

P.G. ENTRANCE EXAMINATION, APRIL 2024

PHYSICS/RADIATION PHYSICS/PHYSICS (NANOSCIENCE)

Time : Two Hours

Maximum : 400 Marks

*Each question carries 4 marks.**1 mark will be deducted for each wrong answer.*

1. If M is the mass of a sphere with radius a , the moment of inertia about a diameter is

(a) $\frac{4}{5} M a^2$.

(b) $\frac{3}{5} M a^2$.

(c) $\frac{1}{5} M a^2$.

(d) $\frac{2}{5} M a^2$.

2. The magnitude of the escape velocity from the surface of the earth is :

(a) 19.2 km/s.

(b) 17.2 km/s.

(c) 11.2 km/s.

(d) 10.2 km/s.

3. If the force of attraction on the surface of the earth is equal to its weight then :

(a) $GM = gR^2$.

(b) $GM = gR^3$.

(c) $GM = gR^4$.

(d) $GM = gR$.

4. If a simple pendulum is taken inside a mine the period :

(a) Has no change.

(b) Increases.

(c) Decreases.

(d) Becomes infinite.

5. When a planet moves around the sun, then :

(a) Areal velocity is constant.

(b) Linear velocity is constant.

(c) Angular velocity is constant.

(d) None.

Turn over

6. The momentum of an electron of mass m which has the kinetic energy as its rest mass energy is :
- (a) $\sqrt{2}mc$. (b) $\sqrt{4}mc$.
(c) $\sqrt{3}mc$. (d) $\sqrt{5}mc$.
7. If T is the kinetic energy and V is the potential energy Lagrangian L is :
- (a) $L = T - V$. (b) $L = T + V$.
(c) $L = T/V$. (d) $L = T^V$.
8. If T is the kinetic energy and V is the potential energy Hamiltonian H is :
- (a) $H = T - V$. (b) $H = T + V$.
(c) $H = T/V$. (d) $H = T^V$.
9. Homogeneity of time leads to conservation of :
- (a) Parity. (b) Linear momentum.
(c) Energy. (d) Angular momentum.
10. A rigid body moving freely in space has _____ degrees of freedom.
- (a) 3. (b) 6.
(c) 9. (d) 4.
11. Electric field lines :
- (a) Circulate clockwise around positive charges.
(b) Radiate outward from positive charges.
(c) Radiate outward from negative charges.
(d) Circulate counter-clockwise around positive charges.

12. At an interface between two media, which of the following components are continuous ?
- (a) Normal component of B and tangential component of E .
 - (b) Normal component of D and tangential component of H .
 - (c) Normal component of H and tangential component of D .
 - (d) Normal component of E and tangential component of B .
13. An electrostatic field $E(r)$ and the corresponding scalar potential $V(r)$ exists in a region of space containing a charge, distribution $\rho(r)$. One of the following quantities is linearly related to $\rho(r)$. Which one is it ?
- (a) $\nabla \cdot \vec{E}$.
 - (b) ∇V .
 - (c) $\nabla^2 V$.
 - (d) $\nabla \cdot V$.
14. For a hollow and solid metal spheres charges reside :
- (a) On the surface.
 - (b) Throughout.
 - (c) Inside.
 - (d) None.
15. The electric field of a charge :
- (a) Increase with distance.
 - (b) Decrease with distance.
 - (c) No change with distance.
 - (d) None.
16. Identify the scalar quantity :
- (a) Force.
 - (b) Momentum.
 - (c) Acceleration.
 - (d) Work.
17. The unit of electric field :
- (a) Volt/meter.
 - (b) N/C.
 - (c) J/Cm.
 - (d) All of the above.

18. Identify Laplaces equation :

(a) $\nabla^2\phi = 0.$

(b) $\nabla^2\phi = q.$

(c) $\nabla^2\phi = \rho.$

(d) $\nabla^2\phi = \frac{\rho}{\epsilon_0}.$

19. $\nabla \cdot \vec{B}$ is always :

(a) 0.

(b) One

(c) Both (a) and (b).

(d) None.

