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ENTRANCE EXAMINATION, JUNE 2012

QUESTION PAPER BOOKLET

Ph.D. (PHYSICS)

Marks: 75

Time: 2.00 hrs. Hall Ticket No.: ______

I. Please enter you **Hall Ticket Number on Page 1 of this question paper and on the OMR sheet** without fail.

II. Read carefully the following instructions:

1. This Question paper has to Sections: **Section A** and **Section B**
2. **Section A** consists of 25 objective type questions of one mark each. **There is negative marking of 0.33 mark for every wrong answer.** The marks obtained by the candidate in this Section will be used for resolving the tie cases.
3. **Section B** consists of 50 objective type questions of one mark each. **There is no negative marking in this Section.**
4. Answers are to be marked on the OMR answer sheet following the instructions provided there upon. An example is shown below

   100. (A) ● (C) (D)

5. Only Scientific Calculators are permitted. Mobile phone based calculators are not permitted. Logarithmic tables are not allowed.
6. Hand over both question booklet and the OMR sheet at the end of the examination.

This book contains 22 pages

III. Values of physical constants:
$c = 3 \times 10^8$ m/s; $h = 6.63 \times 10^{-34}$ J.s; $k_B = 1.38 \times 10^{-23}$ J/K
$e = 1.6 \times 10^{-19}$ C; $\mu_o = 4\pi \times 10^{-7}$ Henry/m; $\epsilon_o = 8.85 \times 10^{-12}$ Farad/m

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SECTION -A

1. For any complex variable $z = x + iy$, the value of $|\sin z|^2$ is

   A. $\sin^2 x + \sin^2 y$
   B. $\sin^2 x + \cos^2 y$
   C. $\sin^2 x + \sinh^2 y$
   D. $\sin^2 x + \cosh^2 y$

2. The value of the integral $\int_{-\infty}^{\infty} \delta'(x) f(x)$ is

   A. $f(0)$
   B. $f'(0)$
   C. $-f'(0)$
   D. $\delta'(0)$

3. The value of the integral $\oint_c \frac{dz}{z^2 + z}$ in which the contour is a circle defined by $|z| = R > 1$ is

   A. $2\pi i$
   B. 2π
   C. 1
   D. 0

4. A particle is constrained to move on the surface of a sphere of radius R. The number of generalized coordinates required to describe the motion of the particle on the surface is

   A. 1
   B. 2
   C. 3
   D. 0

5. A rigid body consists of 6 point masses positioned at the vertices of a regular hexagon. The number of degrees of freedom the system has in the three-dimensional space is

   A. 18
   B. 12
   C. 6
   D. 4

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6. Consider the transformations: $x = r\cos\theta$; $y = r\sin\theta$. The Jacobian of the transformations is

   A. 1

   B. r

   C. r^2

   D. $r^{1/2}$

7. An electron moves in a uniform magnetic field $\boldsymbol{B} = \hat{\mathbf{z}}B$. Construct an operator $\boldsymbol{\pi} = \boldsymbol{p} - e\boldsymbol{A}/c$, where $\boldsymbol{p}$ is the electron momentum operator and $\boldsymbol{A}$ is the vector potential. Choose $\boldsymbol{A}$ in the symmetric gauge. The commutator $[\pi_x, \pi_y]$ is given by

   A. 1

   B. $i\hbar$

   C. $i\hbar(eB/c)$

   D. $i\hbar(c/eB)$

8. A system is in the following coherent superposition of angular momentum eigenstate $|l, m>$:

$$|\psi >= \alpha|1,1> + \beta|1,0> + \gamma|1,-1> .$$

   The expectation values of L^2 and L_z in this state are

   A. $2\hbar^2$ and $(\alpha^2 - \gamma^2)\hbar$

   B. $(\alpha^2 + \beta^2 - \gamma^2)\hbar^2$ and $(\alpha^2 + \beta^2 - \gamma^2)\hbar$

   C. $(\alpha^2 + \gamma^2)\hbar^2$ and $(\alpha^2 - \gamma^2)\hbar$

   D. $2\hbar^2$ and $(\alpha^2 + \beta^2)\hbar$

9. Consider the motion of a particle in a one-dimensional potential which can support many bound states. If you perform a variational calculation for the second excited state, the best choice for the trial wave function is

