D.U. M.Sc. PHYSICS ENTRANCE - 2015 (Series - A)

Time : 3 Hours **M. Marks: 300**

Instructions:

(*i*) This test booklet contains 75 Objective type questions.

(*ii*) Each question carries **4 marks**. **1 mark** will be deducted for each incorrect answer. Only one box should be marked and the marking of more than one box will be treated as wrong answer.

1. A free electron and a free proton of the same energy have their de Broglie wavelengths in the ratio

(a) $\lambda_e/\lambda_p = (m_p/m_e)^{1/2}$ (b) $\lambda_e/\lambda_p = (m_e/m_p)^{1/2}$

(c) $\lambda_e/\lambda_p = (m_p/m_e)$ (d) $\lambda_e/\lambda_p = (m_e/m_p)$

2. The wave function of the particle is given by a linear combination of two of its energy states ψ_1 and ψ_2 (with energy eigen values E_1 and E_2 respectively) as $\psi = \psi_1/a + \psi_2/b$. If a measurement of energy is made, the probability of finding particle energy to be E_1 is

(a) $|b|^2/[|a|^2+|b|^2]$ (b) $|a|^2/[|a|^2+|b|^2]$

(c) $b/(a+b)$ (d) $a/(a+b)$

3. A particle of mass *m* is in a one-dimensional potential given by $V(x) = \infty$ for $x < 0$ and $V(x) = kx^2/2$ for $x > 0$. The first excited state has an energy

(a) $(3/2)\hbar\sqrt{(k/m)}$ (b) $(7/2)\hbar\sqrt{(k/m)}$

(c) $(1/2)\hbar\sqrt{(k/m)}$ (d) $(5/2)\hbar\sqrt{(k/m)}$

4. The wave function for a particle is given by $\psi = Ae^{-|x|}$, where A is a constant. This implies that the potential

(a) is differentiable everywhere

(b) is continuous everywhere but not differentiable at $x = 0$

(c) has discontinuity at $x = 0$

(d) has discontinuities at $x = \pm 1$ but differentiable every else

5. The electric field E and magnetic field B in frame 1 are parallel and related by $E = cB$. If the electric and magnetic fields in another frame are E' and B' respectively, the angle *x* between E' and B' is given by $\cos(x)$ equals,

(a) B/B' (b) B'/B (c) $(B/B')^{1/2}$ (d) $(B'/B)^{1/2}$

6. A linearly polarized electromagnetic wave is incident on a quarter wave plate. The emerge wave will in general be
(a) linearly polarized
(b) elliptically polarized
(c) unpolarized
(d) mixture of linearly polarized and unpolarized wave

7. The magnitude of the Poynting vector gives the
(a) energy transported per unit area per unit time
(b) energy density of the electromagnetic wave
(c) angular momentum density of the electromagnetic wave
(d) angular momentum transported per unit area per unit time

8. An unpolarized ray of light in a medium with refractive index n_1 is incident on a plane glass surface with refractive index $n_2(n_2 > n_1)$. The intensity of the reflected light is minimum when the angle of incidence i is given by
(a) $\tan(i) = n_1 / n_2$ (b) $\tan(i) = n_2 / n_1$
(c) $\tan(i) = 1 / n_1 n_2$ (d) $\tan(i) = n_1 n_2$

9. Assuming LS coupling, the lowest energy level for carbon (Z = 6) is
(a) $^1S_0$ (b) $^3P_0$ (c) $^1D_2$ (d) $^1S_1$

10. Rutherford bombarded 7.7 MeV α particles on $^{14}N_7$ to initiate the nuclear reaction $^{14}N(\alpha, p)^{17}O$. The height of Coulomb barrier faced by α particle is about (Given r_o = 1.2 fm)
(a) 10.6 MeV (b) 2.1 MeV (c) 4.2 MeV (d) 8.4 MeV

11. Based on liquid drop model, the most stable nucleus for isobars of A = 75 has proton number (Z) equal to (Given: a_c = 0.7 MeV and a_s = 23.0 MeV)
(a) 28 (b) 33 (c) 35 (d) 37

12. The probability of electrons being captured by the nucleus is maximum for
(a) K shell electrons
(b) L shell electrons
(c) M shell electrons
(d) Electrons in outermost orbits, independent of which shell they come from

13. An electronic device exhibiting a negative resistance characteristic is the
(a) Zener diode (b) UJT (c) JFET (d) BJT

14. Role of the resistance (R_E) connected with the Emitter of an NPN transistor in the CE amplifier circuit is
(a) to fix the Q point at the center of the load line
(b) to increase the bandwidth of the amplifier
(c) to provide a path to the ac signal to ground
(d) to provide a negative feedback for dc bias stabilization