20. Magnetising field H and magnetic flux density B are related as :

(a) $\vec{B} = \vec{H}.$

(b) $\vec{B} = \mu\vec{H}.$

(c) $\vec{B} = \frac{\mu}{H}.$

(d) $\vec{B} = \frac{\vec{H}}{\mu}.$

21. Schrodinger equation in shorter form is given by $H\psi =$

(a) $E\psi.$

(b) E.

(c) EH.

(d) $E\psi^2.$

22. Energy eigen value of simple harmonic oscillator is given by :

(a) $\left(n + \frac{1}{2}\right)\hbar\omega.$

(b) $\hbar\omega.$

(c) $\left(n + \frac{1}{2}\right)\omega.$

(d) $\frac{1}{2}\hbar\omega.$

23. In a rigid rotator distance between two particles is :

(a) Variable.

(b) Zero.

(c) Infinite.

(d) Constant.

24. The total energy of the electron in the hydrogen atom in the ground state is -13.6eV . Which of the following is its kinetic energy in the first excited state ?
- (a) 13.6 eV . (b) 6.8 eV .
(c) 3.4 eV . (d) 1.825eV .
25. If $\psi(x) = \sin 2x$. For the operator $\frac{d^2}{dx^2}$, the eigen value is :
- (a) 0. (b) 3.
(c) -4 . (d) 4.
26. A wave packet travels with :
- (a) Phase velocity. (b) Zero velocity.
(c) Group velocity. (d) Velocity of light.
27. Zero point energy of a harmonic oscillator is :
- (a) 0. (b) $\hbar\omega$.
(c) $2\hbar\omega$. (d) $\frac{1}{2}\hbar\omega$.
28. The force that allows electrons to move around the nucleus is :
- (a) Nuclear force. (b) Weak nuclear force.
(c) Electrostatic force. (d) Gravitational force.
29. When electrons move from a lower energy level to a higher energy level, energy is :
- (a) Absorbed. (b) Emitted.
(c) Both (a) and (b). (d) None of the above.
30. Which of the following is true regarding the Bohr model of atoms ?
- (a) Assumes that the angular momentum of electrons is quantized.
(b) Uses Faraday's laws.
(c) Predicts continuous emission spectra.
(d) Predicts the same emission spectra for all types of atoms.

31. The speed of light in water is 2.25×10^8 m/s then refractive index of water is :
- (a) 2.32. (b) 1.03.
(c) 1.33. (d) 2.33.
32. Refractive index of medium decreases with :
- (a) Increase in wavelength. (b) Decrease in wavelength.
(c) Decrease in temperature. (d) Both (a) and (c).
33. An object is placed at a distance of 0.25 m in front of a plane mirror. The distance between the object and image will be :
- (a) 0.25 m. (b) 1.0 m
(c) 0.5 m. (d) 0.125 m.
34. Which of the following mirror is used by a dentist to examine a small cavity ?
- (a) Convex mirror.
(b) Plane mirror.
(c) Concave mirror.
(d) Combination of convex and concave mirror.
35. As light travels from a rarer to a denser medium it will have :
- (a) Increased velocity. (b) Decreased velocity.
(c) Decreased wavelength. (d) Both (b) and (c).
36. What happens when white light goes through an achromatic prism combination ?
- (a) Dispersion. (b) Deviation.
(c) Dispersion and deviation. (d) None of the above.
37. Which of the following is Cauchy's formula ?
- (a) $\mu = A + B\lambda^2$. (b) $\mu = A + B/\lambda^2$.
(c) $\mu = A + B\lambda^3$. (d) $\mu = A + B/\lambda^4$.

38. Calculate the dispersive power of crown glass where $\mu_V = 1.456$ and $\mu_R = 1.414$.
- (a) 0.0096. (b) 0.45.
(c) 0.96. (d) 0.096.
39. Which of the following statements is correct regarding the propagation of light of different colours of white light in air ?
- (a) Red light moves fastest.
(b) Blue light moves faster than green light.
(c) All the colours of the white light move with the same speed.
(d) Yellow light moves with the mean speed as that of the red and the violet light.
40. The wavelength of red helium-neon laser in air is 6328 Å. What happens to its frequency in glass that has a refractive index of 1.50 ?
- (a) Increases by a factor of 3.
(b) Decreases by a factor of 1.5.
(c) Remains the same.
(d) Decreases by a factor of 0.5
41. For any substance entropy at absolute zero of temperature must be :
- (a) Zero.
(b) Finite.
(c) Zero for some and non-zero for others.
(d) Unpredictable.
42. The chemical potential of a photon at any temperature is :
- (a) Negative. (b) Zero.
(c) Positive. (d) Either zero or positive.