   A. $Ae^{-\alpha x^2 - \beta x}$

   B. $A(x-a)e^{-\alpha x^2}$

   C. $A(x-a)(x-b)e^{-\alpha x^2}$

   D. $A(x-a)e^{-\alpha(x-\beta)^2}$

10. The electric field in some region is found to vary as $\mathbf{E} = Kr^2\hat{\mathbf{r}}$, in spherical polar co-ordinate. The charge density that creates the electric field is given by

   A. $4\epsilon_o Kr$

   B. $2\epsilon_o Kr^2$

   C. $5\epsilon_o Kr^2$

   D. 0

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11. The electric field corresponding to the potentials $V(\boldsymbol{r},t)=0$ and $\boldsymbol{A}(\boldsymbol{r},t)=-\frac{1}{4\pi\epsilon_o}\frac{qt}{r^2}\,\hat{\mathbf{r}}$ is given by

   A. $\boldsymbol{E}=0$

   B. $\boldsymbol{E}=-\frac{1}{4\pi\epsilon_o}\frac{q}{r^2}\,\hat{\mathbf{r}}$

   C. $\boldsymbol{E}=\frac{1}{4\pi\epsilon_o}\frac{q}{r^2}\,\hat{\mathbf{r}}$

   D. $\boldsymbol{E}=-\frac{1}{4\pi\epsilon_o}\frac{qt}{r^2}\,\hat{\mathbf{r}}$

12. Which of the following statements is wrong?

   A. The electronic polarizability is independent of temperature.

   B. The dipolar or orientational polarizability is independent of the temperature.

   C. For a charge distribution placed in an external electric field, the total energy can be written as if the monopole moment of the charge distribution interacts with potential of the field, the dipole moment interacts with the field strength and the quadrupole moment with the field gradient.

   D. A metal is transparent to ultraviolet light.

13. The phase-space trajectory of a linear harmonic oscillator is

   A. an ellipse.

   B. a circle.

   C. a hyperbola.

   D. a rectangle.

14. Black body radiation emitted from a cavity of volume V held at temperature T has a chemical potential equal to

   A. number of photons (N)

   B. zero

   C. RT

   D. V/N

15. In a class of 30 students, there are 17 girls and 13 boys. Five are A grade students and three of these students are girls. If a student is chosen at random, what is the probability of choosing a girl or an A grade student?

   A. 19/30

   B. 11/15

   C. 17/180

   D. 19/180

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16. If $\boldsymbol{a}_1$, $\boldsymbol{a}_2$, $\boldsymbol{a}_3$ are the primitive lattice vectors in the direct lattice space and $\boldsymbol{b}_1$, $\boldsymbol{b}_2$, $\boldsymbol{b}_3$ are the primitive lattice vectors in the reciprocal lattice space, then

    A. $\boldsymbol{a}_i \cdot \boldsymbol{b}_j = 1$

    B. $\boldsymbol{a}_i \cdot \boldsymbol{b}_j = 2\pi$

    C. $\boldsymbol{a}_i \cdot \boldsymbol{b}_j = 2\pi\delta_{ij}$

    D. $\boldsymbol{a}_i \cdot \boldsymbol{b}_j = 2\pi|\boldsymbol{a}_i||\boldsymbol{b}_j|$

17. Consider a *hkl* plane in a crystal lattice. The reciprocal lattice vector $\boldsymbol{K} = h\boldsymbol{b}_1 + k\boldsymbol{b}_2 + l\boldsymbol{b}_3$

    A. is parallel to the *hkl* plane.

    B. is perpendicular to the *hkl* plane.

    C. is at angle 45° to the *hkl* plane.

    D. does not have any relation with the *hkl* plane.

18. The single particle density of states of a free electron gas in two dimension is

    A. proportional to E.

    B. proportional to $E^{1/2}$.

    C. proportional to E^2.

    D. independent of E.

    where E is the particle energy.

