uniform velocity towards the star takes 4·2 year, according to a ship-borne clock. The speed of the ship is

(A) $c / \sqrt{2}$

(B) $c / 2$

(C) c

(D) $\sqrt{2}c$

10. Work done by the force

$$\vec{F} = (x - y + z)\hat{i} + (x + y + z)\hat{j} + (2x - 3y + z)\hat{k}$$

in moving a particle once around the circle $x^2 + y^2 = 4$ is

(A) 4π

(B) 8π

(C) 6π

(D) 2π

11. A system is described by the Lagrangian

$L = \frac{1}{2}m(\dot{r}^2 + r^2\dot{\theta}^2) - \frac{\alpha}{r}$, which of the following statement is not true? (α is a constant)

(A) p_θ is conserved.

(B) p_r is conserved.

(C) Total energy is conserved.

(D) θ is cyclic.

12. A particle of mass 'm' moves under the potential $V(x, y) = x^4 + 3x^2y^2 + xy^3$ in a finite region of space, the average kinetic energy of the particle is (where E is the total energy)

(A) $\frac{2}{3}E$

(B) $\frac{1}{3}E$

(C) $\frac{1}{2}E$

(D) $\frac{3}{4}E$

13. The Hamiltonian is equal to the total energy for

(A) dissipative systems

(B) conservative systems

(C) non-conservative systems

(D) any system in general

14. In the spherical polar coordinate (r, θ, ϕ) system, the parity operation is given by

(A) $r \to -r, \theta \to -\theta, \phi \to -\phi$

(B) $r \to r, \theta \to 2\pi - \theta, \phi \to 2\pi - \phi$

(C) $r \to r, \theta \to \pi + \theta, \phi \to \pi - \phi$

(D) $r \to r, \theta \to \pi - \theta, \phi \to \pi + \phi$

15. A uniformly charged spherical shell of radius a and total charge Q is spun around its diameter with angular velocity ω. Magnetic moment of this rotating spherical shell is

(A) $\dfrac{1}{3} Q a \omega$

(B) $\dfrac{1}{3} Q a^2 \omega$

(C) $\dfrac{1}{3} Q \omega^2 / a$

(D) $\dfrac{1}{3} Q^2 a \omega^2$

16. A point charge q is located at the common centre of two concentric conducting spheres of radii a and b respectively, as shown in the figure. The electrostatic potential at a distance r (where $a < r < b$) is
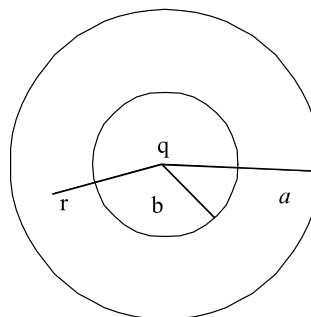
(A) Zero

(B) $\dfrac{q}{4\pi \in_0 a}$

(C) $\dfrac{q}{4\pi \in_0 r}$

(D) $\dfrac{q}{4\pi \in_0 b}$

17. The Lagrangian density for the electromagnetic field does not have a term of the form $\vec{E}.\vec{B}$ because

(A) it is not gauge invariant.

(B) it is not invariant under parity.

(C) it is not Lorentz invariant.

(D) it is neither gauge invariant nor Lorentz invariant.

18. A photon moves from point A to point B, both immersed in water with refractive index μ. If the space-time separation between these two points be R^μ, then (with metric $(1, -1, -1, -1)$)

(A) $R_\mu R^\mu = 0$

(B) $R_\mu R^\mu > 0$ and proportional to $1 - \dfrac{1}{\mu^2}$

(C) $R_\mu R^\mu < 0$ and proportional to $1 - \mu^2$

(D) $R_\mu R^\mu > 0$ and proportional to $\dfrac{(\mu - 1)}{(\mu + 1)}$

19. Dispersion relation for a low density plasma is $\omega^2 = \omega_0{}^2 + c^2 k^2$, where ω_0 is plasma frequency and c is the speed of light in free space. The relationship between the phase velocity (v_p) and group velocity (v_g) is

(A) $v_p = v_g$

(B) $v_p = v_g{}^{1/2}$

(C) $v_p v_g = c^2$

(D) $v_g = v_p{}^{1/2}$

20. Two charges of $+ q$ and $+ q$ are placed at $x = 0$ and $x = a$ respectively. Then

(A) monopole moment is $+ 2q$, dipole moment is zero.