15. The *n*-channel JFET having pinch-off voltage of –5V shows a transconductance of 1mA/V when the applied gate to source voltage (V_{GS}) is –3V. The maximum value of transconductance (in mA/V) for JFET will be
(a) 1.5 (b) 2.0 (c) 2.5 (d) 3.0

16. The ideal OP-AMP with input resistance R_i, output resistance R_o and gain A, has

(a) $R_i = \infty,\ A = \infty,\ R_o = 0$ (b) $R_i = 0,\ A = \infty,\ R_o = 0$

(c) $R_i = \infty,\ A = \infty,\ R_o = \infty$ (d) $R_i = 0,\ A = \infty,\ R_o = \infty$

17. The information in STACK in 8085 microprocessor follows

(a) FIFO (b) LIFO (c) FILO (d) random access

18. The T-states required for the opcode fetch in 8085 microprocessor and the execution time required for opcode fetch if the clock frequency is 2 MHz are respectively.

(a) $4T,\ 2\mu s$ (b) $8T,\ 4\mu s$ (c) $2T,\ 2\mu s$ (d) $8T,\ 2\mu s$

19. Assume the accumulator content in 8085 microprocessor is 00H and flag Z = 1. The content of accumulator (A) and Z flag after the execution of instruction MVI A, 05H are

(a) A = 05H, Z = 1 (b) A = 05H, Z = 0

(c) A = 00H, Z = 1 (d) A = 00H, Z = 0

20. Which of the following is not an infinite loop?

(a)
```
int i =1;
while (1)
{
i++;
}
```
(b)
```
for (;;);
```
(c)
```
int True = 0, False;
while (True)
{
False = 1;
}
```
(d)
```
int y, x = 0;
do
{
y = x;
} while (x == 0);
```

21. For the equation $x^3 - 2x - 5 = 0$ the solution by Newton Rapshon Method is about (Given x_0 = 2)

(a) 2.09983 (b) 2.07065

(c) 2.09455 (d) 2.14122

22. The real root of the equation $\cos x - 3x + 1 = 0$ corrected to four decimal places by the method of iteration is about

(a) 0.8071 (b) 0.6024

(c) 0.7214 (d) 0.6071

23. It is known that the root of the function $f(x)$ lies between 0 and 1. After 10 iterations of the bisection method, the approximate accuracy of the root will be

(a) correct up to 2 places of decimal (b) correct up to 3 places of decimal

(c) correct up to 4 places of decimal (d) correct up to 5 places of decimal

24. The order of truncation error in second-order Runge-Kutta method for finding the solution of ordinary differential equations is

(a) 1 (b) 2 (c) 3 (d) 4

25. During inelastic collision of two bodies, which of the following is conserved?

(a) total linear momentum only (b) total kinetic energy only

(c) both linear momentum and kinetic energy (d) neither linear momentum nor kinetic energy

26. An earth satellite is kept moving in its orbit by the centripetal force provided by
(a) the gravitational attraction of the earth on the satellite
(b) the rocket engine attached to the satellite
(c) the gravitational attraction of the sun on the satellite
(d) the radio waves sent by the ground station to the satellite

27. A sphere rolls on a horizontal plane without slipping. The percentage of kinetic energy which is rotational is about
(a) 58% (b) 50% (c) 18% (d) 28%

28. A muon, whose life-time at rest is 2×10^{-6} sec, is travelling through the laboratory at three-fifth of the speed of light. It will last in
(a) 2×10^{-6} sec (b) 2.5×10^{-6} sec (c) 3.5×10^{-6} sec (d) 3.0×10^{-5} sec

29. In an AC circuit, the voltage V and current I are given by:
$V = 100 \sin(100t)$ volts
$I = 100 \sin(100t + \pi/3)$mA
The power dissipated in the circuit is
(a) 10^4 W (b) 10 W (c) 2.5 kW (d) 2.5 W

30. When a test charge is brought in from infinity along the perpendicular bisector of an electric dipole, the work done is
(a) positive (b) negative (c) zero (d) infinity

31. The ratio of magneto-motive force round the circuit to the magnetic flux is referred as
(a) reactance (b) conductance (c) resistivity (d) reluctance

32. A conducting circular loop is placed in a uniform magnetic field B = 0.04 T with its plane perpendicular to the field. Somehow the radius of the loop starts shrinking at a constant rate of 0.5 mm/sec. The induced emf in the loop at an instant, when the radius is 2cm, will be
(a) 5.0 μV (b) 2.5 μV (c) 10.0 μV (d) 25.0 μV