19. The typical lifetime associated with the excited atomic level of an atom A is 10^{-8} s. The width of the unstable energy level is

    A. 3.3×10^{-8} MeV

    B. 6.6×10^{-8} MeV

    C. 9.9×10^{-8} MeV

    D. 3.3×10^{-8} eV

20. The volume and surface energy contributions to the binding energy (B.E.) of a nucleus is

    A. $B.E = -a_1 A + a_2 A^{2/3}$

    B. $B.E. = -a_1 \frac{(N-Z)^2}{A} + a_2 A^{2/3}$

    C. $B.E. = a_1 A + a_2 A^{2/3}$

    D. $B.E. = \frac{a_1}{A^{1/3}} + a_2 A^{2/3}$

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21. Which of following symmetry is violated in weak interactions?

A. space

B. parity

C. angular momentum

D. rotation

22. Which of the following represents a spherical wave?

A. $U(r) = \frac{A_o}{r} e^{-i(k \cdot r - \omega t)}$

B. $U(r) = \frac{A_o}{r} e^{i(k \cdot r - \omega t)}$

C. $U(r) = A_o e^{i(k \cdot r - \omega t)}$

D. $U(r) = A_o e^{-i(k \cdot r - \omega t)}$

23. Testing a good diode with an ohmmeter should indicate

A. high resistance when forward or reverse biased.

B. low resistance when forward or reverse biased.

C. high resistance when reverse biased and low resistance when forward biased.

D. high resistance when forward biased and low resistance when reverse biased.

24. The primary function of the bias circuit is to

A. hold the circuit stable at bias voltage.

B. hold the circuit stable at input voltage.

C. ensure proper gain is achieved.

D. hold the circuit stable at the designed operating voltage.

25. The numerical error in the Trapezoidal rule of step size h is of the order of

A. h^3

B. h^5

C. h

D. h^2

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SECTION -B

26. Evaluate the integral $\int A \times \frac{d^2A}{dt^2}\, dt$

A. $A \times \frac{dA}{dt} + C$

B. $A.\frac{dA}{dt} + C$

C. $A.A + C$

D. $\frac{dA}{dt}.\frac{dA}{dt} + C$

27. Consider the function $f(x) = e^{-\alpha x^2}$. Its Fourier transform $g(k)$ is proportional to

A. $e^{-k^2/2\alpha}$

B. $e^{-\alpha k^2}$

C. e^{-2k^2/α^2}

D. $e^{-k^2/4\alpha}$

28. The function

$$x^3 - iy^3 + 2ix^2y - 3xy^2$$

satisfies the Cauchy Riemann equations at

A. all points in the complex plane

B. all points on the real axis

C. all points on the imaginary axis

D. at $z = 0$ only

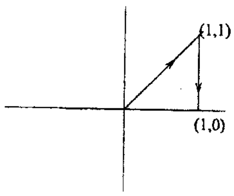
29. The value of the integral $\int_c dz\, e^z$ around the contour c in the complex z-plane shown is

A. $e - 1$

B. $2\pi i(e - 1)$

C. $-e + 1$

D. $e + e^2$



30. The integral $\oint \frac{dz}{(z-2)(z+1)}$ over a circle of radius 3 and centered at 0 is zero because

A. the integrand is analytic everywhere.

B. the integrand is not analytic, but all singular points lie outside the contour.

C. the residue at each singular point is zero.

D. the residues at singular points are nonzero, all the singular points lie inside the contour but the sum of all residues is zero.

31. If $\{P_n(x), n = 1, 2, \cdots\}$ denotes the set of Legendre polynomials satisfying the orthogonality relations

$$\int_{-1}^{1} dx P_n(x) P_m(x) = \frac{2}{2n+1}\delta_{nm}$$

then the value of the integral

$$\int_{-1}^{1} dx[P_1(x) + 2P_2(x) + 3P_3(x)]$$

is

A. 0

B. 2/3

C. 4

D. 6

32. If a Lagrangian is cyclic in a generalized coordinate q, then which of the following equations is in general true?

A. $\frac{\partial H}{\partial q} = 0$

B. $\frac{\partial L}{\partial \dot{q}} = 0$

C. $\frac{\partial H}{\partial \dot{q}} = 0$

D. $\frac{\partial L}{\partial t} = 0$

33. A particle of mass M moves on a plane in the field of force given by $\boldsymbol{F} = -\hat{\boldsymbol{r}}\, kr\cos\theta$, where k is a constant and $\hat{\boldsymbol{r}}$ is the radial unit vector. The corresponding Lagrange equation for the coordinate θ reads