(B) monopole moment is $+ 2q$, dipole moment is undefined.

(C) monopole moment is $+ 2q$, dipole moment is $+ qa$.

(D) both monopole and dipole moments are zero.

21. The time-averaged power radiated by an oscillating electric dipole $\left[\vec{p}(t) = \hat{z}\, p_0 \cos \omega t \right]$ is proportional to

(A) $\omega^{1/4}$

(B) ω^2

(C) ω^4

(D) ω^{-4}

22. Consider the 2×2 matrix $A = (a + b)\, \sigma_1 + (a - b)\, \sigma_2$, where σ_1 and σ_2 are the Pauli spin matrices. The eigenvalues of A are

(A) $\pm\sqrt{a^2 + b^2}$

(B) $\pm\sqrt{2(a^2 + b^2)}$

(C) $\pm\sqrt{\dfrac{a^2 + b^2}{2}}$

(D) $\pm 2\sqrt{a^2 + b^2}$

23. What is the percentage of error if you approximate $\sin\theta$ by θ for $\theta = 4°$?

(A) About 0.006%

(B) About 0.08%

(C) About 0.48%

(D) More than 1%

24. The number of independent components of $T_{ij} = \dfrac{1}{2}\left(x_i p_j + x_j p_i \right) - \dfrac{1}{3}\delta_{ij} \left(\vec{x}.\vec{p} \right)$ in three dimensions is

(A) 5

(B) 6

(C) 8

(D) 9

25. The complex function

$$f(z) = \frac{1}{z(z-1)} \text{ where } 0 < |z| < 1 \text{, can be expressed as}$$

(A) $-\sum\limits_{n=-1}^{\infty} z^n$

(B) $-\sum\limits_{n=0}^{\infty} z^n$

(C) $\sum\limits_{n=-1}^{\infty} z^n$

(D) $\sum\limits_{n=0}^{\infty} z^{-n}$

26. The value of

$$\oint_c \frac{dz}{z^2 + a^2}$$

where $|a| = 1$ and C is the circle of radius 2 units, centred at the origin, and traversed in the anticlockwise direction, is

(A) $\dfrac{2\pi}{|a|}$

(B) 0

(C) $\pi / |a|$

(D) $-\pi / |a|$

27. There are on average 12 buses per hour at a point on certain road, but at random times. The probability that there is no bus in five minutes is closest to

(A) 0·37

(B) 1

(C) Zero

(D) 0·63

28. The matrix A is given by:

$$A = \begin{pmatrix} 2 & 1+i & 1+2i \\ 1-i & 3 & 2 \\ 1-2i & 2 & -1 \end{pmatrix}$$

The eigenvalues are (approximately)

(A) 5·35, 2·13, −1·48

(B) 5·35, −2·48, 1·13

(C) 4·54 + 0·61i, −0·96 − 1·07i, 0·42 + 0·46i

(D) 4·75 + 0·53i, −2·64 + 0·02i, 1·88 − 0·55i

29. For a particle scattering by a perfectly rigid sphere of radius R, the total scattering cross-section at low and high energies respectively are given as

(A) $2\pi R^2$ and $4\pi R^2$

(B) πR^2 and $2\pi R^2$

(C) $4\pi R^2$ and $2\pi R^2$

(D) $2\pi R^2$ and πR^2

30. If $|n\rangle$ denotes the n-th bound state normalized eigenvector of a simple harmonic oscillator then for the state $|\psi\rangle = n\left(|0\rangle + 3i|2\rangle\right)$ the expectation value, $<x>$, is

(A) $3|N|^2 \sqrt{\dfrac{\hbar}{2m\omega}}$

(B) $\dfrac{3}{2}|N|^2 \sqrt{\dfrac{\hbar}{2m\omega}}$

(C) Zero

(D) $2|N|^2 \sqrt{\dfrac{\hbar}{2m\omega}}$

31. If all the eigenfunctions of the Hermitian operator $\hat{A}$ are also eigenfunctions of the Hermitian operator $\hat{B}$ then the product of the uncertainties of the simultaneous measurement of the corresponding dynamical variables *A* and *B* is

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

(B) Zero

(C) $\dfrac{\langle \hat{A}\hat{B}\rangle}{2}$

(D) $\dfrac{\langle [\hat{A},\hat{B}]\rangle}{2}$

32. Three spin $-\dfrac{1}{2}$ particles are put together. The Hilbert space of the spin wavefunctions of the combined system is