43. A gas of molecular mass m is at temperature T and it obeys Maxwell-Boltzmann velocity distribution, the most probable speed of molecules is given by :
- (a) $\sqrt{\frac{2kT}{m}}$ (b) $\sqrt{\frac{3kT}{m}}$
(c) $\sqrt{\frac{2kT}{\pi m}}$ (d) $\sqrt{\frac{8kT}{\pi m}}$
44. When the temperature of a blackbody is doubled, the energy density, would increase :
- (a) 6 times. (b) 16 times.
(c) 26 times. (d) 36 times.
45. A blackbody at temperature T emits radiation at a peak wavelength λ . If the temperature of the blackbody becomes $2T$, the new peak wavelength is :
- (a) λ . (b) 2λ .
(c) 3λ . (d) $\frac{\lambda}{2}$.
46. The internal energy of N one dimensional harmonic oscillators is :
- (a) $2NkT$. (b) $3NkT$.
(c) NkT . (d) $4NkT$.
47. Which equation given below represents first law of thermodynamics :
- (a) $TdS = dU + PdV$. (b) $dU = TdS + PdV$.
(c) $PdV = dU + TdS$. (d) None.
48. The electronic energy density in a white dwarf is E . What is the pressure ?
- (a) $\frac{1}{3}E$. (b) $\frac{2}{3}E$.
(c) $\frac{4}{3}E$. (d) $\frac{5}{3}E$.

49. The efficiency of a carnot engine operating between 0K and 100K is :
- (a) 50. (b) 45.
(c) 100. (d) 20.
50. During free expansion of an ideal gas under adiabatic condition, the internal energy of the gas :
- (a) Decreases.
(b) Initially decreases and then increases.
(c) Increases.
(d) Remains constant.
51. One of the following properties of a nucleus is decided by the shape of the nucleus. Which one is it?
- (a) Mass of the nucleus.
(b) Electric dipole moment.
(c) Electric quadrupole moment.
(d) Magnetic moment.
52. Nuclear forces are :
- (a) Short range and spin independent.
(b) Long range and attractive.
(c) Short range and spin dependent.
(d) Long range and repulsive.
53. In the following elementary particle interaction, identify the particle a :
- $$p + a \rightarrow \Sigma^- + K^+$$
- (a) π^- . (b) n .
(c) e . (d) π^+ .

54. Which of the following elementary particle reactions is not possible because of conservation laws ?

(a) $\pi^0 \rightarrow \gamma + \gamma$.

(b) $\Lambda^0 \rightarrow e^+ \pi^-$.

(c) $\Sigma^0 \rightarrow \Lambda^0 + \gamma$.

(d) $p \rightarrow n + e^+ + \nu$.

55. The particle x , that can give rise to the reaction is $x + p \rightarrow n + e^+$.

(a) ν_e .

(b) $\bar{\nu}_e$.

(c) ν_μ .

(d) $\bar{\nu}_\mu$.

56. A quark can appear in :

(a) 2 colours.

(b) 3 colours.

(c) 1 colour.

(d) 4 colours.

57. Mediator of strong interaction is :

(a) Quarks.

(b) Photons.

(c) Gluons.

(d) w bosons.

58. Mesons are composed of :

(a) A colorless quark-antiquark pair.

(b) Three quarks with three different colours.

(c) Three quarks of the same colour.

(d) Any odd number of quarks.

59. Which of the following particles are responsible for holding together quarks to form hadrons ?

(a) Mesons.

(b) Photons.

(c) Intermediate vector bosons.

(d) Gluons.