A. $M\ddot{r} - Mr\dot{\theta}^2 + kr\cos\theta = 0$

B. $M\ddot{r} - Mr\dot{\theta}^2 = 0$

C. $M\ddot{r} - Mr^2\dot{\theta} = 0$

D. $\frac{d}{dt}(Mr^2\dot{\theta}) = 0$

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34. A particle of mass m moves under the action of a central force whose potential is $V(r) = kmr^2, (k > 0)$. Then for what angular momentum will the orbit be a circle of radius a?

A. $ma^2\sqrt{k}$

B. $ma^2\sqrt{ka}$

C. $ma^2\sqrt{2ka}$

D. $ma^2\sqrt{3ka}$

35. The mutual potential energy V of two particles depends on their mutual separation r as $V = \frac{a}{r^3} - \frac{b}{r}$, $a > 0$, $b > 0$. For what separation r are the particles in static equilibrium?

A. $\frac{a}{b}$

B. $\frac{2a}{b}$

C. $\frac{3a}{b}$

D. $\frac{4a}{b}$

36. A mass m moves in a circular orbit of radius r_0 under the influence of a central force whose potential is $-k/r^n$. The circular orbit will be stable under small oscillations if

A. n is less than 1.

B. n is less than 2.

C. n is greater than 2.

D. n is greater than 2 but less than 3.

37. For what values of m, n do the transformation equations: $Q = q^m \cos np$, $P = q^m \sin np$, represent a canonical transformation?

A. $m = 1$, $n = 2$

B. $m = \frac{1}{2}$, $n = 2$

C. $m = 1$, $n = \frac{1}{2}$

D. $m = \frac{1}{2}$, $n = \frac{1}{2}$

38. To minimize errors while fitting a curve to a given data the best method would be to use a

A. linear interpolation.

B. polynomial curve fitting.

C. binomial interpolation.

D. trigonometric function.

39. The Newton-Raphson method can be used to solve the following equation:

A. $x^3 - 4x^2 - x + 2 = 0$

B. $x + 2y = 3;\ 5x + 3y = 5$

C. $\frac{2}{x^3} - x + 5 = 0$

D. $x + y + z = 1;\ 4x + 3y - z = 6;\ 3x + 5y + 3z = 4$

40. A one-dimensional harmonic oscillator of mass m, charge e and frequency ω is oscillating on the x-axis about the origin. An electric field of magnitude E is applied along the positive x-axis. What is the exact energy of the first excited state of the system?

A. $\frac{3}{2}\hbar\omega - eE$

B. $\frac{3}{2}\hbar\omega - \left(\frac{eE}{2m\omega}\right)^2$

C. $\frac{3}{2}\hbar\omega - \frac{(eE)^2}{2m\omega^2}$

D. $\frac{3}{2}\hbar\omega + eE$

41. What is the expectation value of the operator $\frac{d^2}{dx^2}$ in the state $\psi = e^{-\alpha x^2}$?

A. 0

B. $\sqrt{\pi/\alpha}$

C. $\left(-\sqrt{\frac{\pi\alpha}{2}}\right)$

D. $2\sqrt{\pi}(\sqrt{\alpha} - 1)$

42. Consider the motion of a particle in a one-dimensional box of length L. The energy difference between any two consecutive energy levels is proportional to

A. $\frac{1}{L}$

B. $\frac{1}{L^2}$

C. $\frac{1}{L^3}$

D. $\sin(\pi/L)$

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43. Consider the quantum mechanical Hamiltonian

$$H = \frac{p_1^2}{2m} + \frac{p_2^2}{2m} + \frac{1}{2}m\omega^2(x_1^2 + x_2^2) + \lambda(x_1^2 + x_2^2).$$

What is the exact ground state energy of this system?