33. Consider a Boolean expression $F = (B + BC)(B + \bar{B}C)(B + D)$
The minimum number of NAND gates required to implement this 'F' will be
(a) 0 (b) 2 (c) 3 (d) 4

34. The number of comparators in a 4-bit flash A to D converter is
(a) 4 (b) 5 (c) 15 (d) 16

35. The functional difference between SR flip-flop and JK flip-flop is that
(a) JK flip-flop has a feedback path
(b) JK flip-flop can accept both inputs as 1
(c) JK flip-flop does not require an external clock pulse
(d) JK flip-flop is faster than SR flip-flop

36. The binary number corresponding to a decimal number 9.625 can be expressed as
(a) 1100.101 (b) 1001.110 (c) 1001.101 (d) 1100.011

37. The velocity of a traveling wave on a string under fixed tension
(a) does not change when frequency varies (b) does not change when wavelength varies
(c) decrease with increase of frequency (d) decrease with decrease in wavelength

38. Two springs of force constant K_1 and K_2 are arranged in a parallel arrangement and a mass '*m*' is suspended from it. The arrangement is equivalent to a single spring of constant K given by
(a) $K_1 - K_2$ (b) $K_1 + K_2$ (c) $K_1K_2/(K_1 + K_2)$ (d) K_1/K_2

39. Two vibrating strings of lengths L and 3L and radii 3R and R, respectively, are stretched under the same tension. Both the strings vibrate in their fundamental modes, the one of length L with frequency ν_1 and the other with frequency ν_2. If the two strings are made of same material then the ratio ν_1/ν_2 is given by

(a) 1 (b) $3^{1/2}$ (c) 3 (d) 9

40. In a standing wave, the phase difference between any two points confined between adjacent node and antinode

(a) is always zero (b) is between $\pi/4$ and $\pi/2$

(c) is between $\pi/2$ and π (d) changes periodically

41. If 'Z' is the atomic number and 'A' is the atomic weight of the element then according to Moseley's law, the frequency of the characteristic x-ray is proportional to

(a) Z^2 (b) A^2 (c) $Z^{3/2}$ (d) $A^{1/2}\ Z^{1/3}$

42. In M.K.S units, Bohr magneton is given by

(a) em/4h (b) $eh/2\pi m$ (c) $eh/4\pi m$ (d) $mh/2e\pi$

43. The typical wavelengths emitted by diatomic molecules in pure vibrational and pure rotational transitions are respectively in the region of

(a) infrared and visible (b) visible and infrared

(c) infrared and microwave (d) microwave and infrared

44. The value of Einstein's coefficient A_{21} for a two level atomic system is 4×10^2 sec^{-1}. The spontaneous life time is

(a) 5×10^{-2} sec (b) 2.5×10^{-3} sec

(c) 5×10^{-3} sec (d) 2.5×10^{3} sec

45. Two lenses of power +5D and –2D are in contact and are coaxially situated. The power of the combination is

(a) –3D (b) +3D (c) –7D (d) +7D

46. When a liquid is introduced between the lens and the plate in the Newton Ring apparatus, the diameter of the 15th ring changes from 2cm to 1.8cm. The refractive index of the liquid is

(a) 1.05 (b) 1.11 (c) 1.23 (d) 1.33

47. When the movable mirror of the Michelson interferometer is moved through a distance of 0.030 mm under the illumination of a wavelength 6000Å, the number of displaced fringes is

(a) 0 (b) 10 (c) 100 (d) 600

48. A beam of light of wavelength 600 nm from a distant source falls on a single slit 1.00 mm wide and the resulting diffraction pattern is observed on a screen 2m away. The distance between the first dark fringe on either side of the central maximum is

(a) 0.6 mm (b) 1.2 mm (c) 1.8 mm (d) 2.4 mm

49. The spectroscopic Lande g-factor for a state $^2P_{1/2}$ is

(a) 1 (b) 2/3 (c) 3/2 (d) 2

50. The Debye temperature of a metal is 450 K. Its Debye frequency in Hz is of the order of

(a) 10^{11} (b) 10^{13} (c) 10^{16} (d) 10^{20}

51. In the Davission-Germer experiment, the hump is most prominent when the electron is accelerated by

(a) 24V (b) 34V (c) 54V (d) 64V

52. The susceptibility of a diamagnetic material is about

(a) -10^{-5} (b) 10^{-7} (c) 10^{2} (d) 10^{3}

53. If σ and E are the electrical conductivity and the applied field respectively, the heat developed across a conductor per unit volume per second is

