P.G. ENTRANCE EXAMINATION, APRIL 2022

PHYSICS/RADIATION PHYSICS/PHYSICS (NANO SCIENCE)

Time : Two Hours Maximum : 200 Marks

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

1. A white dwarf star has volume V and contains N electrons so that density of electron is $n = \frac{N}{V}$. Taking temperature of star to be 0 K, the average energy per electron in the star is $\epsilon_0 = \frac{3\hbar^2}{10m}\left(3\pi^2 n\right)^{\frac{2}{3}}$, where m is the electron mass. The electronic pressure in the star is :

   (A) $n\epsilon_0$.

   (B) $2n\epsilon_0$.

   (C) $\frac{1}{3}n\epsilon_0$.

   (D) $\frac{2}{3}n\epsilon_0$.

2. Given that the atomic mass of ^{14}N is 14.003074 u and that of the sum of the atomic masses of ^{1}H and ^{13}C is 14.011179 u. How much energy is released in the $^{1}H + {}^{13}C \rightarrow {}^{14}N$ reaction ($1u = 1.66 \times 10^{-27}$ kg.).

   (A) 7.55 MeV.

   (B) 7.55 keV.

   (C) 7.55 eV.

   (D) 7.55 GeV.

3. The number of lattice points per unit cell of BCC structure is ———.

   (A) One.

   (B) Two.

   (C) Three.

   (D) Four.

4. The crystal structure of table salt is ———.

   (A) Fcc.

   (B) Triclinic.

   (C) Monoclinic.

   (D) Orthorhombic.

5. A loosely bound pair of electrons with opposite spins and moving with the same speed in opposite directions is called a ———.

   (A) Tachyon.

   (B) Cooper pair.

   (C) Fermion.

   (D) Neutrino.

6. The frequency range of IR spectrum is ———.

   (A) 2,500 – 16,000 nm.

   (B) 100 – 400 nm.

   (C) 10 – 100 nm.

   (D) 10 – 100 nm.

7. In the case of a linear molecule moment of inertia is ———.

(A) $I_A = 0$ while $I_B = I_C$.

(B) $I_A = 1$ while $I_B = I_C$.

(C) $1_A = 0$ while $I_B \leq I_C$.

(D) $I_A = 0$ while $I_B \neq I_C$.

8. Which of the following statements are correct :

(i) Value of entropy for a reversible process is irrespective of the path.

(ii) An isolated system should have an adiabatic boundary.

(A) Only (i).

(B) Only (ii).

(C) Both (i) and (ii).

(D) Neither (i) nor (ii).

9. The expression $S = -aT^3 - 2bT^2 + S_0$ represents the entropy of a system at a fixed volume where, T represents the temperature, a, b and S_0 are constants. In this case, which of the following represent the specific heat of the system at the constant volume :

(A) $-aT^4 - 2bT^3 + TS_0$.

(B) $-aT^2 - 2bT$.

(C) $-3aT^3 - 4bT^2$.

(D) $-aT^3 - 2bT^2 + S_0$.

10. The internal energy of an ideal gas at 100°C is around :

(A) 4600 J.

(B) 1200 J.

(C) 550 J.

(D) 150 J (10).

11. A closed cylinder with 16 g of oxygen (O_2) is heated from 300 K to 350 K. Evaluate the amount of heat transferred to oxygen :

(A) 60 J.

(B) 625 J.

(C) 520 J.

(D) 1800 J.

12. For a black body at a finite temperature, as the wavelength of the emitted radiation decreases, the intensity of the radiations ———.

(A) Increases.

(B) Decreases.

(C) First increases then decrease.

(D) First decreases then increase.

13. In an isotropic medium, the optical properties are :

(A) Linearly increasing or decreasing.

(B) Infinity along all direction.

(C) Same along all direction.

(D) Direction dependance.

14. The condition for destructive interference in super position of two sine waves are :

(A) $a.a = a_1 + a_2$.

(B) $a = a_1 - a_2$.

(C) $a = a_1/a_2$.

(D) $a = a_1 a_2$.

15. The wave length of sodium light is :

(A) 589 nm.

(B) 800 nm.

(C) 418 nm.

(D) 618 nm.

16. The diameters of the 5^{th} and 15^{th} rings in a Newton's ring experiment are 0.30 cm. and 0.62 cm, respectively. The diameter of 25^{th} ring will be :

(A) 0.5533 cm.

(B) 1.003 cm.

(C) 1.663 cm.

(D) 0.8239 cm.

17. In a Michelson interferometer :

(A) One concave lens and two plane mirrors are used.

(B) One half silvered glass plate and two concave mirrors are used.

(C) One half silvered glass plate and two plane mirrors are used.

(D) One half silvered glass plate and two convex lens are used.

18. Two large metal plates (each of area A), are held at a distance d apart. Suppose, we put a charge Q on each plate, what is the electrostatic pressure on the plates ?