A. $\hbar\omega\left(1 + \frac{2\lambda}{m\omega^2}\right)^{1/2}$

B. $\hbar\omega + \lambda\omega^2$

C. $(1 + \lambda)\hbar\omega$

D. $\hbar\omega\left(1 + \frac{\lambda}{m\omega^2}\right)^{1/2}$

44. A one-dimensional simple harmonic oscillator described by the Hamiltonian

$$H = \frac{p^2}{2m} + \frac{1}{2}m\omega^2 x^2$$

is subjected to a small interaction potential $H_I = \frac{\lambda}{x^2+a^2}$, where λ and a are constants and $a \ll \sqrt{\hbar/m\omega}$. The correction to the ground state energy of the oscillator to first order in λ is

A. $\frac{\lambda}{a}\sqrt{\frac{m\omega\pi}{\hbar}}$

B. $\sqrt{\frac{\lambda}{a}\frac{m\omega\pi}{\hbar}}$

C. $\frac{\lambda\hbar}{am}$

D. 0

45. Consider the Hamiltonian:

$$H = -\frac{\hbar^2}{2m}\frac{d^2}{dx^2} + \frac{1}{2}m\omega^2 x^2.$$

You are asked to use the Rayleigh-Ritz variational theory to obtain the ground state energy of this Hamiltonian with a trial function $Ae^{-\alpha x^2}$. The result is

A. $\frac{1}{2}\hbar\omega$

B. $\frac{1}{\sqrt{2}}\hbar\omega$

C. $\frac{3}{2}\hbar\omega$

D. $\hbar\omega$

where α is a real positive number and A is the normalization constant.

46. An ideal gas of particles, each of mass m at temperature T is subjected to a uniform gravitational field of acceleration due to gravity "g". The average potential energy per particle is

A. $\frac{1}{2}k_BT$

B. gk_BT/m

C. mgk_BT

D. k_BT

47. A classical system of N distinguishable and non-interacting particles of mass m is placed in a three-dimensional harmonic well $U(r) = r^2/2V^{2/3}$ where V is a constant. The Helmholtz free energy of the system is proportional to

A. $-Nk_BTlnV$

B. $-Nk_BTV^{2/3}$

C. $-NVk_BTlnV$

D. $-Nk_BTe^{lnV/V}$

48. The canonical partition function of N non-interacting quantum mechanical harmonic oscillators of frequency ω in three dimensions is given by

A. $1/(e^{\hbar\omega/2k_BT} + e^{-\hbar\omega/2k_BT})^{3N}$

B. $1/(e^{\hbar\omega/k_BT} + e^{-\hbar\omega/k_BT})^{3N}$

C. $1/(e^{\hbar\omega/2k_BT} + e^{-\hbar\omega/2k_BT})^{N}$

D. $1/(e^{\hbar\omega/k_BT} + e^{-\hbar\omega/k_BT})^{N}$

49. A system of particles (N) can occupy two energy levels $+\epsilon$ and $-\epsilon$. If N_+ be the number of particles in $+\epsilon$ and N_- is the number in $-\epsilon$, the entropy of the system is given by

A. $S = k_B[N \ln N - N_+ \ln N_+ - N_- \ln N_-]$

B. $S = k_B[N \ln N - N]$

C. $S = k_B[N_+ \ln N_+ - N_- \ln N_-]$

D. $S = k_B[2N - N \ln N]$

50. A system of N particles at temperature T can occupy only two orbitals of energies zero and ϵ. The Helmholtz free energy of the system is

A. $k_BT \ln(1 + e^{\beta\epsilon})$.

B. $-k_BT \ln(1 + e^{-\beta\epsilon})$.

C. $-Nk_BT \ln(1 + e^{-\beta\epsilon})$.

D. $Nk_BT \ln(1 + e^{-\beta\epsilon})$.

where $\beta = \frac{1}{k_BT}$.