(a) σE^2 (b) $\sigma^2 E$ (c) σ / E (d) E^2/σ

54. Transition temperature T_c and critical field H_c for a superconductor are related as

(a) $H_c = H_0\left[1-\frac{T}{T_c}\right]$ (b) $H_c = H_0\left[\frac{T}{T_c}-1\right]$

(c) $H_c = H_0\left[1-\left(\frac{T}{T_c}\right)^2\right]$ (d) $H_c = H_0\left[\left(\frac{T}{T_c}\right)^2-1\right]$

55. The vapour pressure (p), in mm of Hg, of solid ammonia is given by the relation:
ln p = 23.01 – (3754/T), where T is the absolute temperature. The vapour pressure, in mm of Hg, of liquid ammonia is given by the relation ln p = 19.49 – (3063/T). The temperature of the triplet point is about

(a) 191.3 K (b) 196.3 K (c) 206.3 K (d) 296.3 K

56. The 10g of ice at 0ºC is converted into water at the same temperature. Take latent heat of fusion as 80 cal/g. The change in entropy in cal/K is about

(a) zero (b) 0.34 (c) 2.93 (d) 3.92

57. A quantity of dry air at 27ºC is compressed suddenly to one-third of its volume. Take γ to be 1.5 for dry air. Change in temperature of the gas is about

(a) 179K (b) 199K (c) 209K (d) 219K

58. Assume that each copper atom contributes one free electron to the electron gas. The density of copper is 8.94×10^3 kg/m^3 and its atomic mass is 63.5 amu. The Fermi energy (in joule) in copper is of the order of

(a) 10^{-18} (b) 10^{-13} (c) 10^{13} (d) 10^{18}

59. The entropy of the system in statistical mechanics is defined as (k is the Boltzmann constant and Ω is the number of microstates accessible to the system)

(a) $S = k\ln\Omega$ (b) $S = (k/2)\ln\Omega$ (c) $S = 2k\ln\Omega$ (d) $S = k^2\ln\Omega$

60. If E_1 is the energy of the lowest state of a one-dimensional potential box of length 'a' and E_2 is the energy of the lowest state when the length of the box is 'a/2', then

(a) $E_2 = 2E_1$ (b) $E_2 = E_1/2$ (c) $E_2 = E_1/4$ (d) $E_2 = 4E_1$

61. The white dwarf stars are stable due to

(a) electron degeneracy pressure
(b) gravitational attraction
(c) heat generated by fusion against gravitational collapse
(d) fission

62. Let $\vec{r} = \hat{x}r\cos\omega t + \hat{y}r\sin\omega t$. For constant r and ω, calculate $\vec{r}x\frac{d\vec{r}}{dt}$.

(a) $r^2\omega\hat{x}$ (b) $r^2\omega\hat{y}$ (c) $r^2\omega\hat{z}$ (d) $r^2\omega\cos(2\omega t)\hat{z}$

63. The integral $\int_{-\infty}^{+\infty} x^{2n}e^{-x^2}dx$ is equal to

(a) $\Gamma(n+1)$ (b) $\Gamma(n-1)$ (c) $\Gamma\left(n-\frac{1}{2}\right)$ (d) $\Gamma\left(n+\frac{1}{2}\right)$

64. Let $F(\omega)$ be the Fourier transform of $f(t)$ and $G(\omega)$ be the Fourier transform of $g(t) = f(t+a)$. The $G(\omega)$ and $F(\omega)$ are related with one another as

(a) $G(\omega) = e^{-i(a+t)\omega}F(\omega)$ (b) $G(\omega) = e^{-ia\omega}F(\omega)$

(c) $G(\omega) = e^{+i\omega t}F(\omega)$ (d) $G(\omega) = e^{+i\omega(t+a)}F(\omega)$

65. A finite amount of heat released at $t = 0$ spreads uniformly in all directions from the origin in a medium initially at zero temperature everywhere. The spatial and temporal temperature distribution is given as $\frac{c}{\sqrt{t^3}}e^{-r^2/(4a^2t)}$ where a and C are some constants. The time it takes for the temperature at distance 'r' from the origin to attain its maximum value, is

(a) $\frac{r^2}{6a^2}$ (b) $\frac{r^2}{4a^2}$ (c) $\frac{3r^2}{8a^2}$ (d) $\frac{r^2}{a^2}$

66. The Euler-Lagrangian equation for a system is given as $\ddot{x} = -\gamma\dot{x} - \frac{k}{m}$. Which of the following Lagrangians will describe this system?