(A) $\frac{Q}{2\varepsilon_0 A}$.

(B) $\frac{Q^2}{2\varepsilon_0 A}$.

(C) $\frac{Q}{2\varepsilon_0 A^2}$.

(D) $\frac{Q^2}{2\varepsilon_0 A^2}$.

19. What is the general solution to Laplace's equation in spherical co-ordinates for the special case where V depends only on r. (c and k are constants) :

(A) $V = -cr$.

(B) $V = cr$.

(C) $V = \frac{c}{r} + k$.

(D) $V - \frac{c}{r} + k$.

20. Suppose the electric field inside a large piece of dielectric is E_o, so that the electric displacement is $D_0 = \varepsilon_0 E_0 + P$. If a small spherical cavity is hollowed out of the material, find the field and electric displacement at the centre of the cavity in terms of E_0 and P.

(A) $E = E_0 + \frac{1}{3\varepsilon_0} P, D = D_0 - \frac{2}{3} P.$

(B) $E = E_0 - \frac{1}{3\varepsilon_0} P, D = D_0 + \frac{2}{3} P.$

(C) $E = E_0 - \frac{2}{3\varepsilon_0} P, D = D_0 - \frac{1}{3} P.$

(D) $E = E_0 + \frac{2}{3\varepsilon_0} P, D = D_0 + \frac{1}{3} P.$

21. Suppose the field inside a large piece of magnetic material is B_0, so that $H_0 = \frac{1}{\mu_0} B_0 - M$. If a small spherical cavity is hollowed out of the material, find the field at the centre of the cavity in terms of B_0 and M. Also find H at the centre of the cavity in terms of H_0 and M.

(A) $B = B_0 - \frac{2}{3} \mu_0 M, H = H_0 + \frac{1}{3} M.$

(B) $B = B_0 + \frac{2}{3} \mu_0 M, H = H_0 - \frac{1}{3} M.$

(C) $B = B_0 - \frac{1}{3} \mu_0 M, H = H_0 + \frac{2}{3} M.$

(D) $B = B_0 + \mu_0 M, H = H_0 - \frac{2}{3} M.$

22. The energy contained in a small volume through which an electromagnetic wave is passing, oscillates with :

(A) Zero frequency.

(B) The frequency of the wave.

(C) Half the frequency of the wave.

(D) Double the frequency of the wave.

23. Which of the following quantities have the same dimensional formula ?

(A) Energy and torque.

(B) Energy and angular momentum.

(C) Angular momentum and torque.

(D) Torque and strain.

24. If an observer is approaching the velocity of light, length and time measured by the observer will be ——— and ———, respectively.

(A) Larger, larger. (B) Lesser, lesser.

(C) Larger, lesser. (D) Lesser, larger.

25. Ice skating is possible and practical because of a unique property of water. Is it because :

(A) The coefficient of kinetic friction of steel on frozen water decreases with decreasing temperature.

(B) Ice readily sublimes.

(C) The melting point decreases with increasing pressure.

(D) Ice is a good thermal insulator.

26. A force which does not act on a particle, but appears due to acceleration of the frame is known as :

(A) Frictional force. (B) Fictitious force.

(C) Central force. (D) Centripetal force.

27. For a freely falling body, the sum of potential and kinetic energy is :

(A) Constant only at the starting point.

(B) Constant only at the final point.

(C) Constant throughout the motion.

(D) Varying continuously from point to point.

28. A 100 W incandescent bulb operating at 250 V a.c. would have an impedance of :

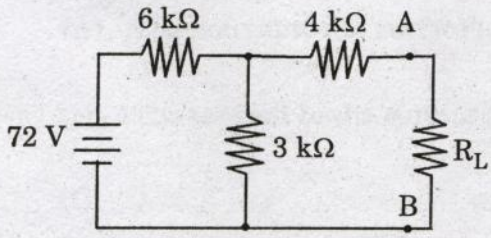
(A) 100 Ohms.

(B) 225 Ohms.

(C) 625 Ohms.

(D) 820 Ohms.

29. In the circuit given below, an unknown resistance R_L is connected between A and B, the



equivalent Thevenin's voltage and resistance are :

(A) 36 V and 4 Ω.

(B) 36 V and 2 Ω.

(C) 24 V and 6 Ω.

(D) 24 V and 3 Ω.

30. A common emitter transistor amplifier with potential divider biasing configuration with a V_{CC} = 12 V is set up with resistances R_1 = 10 K (connected to V_{CC}), R_2 = 2.2 K, R_C = 3.6 K and R_E = 1 K. The value of V_E is :

(A) 1.46 V.

(B) 5.27 V.

(C) 6.0 V.

(D) 6.73 V.

31. An emitter follower is a :

(A) Common emitter amplifer.

(B) Common collector amplifier.

(C) Common base amplifier.

(D) Common emitter amplifier with bypassed resistance.