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51. The electronic specific heat at low temperature T is

A. independent of T.

B. proportional to $T^{1/2}$.

C. proportional to T.

D. proportional to T^2.

52. For a constant and uniform magnetic field of strength B applied in the z-direction, the vector potential in the Landau gauge is given by

A. $(-Bx, By, 0)$

B. $(-By/2, Bx/2, 0)$

C. $(0, Bx, 0)$

D. $(0, 0, Bz)$

53. A distribution of electric charge is spherically symmetric about an origin O. If the total charge within the sphere of radius r about the center O is equal to $r^2(e^{-r} - e^{-2r})$, the potential can be written as

A. $\left(e^{-r} - \frac{e^{-2r}}{2}\right)$

B. $\left(e^{-r} - e^{-2r}\right)$

C. $\left(e^{-r} - e^{-2r}\right) r^2$

D. $\left(e^{-2r} - e^{-r}\right)/2$

54. Three point charges are located at the following places: $2q$ at $(0, 1, 0)$; q at $(0, -1, 1)$ and $-q$ at $(0, 0, -1)$. The dipole potential at $(0, 0, z)$ (for $z \gg 1$) is given by

A. $\frac{q}{\pi \epsilon_o z}$

B. $\frac{q}{\pi \epsilon_o z^2}$

C. $\frac{2q^2}{\pi \epsilon_o z^2}$

D. $\frac{2q^2}{\pi \epsilon_o z}$

55. If the surface current density in the $x - y$ plane is given by $\boldsymbol{J}(x, y) = (\hat{\imath}x^2 + \hat{\jmath}y^2)$, then the charge density will change with time at the rate of

A. $2(x + y)$

B. $(x - y)$

C. $-(x - y)$

D. $-2(x + y)$

56. A point charge $-e$ of unit mass is situated inside a unit sphere filled with a uniform distribution of total positive charge e. The point charge will oscillate simple harmonically with a period

A. $2\pi e$

B. $\pi e^2/2$

C. $2\pi/e$

D. $2\pi/e^2$

57. The primitive translation vectors of the hexagonal space lattice may be taken as

$$\mathbf{a}_1 = (3^{1/2}a/2)\hat{\mathbf{x}} + (a/2)\hat{\mathbf{y}} \;\; ; \;\; \mathbf{a}_2 = -(3^{1/2}a/2)\hat{\mathbf{x}} + (a/2)\hat{\mathbf{y}} \;\; ; \;\; \mathbf{a}_3 = c\hat{\mathbf{z}} \; .$$

The third component of the primitive translations of the reciprocal lattice is given by

A. $a\hat{\mathbf{z}}$

B. $\frac{c}{2}\hat{\mathbf{z}}$

C. $c\hat{\mathbf{x}}$

D. $c\hat{\mathbf{z}}$

58. Consider a vibrating solid. The Helmholtz free energy of a phonon mode of frequency ω at temperature T is given by

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

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

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

D. $\frac{3}{2}k_BT\left[\frac{\hbar\omega}{k_BT} + \ln(1 - e^{-\hbar\omega/k_BT})\right]$

59. Consider the presence of point defects in the form of vacancies in thermal equilibrium in a monatomic simple cubic crystal of N sites. What is the number of such defects in the solid at temperature T if it costs an energy E to create one vacancy. Assume $k_BT \ll E$.

A. $Ne^{-E/2k_BT}$

B. NE/k_BT

C. $Ne^{-k_BT/E}$

D. Ne^{-E/k_BT}

60. The number of optical phonon branches for a three-dimensional lattice containing N unit cells with each cell containing r atoms equals

A. 3

B. r

C. $3r$

D. $3r - 3$

61. Assume that the energy E vs. $\boldsymbol{k}$ relationship for electrons in the conduction band of a crystal can be approximated by $E = ak^2$+constant. It is found that the cyclotron resonance for electrons of the crystal in a magnetic field $B = 0.1 Weber/m^2$ occurs at $\omega_c = 1.8 \times 10^{11} rad/sec$. What is the value of a?