(A) 6-dimensional, reducible to $4 \oplus 2$ [the dimensionalities of the irreducible representations]

(B) 6-dimensional, reducible to $2 \oplus 2 \oplus 2$

(C) 8-dimensional, reducible to $3 \oplus 3 \oplus 2$

(D) 8-dimensional, reducible to $4 \oplus 2 \oplus 2$

33. In the one-dimensional infinite square-well case, the wavefunction ψ and its derivative $d\psi/dx$ are, at the boundaries, respectively

(A) continuous and discontinuous

(B) discontinuous and continuous

(C) both continuous

(D) both discontinuous

34. One of the energy eigenvalues, $\in$, of a quantum mechanical system is fourfold degenerate. The system is perturbed with a time-independent perturbation H′. The matrix of H′ in the subspace of $\in$ is

$$H' = \begin{pmatrix} 0 & \xi & 0 & 0 \\ \xi & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

The first order correction in the energy is given by

(A) $\xi, -\xi, 0, 0$

(B) $\xi, \xi, 0, 0$

(C) $\xi, -\xi, \xi, -\xi$

(D) $0, \xi, 0, \xi$

35. At time t = 0, the wavefunction of a particle is given by $|\psi(0)\rangle = \dfrac{1}{\sqrt{2}}\left[|\phi_1\rangle + |\phi_2\rangle\right]$, where $|\phi_1\rangle$ and $|\phi_2\rangle$ are the orthonormalized eigenstates with eigenvalues E_1 and E_2 respectively ($E_2 > E_1$). The shortest time after which $|\psi(t)\rangle$ will become orthogonal to $|\psi(0)\rangle$ is

(A) $\hbar\pi / (E_2 - E_1)$

(B) $-\hbar\pi / 2(E_2 - E_1)$

(C) $\sqrt{2}\hbar\pi / (E_2 - E_1)$

(D) $2\hbar\pi / (E_2 - E_1)$

36. Clausius-Mossotti equation represents relation between

(A) dielectric permittivity and polarizability

(B) electrical susceptibility and polarization

(C) permeability and magnetization

(D) electric dipole moment and electric field

37. An exciton is

(A) a bound electron hole pair.

(B) an electron bound to a negative ion vacant lattice site.

(C) a hole bound to a positive ion vacant lattice site.

(D) a bound electron positron pair.

38. Which of the following does not describe the Bragg diffraction condition?

(A) $2d \sin\theta = n\lambda$

(B) $\Delta \vec{K} = \vec{G}$

(C) $\vec{a} . \Delta \vec{K} = 2\pi n$

(D) $2\vec{K} . \vec{G} = G^2$

39. Consider the plane with indices (100); the lattice is *fcc* and the indices refer to the conventional unit cell. Indices of this plane referred to the primitive axes of the lattice is

(A) (101)

(B) (011)

(C) (111)

(D) (202)

40. Energy band gap size for semiconductor is in the range of

(A) $1 - 2$ eV

(B) $2 - 3$ eV

(C) $3 - 4$ eV

(D) > 4 eV

41. If N and n are the concentrations of lattice points and Schottky defects respectively, the entropy of creating the defects in a crystal is $S = k_B \ln W$ where W is given by

(A) $n!$

(B) $\dfrac{N!}{n!}$

(C) $\dfrac{N!}{(N-n)!}$

(D) $\dfrac{N!}{n!(N-n)!}$

42. The energy dispersion $(E - k)$ relation for electrons in a one dimensional array of atoms having lattice constant 'a' and total length L is, $E = E_0 - \beta - 2\gamma \cos ka$ where, E_0, β and γ are constants and k is the wave vector. The density of electronic states (including spin degeneracy) in the band, and the effective mass at the band centre are given by

(A) $\dfrac{L}{\pi\gamma a \sin(ka)}$ and $\dfrac{\hbar^2}{\gamma a^2}$

(B) $\dfrac{L}{2\pi\gamma a \sin(ka)}$ and $\dfrac{\hbar^2}{2\gamma a^2}$

(C) $\dfrac{L}{2\pi\gamma a \cos(ka)}$ and ∞

(D) $\dfrac{L}{\pi\gamma a \cos(ka)}$ and ∞

43. The ratio of the thermal conductivity to the electrical conductivity for metals is proportional to

(A) $\sqrt{T}$

(B) T

(C) $\dfrac{1}{T}$

(D) $T^{3/2}$

where, T is the absolute temperature.