60. Protons and neutrons are fermions and also baryons. Which of the following describes protons and neutrons ?

- (a) They are composed of three quarks and have a half integer spin.
- (b) They are composed of a quark and an antiquark and have a half integer spin.
- (c) They are composed of three quarks and have zero or integer spin.
- (d) They are composed of a quark and an antiquark and have zero or integer spin.

61. The susceptibility of a diamagnetic material is :

- (a) Positive and proportional to temperature.
- (b) Negative and inversely proportional to temperature.
- (c) Negative and independent of temperature.
- (d) Positive and inversely proportional to temperature.

62. Which of the following is the correct expression for the relation between Einstein's co-efficients A and B ?

- | | |
|---------------------------------|---------------------------------|
| (a) $\frac{8\pi h\nu^3}{c^3}$. | (b) $\frac{\pi h\nu^3}{c^3}$. |
| (c) $\frac{8\pi\nu^3}{c^3}$. | (d) $\frac{8\pi h\nu^3}{c^2}$. |

63. Process in which a photon is absorbed by the atom, causing an electron to jump from a lower energy level to a higher energy level :

- | | |
|------------------------------|---------------------------|
| (a) Absorption of Radiation. | (b) Spontaneous Emission. |
| (c) Stimulate Emission. | (d) Population Inversion. |

64. Which of the following statement is not correct in the context of a laser ?

- (a) The emitted radiation do not have precisely defined frequency.
- (b) The emitted radiation is highly coherent and intense.
- (c) Lasing action requires population inversion.
- (d) More photons come out compared to the incident photon.

Turn over

65. Which of the following is a unique property of Laser ?
- (a) Directional.
 - (b) Speed.
 - (c) Coherence.
 - (d) Wavelength.
66. Electrons present in p-type material due to thermal pair generation are :
- (a) Majority carriers.
 - (b) Minority carriers.
 - (c) Dual carriers.
 - (d) None.
67. Semi-conductors germanium and silicon are :
- (a) Pentavalent.
 - (b) Trivalent.
 - (c) Divalent.
 - (d) Tetravalent.
68. P-N junction when reversed biased acts as a :
- (a) Capacitor.
 - (b) Inductor.
 - (c) On switch.
 - (d) Off switch.
69. Which one of the following band is completely filled in case of conductors ?
- (a) Conduction band.
 - (b) Fermi band.
 - (c) Valence band.
 - (d) Forbidden band.
70. A hole is equivalent to :
- (a) A negative charge.
 - (b) A positive charge.
 - (c) A neutral particle.
 - (d) An electron.
71. Which number system has a base 16 :
- (a) Hexadecimal.
 - (b) Octal.
 - (c) Binary.
 - (d) Decimal.
72. A SCR (Silicon Controlled Rectifier) is a :
- (a) Device with 3 junctions :
 - (b) Device with 2 junctions.
 - (c) Device with 1 junction.
 - (d) Device with 4 junctions.

73. Which of these sets of logic gates are known as universal gates ?
- (a) XOR, NAND, OR.
 - (b) OR, NOT, XOR.
 - (c) NOR, NAND, XNOR.
 - (d) NOR, NAND
74. The binary number 10101 is equivalent to decimal number.
- (a) 19.
 - (b) 12.
 - (c) 27.
 - (d) 21.
75. The NOR gate is OR gate followed by :
- (a) AND gate.
 - (b) NAND gate.
 - (c) NOT gate.
 - (d) None of the above.
76. What should be the order of the size of an obstacle or aperture for diffraction light ?
- (a) Order of wavelength of light.
 - (b) Order of wavelength of obstacle.
 - (c) Order in ranges of micrometer.
 - (d) Order in ranges of nanometer.
77. Polarization of light proves :
- (a) The corpuscular nature of light.
 - (b) Quantum nature of light.
 - (c) Transverse wave nature of light
 - (d) Longitudinal wave nature of light.
78. When exposed to sunlight, thin films of oil on water exhibit brilliant colors due to the phenomenon of :
- (a) Interference.
 - (b) Diffraction.
 - (c) Dispersion.
 - (d) Polarization.

79. Which of the following phenomenon cannot explained by Huygen's wave theory ?

- (a) Diffraction.
- (b) Interference.
- (c) Polarisation.
- (d) Photoelectric effect.