A. $6.2 \times 10^{-20} Jm^2$

B. $6.2 \times 10^{-60} Jm^2$

C. $6.2 \times 10^{-18} Jm^2$

D. $6.2 \times 10^{-38} Jm^2$

62. For low energy nucleon-nucleon scattering the singlet and triplet scattering lengths are given as $a_s = -24$ fm. and $a_t = 6$ fm. The scattering cross section is given as

A. 14.3 b

B. 21.5 b

C. 15.2 b

D. 1.56 b

63. The total absorption coefficients for 5 MeV photons in lead is about 0.45 cm^{-1}. What thickness of lead would be required to reduce the intensity of such photons to 0.06 of the initial value

A. 6.25 cm

B. 62.5 cm

C. 0.625 cm

D. 0.0625 cm

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64. Consider the α-decay of ${}^{240}_{94}Pu$:

$$ {}^{240}_{94}Pu \longrightarrow {}^{236}_{92}U + {}^{4}_{2}He. $$

The emitted α particles are observed to have energies of 5.17 MeV. The Q value of the process is

A. 5.26 MeV

B. 5.17 MeV

C. 5.10 MeV

D. 5.36 MeV

65. An atom of mass M can be excited to a state of mass $M + \Delta$ by photon capture. The frequency of the photon which can cause this transition is

A. $\Delta C^2/2h$

B. $\Delta C^2/h$

C. $\Delta^2 C^2/2Mh$

D. $\Delta(\Delta + m)C^2/2Mh$

66. An electron of momentum 0.511 MeV/c is observed in the laboratory. What are its β and $\gamma = (1 - \beta^2)^{-1/2}$ values?

A. $\beta = 1/\sqrt{2}$, $\gamma = \sqrt{2}$

B. $\beta = \sqrt{2}$, $\gamma = 1/\sqrt{2}$

C. $\beta = 2$, $\gamma = 1/2$

D. $\beta = 1/2$, $\gamma = 2$

67. The minimum energy that a photon must have in the collision with an electron at rest, in order to produce a positron through the following reaction $\gamma + e^- \rightarrow e^- + e^+ + e^-$ is

A. $m_e c^2$

B. $2m_e c^2$

C. $3m_e c^2$

D. $4m_e c^2$

68. For a system in thermal equilibrium what is the temperature at which the spontaneous and stimulated emission rates are equal for a wavelength of 500 nm?

A. 41562 K

B. 415.62 K

C. 4.16×10^5 K

D. 0.416 K

69. The interference equation given by

$$I = 2I_o[1 + \cos(k \sin\theta x)]$$

represents

A. interference of two equal intensity oblique plane waves.

B. interference of two collinear plane waves.

C. interference of two spherical waves.

D. interference of a plane wave and a spherical wave.

70. The influence of the magnetic field on the spectral structure of the prominent yellow light ($\lambda \sim 6000\mathring{A}$) from excited sodium vapour is being examined. The spectrum is observed for light emitted in a direction perpendicular to the magnetic field, using a spectroscope of resolution 1×10^5. What is the magnetic field required to resolve clearly the splitting of lines by the magnetic field?

A. 0.3 T

B. 0.03 T

C. 0.6 T

D. 0.06 T

71. A linearly polarised wave is incident at the Brewster angle on a glass slab with the plane of polarization perpendicular to the plane of incidence. The reflected wave is

A. Linearly polarised.

B. left circularly polarised.

C. right circularly polarised.

D. elliptically polarised.

72. Synchronous counters eliminate the delay problems encountered with asynchronous counters because the

A. input clock pulses are applied only to the first and last stages.

B. input clock pulses are applied only to the last stage.

C. input clock pulses are not used to activate any of the counter stages.

D. input clock pulses are applied simultaneously to each stage.

73. When a MOD 5 counter is cascaded with MOD 3 counter, the overall MOD number is equal to

A. 15

B. 8

C. 2

D. log(15)

A -59

74. An op-amp comparator has a gain of 100,000. If an input voltage difference of 0.2 mV above reference is applied with a supply of 12 V, then the output of the comparator is

A. 20 V

B. 12 V

C. 10 V

D. 15 V

75. If a 4-bit Analog to Digitial converter (ADC) has a reference of 5 volts, its resolution is

A. 0.3125 V

B. 3.125 V

C. 0.78125 V

D. -3.125 V