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44. Spontaneous magnetisation in ferromagnets occurs due to

    (A) externally applied magnetic field.

    (B) van der Waals' interaction between the dipoles.

    (C) exchange interaction among the dipoles.

    (D) orbital and spin motion of the electrons.

45. According to Hall effect, if a conducting material is placed in a uniform magnetic field and a current is passed, a voltage is found to be developed at

    (A) parallel to the current.

    (B) parallel to the magnetic field.

    (C) perpendicular to the magnetic field and current.

    (D) $45°$ to the magnetic field and current.

46. Consider the circuit shown below. If $R_1 = 100\Omega$, $R_2 = 1k\Omega$, $V_{out} = 550$ mV then V_i is equal to
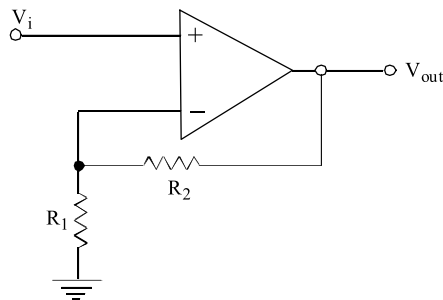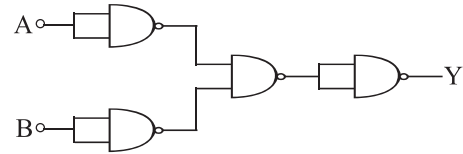
    (A) -50 mV

    (B) -5 mV

    (C) 550 mV

    (D) 50 mV

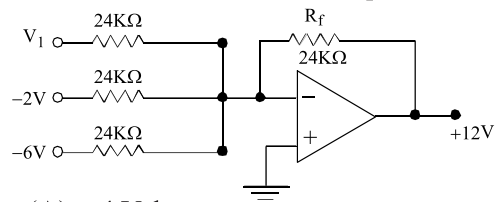**47.** Use boolean algebra to judge if $A + \overline{A}B$ is equal to

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

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

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

    (D) $A + B$

48. In the circuit shown below, for two-input A and B, the output (Y) is

    (A) $\overline{A \cdot B}$

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

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

    (D) $A + B$

**49.** In circuit shown below, V_1 equals

    (A) $+4$ Volts

    (B) $+20$ Volts

    (C) -20 Volts

    (D) -4 Volts

50. Which of the following conditions are needed to properly bias an *n-p-n* transistor amplifier?

    (A) Forward bias the base-emitter junction and reverse bias the base-collector junction.

    (B) Forward bias the collector-base junction and reverse bias the emitter-base junction.

    (C) Apply a positive voltage on the n-type material and reverse bias the emitter-base junction.

    (D) Apply a large voltage to the base.

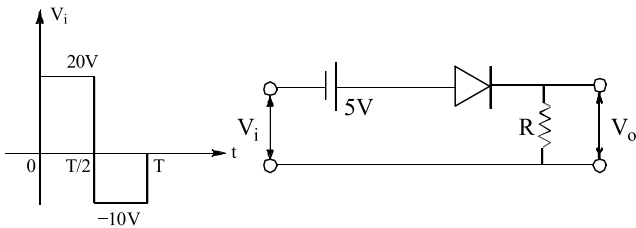**51.** What is the output waveform?
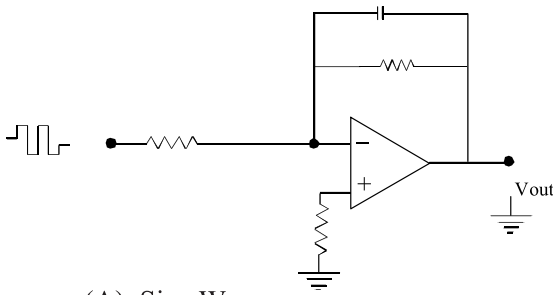
(A) Sine Wave