80. The surface of constant phase is called as :

- (a) Wavelets.
- (b) Wave.
- (c) Wavefront.
- (d) None.

81. If $\vec{a} + \vec{b} + \vec{c} = 0$ and $|\vec{a}| = 3$, $|\vec{b}| = 5$ and $|\vec{c}| = 7$, the angle between $\vec{a}$ and $\vec{b}$ is :

- (a) $\pi/6$.
- (b) $2\pi/3$.
- (c) $\pi/3$.
- (d) $3\pi/3$.

82. $\nabla f(\vec{r}) \times \vec{r}$ is equal to :

- (a) 0
- (b) $\frac{\vec{r}}{r}$.
- (c) $\frac{\vec{r}}{r^2}$.
- (d) $\frac{\vec{r}}{r^3}$.

83. The directional derivative of $\phi = x^2yz + 4xz^2$ at $(1, -2, -1)$ in the direction of $2\hat{i} - \hat{j} - 2\hat{k}$ is:

- (a) $\frac{21}{3}$.
- (b) $\frac{17}{7}$.
- (c) $\frac{13}{3}$.
- (d) $\frac{37}{3}$.

84. Tensor of first rank is called :

- (a) A scalar.
- (b) A second rank tensor.
- (c) A vector quantity.
- (d) Alternate tensor.

85. The number of elements in a tensor of rank r in n dimensional space is :
- (a) r^n . (b) n^r .
(c) nr . (d) $r!n$.
86. Which one of the following sets form a group under multiplication ?
- (a) $(1, i)$. (b) $(i, -i)$.
(c) $(1, -1)$. (d) $(1, 0)$.
87. Rotations of a circle about an axis passing through its centre and perpendicular to the plane of the circle will form :
- (a) An orthogonal group. (b) A unitary group.
(c) Lorentz group. (d) A set only.
88. The eigen values of $\begin{bmatrix} -5 & 2 \\ 2 & -2 \end{bmatrix}$ are :
- (a) 1, 3. (b) -1, -6.
(c) 1, -6. (d) -2, -5.
89. A system, after passing through different states returns back to its original state, is called :
- (a) Cyclic process. (b) Isothermal process.
(c) Adiabatic process. (d) Isobaric process.
90. Which of the following is not a thermodynamic state of matter ?
- (a) Temperature. (b) Pressure.
(c) Work. (d) Volume.
91. The door of a domestic refrigerator is kept open while the switch is on. Then the room will :
- (a) Get heated. (b) Get neither heated nor cooled.
(c) Gets cooled. (d) Gets heated first and then cools.

92. When the pressure of the system remains constant, it is called _____ process.
- (a) Isobaric. (b) Isothermal.
(c) Adiabatic. (d) Isochoric.
93. Which Thermodynamic process where heat is not exchanged with the surroundings is :
- (a) Isothermal. (b) Adiabatic.
(c) Isobaric. (d) Isotropic.
94. Which of the following law was put forward by Nernst ?
- (a) The first law of thermodynamics.
(b) The second law of thermodynamics.
(c) Third law of thermodynamics.
(d) None of the above.
95. What is the percentage of free space in a bcc (body centred cubic) unit cell ?
- (a) 28. (b) 34.
(c) 32. (d) 30.
96. How many atoms are present in each unit cell of an fcc crystal ?
- (a) 8. (b) 6.
(c) 5. (d) 4.
97. Which one of the following exhibits the most well defined X-ray diffraction pattern ?
- (a) A polycrystal. (b) An amorphous material.
(c) A single crystal. (d) A plastically deformed crystal.
98. In a crystal lattice, what are the vacancies created by the absence of certain atoms known as ?
- (a) Hertz defects. (b) Schottky defects.
(c) Pauli defects. (d) Crystal defects.

99. The atomic packing factor for face centered cubic (FCC) crystal structure is :

(a) 0.63.

(b) 0.74.

(c) 7.4.

(d) 6.3.

100. Which of the following conditions favours the existence of a substance in the solid state ?

(a) High temperature.

(b) Low temperature.

(c) High thermal energy.

(d) Weak cohesive forces.