32. A Zener diode (V_z = 5.6 V) and a series resistance of 2 kΩ is connected to a voltage source of 10 V. Current through the diode is :

(A) 11.2 mA.

(B) 5.6 mA.

(C) 4.4 mA.

(D) 2.2 mA.

33. If A and B are non-singular square matrices of order n, $((AB)^T)^{-1})$ is not equal to :

(A) $\left((AB)^{-1}\right)^T$.

(B) $\left(B^T A^T\right)^{-1}$.

(C) $\left(B^{-1} A^{-1}\right)^T$.

(D) $\left(A^{-1} B^{-1}\right)^T$.

34. If $\phi(r, \theta)$ = constant, represents the surface of a sphere of radius r, then $\nabla\phi$ is along :

(A) The normal to the surface at (r, θ).

(B) The tangent to the surface at (r, θ).

(C) 0.

(D) None of these.

35. If $\vec{V} = x\hat{i}$, the divergence of $\vec{V}$ is :

(A) 1.

(B) 0.

(C) x.

(D) None of these.

36. For an object moving in uniform circular motion, the direction of the instantaneous acceleration vector is :

(A) Tangent to the path of motion.

(B) Equal to zero.

(C) Directed radially outward.

(D) Directed radially inward.

37. Work is equal to which of the following ?

(A) The cross product of force and displacement.

(B) The product of force times time.

(C) Force divided by time.

(D) The dot product of force and displacement.

38. Work is defined as :

(A) A scalar quantity.

(B) Always a positive quantity.

(C) A vector quantity.

(D) Always zero.

39. Five volts are applied across the plates of a parallel plate capacitor. The distance of separation of the plates is 0.02 meters. What is the magnitude of the electric field inside the capacitor ?

(A) 250 V/m.

(B) 100 V/m.

(C) 50 V/m.

(D) 10 V/m.

40. For a negative point charge, the electric field vectors :

(A) Circle the charge.

(B) Point radially in toward the charge.

(C) Point radially away from the charge.

(D) Cross at infinity.

41. Five Coulombs of charge are placed on a thin-walled conducting shell. Once the charge has come to rest, the electric potential inside the hollow conducting shell is :

(A) Zero.

(B) Uniform inside the sphere and equal to the electric potential on the surface of the sphere.

(C) Smaller than the electric potential outside the sphere.

(D) Varying as one over r squared.

42. An infinitely long wire carries a current of three amps. The magnetic field outside the wire :

(A) Points radially away from the wire.

(B) Points radially inward.

(C) Circles the wire.

(D) Is zero.

43. ^{60}Co is a radioactive nucleus of half-life 2 ln 2 × 10^8s. The activity of 10 g of ^{60}Co disintegrations per second is :

(A) $\frac{1}{5} \times 10^{10}$.

(B) 5×10^{10}.

(C) $\frac{1}{5} \times 10^{14}$.

(D) 5×10^{14}.

44. Two spherical nuclei have mass numbers 216 and 64 with their radii R_1 and R_2 respectively. The ratio $\frac{R_1}{R_2}$ is :

(A) 3.0.

(B) 1.5.

(C) 4.0.

(D) 2.5.

45. A nucleus has a size of 10^{-15} m. Consider an electron is bound within the nucleus. The estimated energy of this electron is of the order of :

(A) 1 MeV.

(B) 10 MeV.

(C) 100 MeV.

(D) 10000 MeV.

46. The wavefunction in the ground state of hydrogen atom is $\psi = N\left[1/\left(\pi a^3\right)\right]^{1/2} \exp\left(-r/a\right)$. The average of r is ———.

(A) 0.

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

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

(D) $\frac{1}{2}a$.

47. The expectation value of momentum of a particle with wave function $\psi = N \exp[-x^2/(2a^2) + ikx]$, is :

(A) $\hbar k$.

(B) $\hbar k / a$.

(C) 0.

(D) $i\hbar / a^2$.

48. The kinetic energy of an electron taken from a metal having a work function W = 1.26 eV with a photon of wavelength λ = 520 nm, is equal to :

(A) 1.34 eV.

(B) 1.12 eV.

(C) 1.08 eV.

(D) 1.46 eV.

49. When X-rays of wavelength $\lambda = 15.12$ pm are incident on a block of carbon, the wavelength of radiation happening in the direction perpendicular to the direction of the incident X-ray is :

(A) 14.12 p.m.

(B) 15.12 p.m.

(C) 16.38 p.m.

(D) 17.54 p.m.

50. The steady state of a particle confined to the region $[-a, +a]$ is described by the function $\phi(x) = \sqrt{\frac{1}{a}} \cos\left[\frac{3\pi}{2a}x\right]$. The probability of a particle being present in the interval $\left[0, \frac{a}{3}\right]$ is :

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

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

(C) $\frac{1}{4}$.

(D) $\frac{1}{6}$.