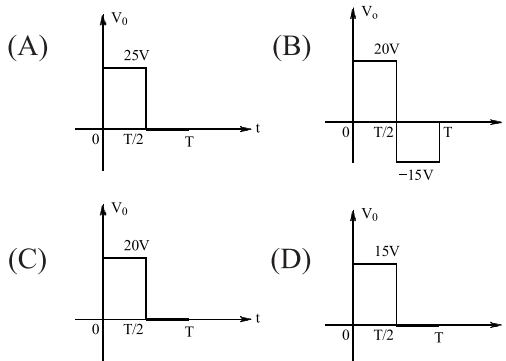(B) Square Wave

(C) Saw-tooth Wave

(D) Triangular Wave

52. A 4 bit D/A converter produces an output voltage of 4·5 V for an input code of 1001. The value of the output voltage for an input code of 1101 is
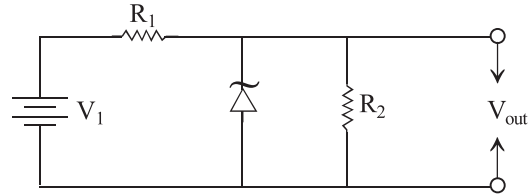
(A) 4·5 V

(B) 2·5 V

(C) 3·5 V

(D) 6·5 V

53. The input signal and the network to which it is applied are shown below:

Output waveform will be

54. In the circuit shown below, $V_1 = 10V$, $R_1 = 1k\Omega$, $V_z = 6V$ and $I_{knee} = 1mA$. The minimum value of R_2, so that the diode operates in the Zener region is

(A) 1 kΩ

(B) 5 kΩ

(C) 2 kΩ

(D) 3 kΩ

Here, V_z is the voltage across the Zener.

55. How is a J-K flip-flop made to toggle?

(A) J = 0, K = 0

(B) J = 1, K = 0

(C) J = 0, K = 1

(D) J = 1, K = 1

56. A medium suitable for producing LASER radiation has been activated to the condition of population inversion. In this situation the system

(A) has positive temperature (in Kelvin).

(B) has negative temperature (in Kelvin).

(C) has temperature of 0K.

(D) may have positive and negative temperature (in Kelvin).

57. Consider a H_2 molecule. If ψ_{1s} be the wavefunction of H-atom in 1s state then the orbital

$$\Phi = \frac{1}{2}\left[\Psi_{1s}\left(r_{A1}\right)\Psi_{1s}\left(r_{A2}\right) + \Psi_{1s}\left(r_{B1}\right)\Psi_{1s}\left(r_{B2}\right)\right]$$

represents $\left(\vec{r}_{Ai}\ \text{and}\ \vec{r}_{Bi}\right.$ (for i = 1, 2) are the position vector of the ith electron with respect to the nuclei A and B respectively,)

(A) an ionic bonding

(B) a covalent bonding

(C) neither ionic nor covalent

(D) two separated H-atom

58. Which of the following is true?
ESR and NMR spectroscopies are related to

(A) radio and microwave regimes, respectively.

(B) radio and IR regimes respectively.

(C) microwave and radiowave regions, respectively.

(D) microwave and IR regions respectively.

59. Due to hyperfine structure, the $2p_{3/2}$ level is found to split into a doublet in case of hydrogen, and a triplet in case of deuterium. The difference can be attributed to the difference in their

(A) reduced mass

(B) nuclear mass

(C) nuclear spin

(D) proton-neutron interaction

60. The ratio of the shifts of the energy levels of $3p_{1/2}$ and $3p_{3/2}$ states of sodium atom due to spin-orbit coupling, $\dfrac{\Delta E_{3/2}}{\Delta E_{1/2}}$ is

(A) 2

(B) -2

(C) $\dfrac{1}{2}$

(D) $-\dfrac{1}{2}$

61. In presence of a weak magnetic field, B, both $p_{1/2}$ state and $S_{1/2}$ state are split into two levels each. However, the energy seperation between the doublet in two cases are not equal. $\Delta E_{p_{\frac{1}{2}}}$ and $\Delta E_{s_{\frac{1}{2}}}$ are given by

(A) $\dfrac{2}{3}\mu_B B$ and $2\mu_B B$ respectively

(B) $2\mu_B B$ and $\dfrac{2}{3}\mu_B B$ respectively

(C) $\mu_B B$ and $2\mu_B B$ respectively

(D) $2\mu_B B$ and $\dfrac{2}{3}\mu_B B$ respectively

62. The number of radial nodes in (nlm) state of hydrogen atom is

(A) n

(B) $n-l$

(C) $n-l-1$

(D) $n-l-m$

63. Raman transition between two rotational states in a homonuclear diatomic molecule takes place when ($\wedge$ and K are the electronic and rotational quantum numbers of the molecule)

(A) $\Delta \wedge = 0$ and $\Delta K = \pm 2$

(B) $\Delta \wedge = 0$ and $\Delta K = +1$

(C) $\Delta \wedge = 0$ and $\Delta K = -1$

(D) $\Delta \wedge = 0$ and $\Delta K = 0$

64. Franck Condon principle holds because

(A) the periods of nuclear motion are much longer than the periods of electronic ones.