(a) $L = \frac{1}{2}\exp(\gamma t)(m\dot{x}^2 - kx^2)$ (b) $L = \frac{1}{2}\exp(\gamma t)(m\dot{x}^2 - kx^2)$

(c) $L = \frac{1}{2}\exp(-\gamma t)(m\dot{x}^2 + kx^2)$ (d) $L = \frac{1}{2}\exp(-\gamma t)(m\dot{x}^2 - kx^2)$

67. The imaginary part of an analytic function in Cartesian coordinate is $2xy$. The real part is given by

(a) $x^2 + y^2 = a^2$ (b) $x^2 - y^2 = a^2$

(c) $-x^2 + y^2 = a^2$ (d) $-x^2 - y^2 = a^2$

68. The Laurent series of a function $f(z)$ about $z = 2$ is given by

$$f(z) = \frac{1}{2(z-2)^3} - \frac{1}{4(z-2)^2} + \frac{1}{8(z-2)} - \frac{1}{16} + \frac{z-2}{32} - .....$$

The order of the pole and the value of the residue are

(a) Order = 3 and Residue = $\frac{1}{2}$ (b) Order = 2 and Residue = $-\frac{1}{4}$

(c) Order = 1 and Residue = $\frac{1}{8}$ (d) Order = 3 and Residue = $\frac{1}{8}$

69. The Bessel function $J_1(x)$ has its first zero at x = 3.8317. The intensity of light of wavelength λ in the diffraction pattern from a circular aperture of size 'a' at angle α is proportional to $\left\{J_1\left(\frac{2\pi a}{\lambda}\sin\alpha\right)\right\}^2$. The angle α at which the intensity will fall to zero for a typical wavelength of 5.5×10^{-7} m and a = 0.5cm, is about

(a) 14 sec (b) 23 minutes (c) 24 degrees (d) 7 radians

70. Which of the following statements is true for a square matrix A?

(a) If $A^2 = 0$, it necessarily implies that A = 0

(b) If A is real and orthogonal, its eigenvalues will always be real

(c) If A is hermitian, its diagonal entries are always real

(d) If A is anti-hermitian (skew-hermitian), its diagonal entries are always zero

71. The magnitude of $\oint \vec{r} \times \overrightarrow{dr}$ over the perimeter of an ellipse described by $\vec{r} = \hat{x}a\cos\theta + \hat{y}b\sin\theta$, is

(a) $\pi ab/2$ (b) πab (c) $2\pi ab$ (d) ab

72. In which quadrants of the complex plane, is the function $f(z) = |x| - i|y|$ analytic?

(a) Only in the fourth quadrant

(b) Only in the first and third quadrants

(c) Only in the second and fourth quadrants

(d) In all the quadrants

73. The Laplace transforms $L\{f(t)\} = \int_0^\infty e^{-st} f(t)dt$ of $\cos h(kt)$ and $\sin h(kt)$ are given as

(a) $L\{\cos h\, kt\} = \dfrac{k}{s^2 + k^2}$ and $L\{\sin h\, kt\} = \dfrac{s}{s^2 + k^2}$

(b) $L\{\cos h\, kt\} = \dfrac{s}{s^2 + k^2}$ and $L\{\sin h\, kt\} = \dfrac{k}{s^2 + k^2}$

(c) $L\{\cos h\, kt\} = \dfrac{k}{s^2 - k^2}$ and $L\{\sin h\, kt\} = \dfrac{s}{s^2 - k^2}$

(d) $L\{\cos h\, kt\} = \dfrac{s}{s^2 - k^2}$ and $L\{\sin h\, kt\} = \dfrac{k}{s^2 - k^2}$

74. A vector C_i and a tensor C_{jk} are related as $C_i = \frac{1}{2} \epsilon_{ijk} C_{jk}$ where ϵ_{ijk} is the Levi-Civita symbol. The tensor C_{jk} is given by

(a) $\begin{pmatrix} 0 & C_3 & C_2 \\ C_3 & 0 & C_1 \\ C_2 & C_1 & 0 \end{pmatrix}$

(b) $\begin{pmatrix} 0 & C_3 & C_2 \\ -C_3 & 0 & -C_1 \\ -C_2 & C_1 & 0 \end{pmatrix}$

(c) $\begin{pmatrix} 0 & -C_3 & C_2 \\ C_3 & 0 & C_1 \\ -C_2 & -C_1 & 0 \end{pmatrix}$

(d) $\begin{pmatrix} 0 & C_3 & -C_2 \\ -C_3 & 0 & C_1 \\ C_2 & -C_1 & 0 \end{pmatrix}$

75. Under a rotation by an angle θ about the x-axis, the vector that remains invariant is

(a) $2\hat{x} - \hat{y} + \hat{z}$ (b) $3\hat{z}$ (c) $5\sqrt{2}\hat{x}$ (d) $\sqrt{3}\hat{y}$