(B) the periods of nuclear motion are much shorter than the periods of electronic ones.

(C) the periods of nuclear motion are same as the periods of electronic ones.

(D) there is as such no correlation between the periods of nuclear and electronic motion.

65. Ground state energy of a hydrogen atom is $-13 \cdot 6$ eV and if the ground state energy of a helium atom is denoted by E°_{He}. Then

(A) $-13 \cdot 6$ eV $< E^\circ_{He} < -6 \cdot 8$ eV

(B) $E^\circ_{He} = -27 \cdot 2$ eV

(C) $-27 \cdot 2$ eV $< E^\circ_{He} < -13 \cdot 6$ eV

(D) $E^\circ_{He} < -27 \cdot 2$ eV

66. The ratio of asymmetry energy of $_{20}Ca^{42}$ and $_{19}K^{40}$ is

(A) 20 : 21

(B) 20 : 19

(C) 19 : 20

(D) 19 : 21

67. If weak interaction is mediated by bosons of rest mass 80 GeV/c^2, the typical range of weak interaction will be (given, $\hbar c = 0 \cdot 2$ GeV-fm)

(A) $0 \cdot 25 \times 10^{-2}$ fm

(B) 1 fm

(C) 25 fm

(D) 400 fm

68. $K^0 (\equiv d\bar{s})$ has spin zero. Its magnetic moment in the quark model, in terms of the magnetic moments of d and s quarks, written as μ_d and μ_s respectively, is

(A) 0

(B) $\mu_d + \mu_s$

(C) $\mu_d - \mu_s$

(D) $-\mu_d - \mu_s$

69. Which of the following processes is forbidden?

(A) $K^\circ \rightarrow \pi^+ + \pi^- + \pi^\circ$

(B) $K^\circ \rightarrow \pi^+ + \pi^-$

(C) $\mu^- \rightarrow e^- + v_e + \bar{v}_\mu$

(D) $\pi^\circ \rightarrow \gamma + \gamma$

70. The $0^+ \rightarrow 0^-$ β-decay is

(A) Allowed, Fermi transition

(B) Allowed, Gamow-Teller transition

(C) First forbidden, Fermi transition

(D) First forbidden, Gamow-Teller transition

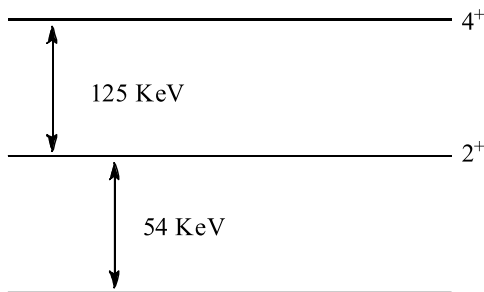**71.** The ground state spin of $_{19}K^{39}$ is

(A) $\frac{1}{2}$

(B) $\frac{3}{2}$

(C) $\frac{5}{2}$

(D) 2

72. Binding energy per nucleon saturates as one moves to heavier nuclei. This shows that nuclear force is

(A) short range

(B) charge independent

(C) spin independent

(D) a type of strong interaction

73. The first three energy levels of an even-even nucleus are shown below:

The expected spin-parity and energy of the next level are

(A) 6^+, 200 KeV

(B) 6^+, 375 KeV

(C) 2^+, 232 KeV

(D) 4^+, 448 KeV

74. Pions have isospin 1, nucleons have isospin ½ and deuteron has isospin 0. If strong interaction conserves isospin, the ratio of the cross-sections

$$\sigma\left(pp \rightarrow \pi^+ d\right) / \sigma\left(pn \rightarrow \pi^\circ d\right)$$

should be

(A) 1 : 1

(B) 2 : 1

(C) 4 : 1

(D) 1 : 2

75. The radioactive nucleus X can undergo β^- decay to Y with a half-life of 60 days, and also β^+ decay to Z with a half-life of 12 days. If you start with N_0 number of X atoms, when will you have $N_0/2$ number of X atoms?

(A) 72 days

(B) 48 days

(C) 10 days

(D) 5 days

ROUGH WORK

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