NITESHPHYZICS

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PHYSICS

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1. A satellite is revolving around the earth at a height of 600 km. Calculate the time period of the satellite (Radius of the earth is 6400 Km and mass of the earth is 6.4×10^{24} Kg)
   A. 7×10^3 B. 5.8×10^2 C. 7×10^2 D. 5.8×10^3s ✔

2. A particle moves in the X$_Y planeaccordingtothefollowingcondition$:x=R sin$(\omega t) + \omega Rt, y = Rcos(\omega t) + R$, where ω and R are constant. The maximum speed of the particle is
   A. $v = \omega R\sqrt{2}$ B. $v = \omega R2$ ✔ C. $v = \omega R$ D. $v = \omega R2\sqrt{2}$

3. A nuclear explosion releasing energy E creates a shock-wave in the atmosphere with initial density ρ. A possible approximate value of radius R of the wave-front at time t is given as
   A. $R = \left(\frac{Et^2}{\rho}\right)^{1/2}$ B. $R = \left(\frac{Et^2}{\rho}\right)^{1/3}$ C. $R = \left(\frac{Et^2}{\rho}\right)^{1/4}$ D. $R = \left(\frac{Et^2}{\rho}\right)^{1/5}$ ✔

4. A particle of mass m_1 is moving along the x-axis with velocity u_1 and another particle of mass m_2 is at rest at the origin. The two particles undergo elastic collision and start moving with velocities v_1 and v_2 Which one of the following expressions is correct?

   A. $\frac{m_2}{m_1} = 1 - \frac{2v_1}{v_2}$ ✔
   B. $\frac{m_2}{m_1} = 1 + \frac{2v_1}{v_2}$
   C. $\frac{m_2}{m_1} = 1 - \frac{v_1}{v_2}$
   D. $\frac{m_2}{m_1} = 1 + \frac{v_1}{v_2}$

5. A particle of mass m is moving along a circle of radius r_o in a horizontal plane with speed v_o as it is connected to the center of the circle through an in-extensible string. The other end of the string is being pulled down through a vertical tube at a slow rate resulting in the gradual reduction in the radius of the circular orbit of the particle from its initial value r . The work done by the pulling force in reducing the radius from r_o to r is

   A. $W = \frac{1}{2}mv_o^2\left(\frac{r_o^2}{r^2} - 1\right)$ ✔
   B. $W = \frac{1}{2}mv_o^2\left(\frac{r_o^2}{r^2} + 1\right)$
   C. $W = \frac{1}{2}mv_o^2\left(\frac{r^2}{r_o^2} - 1\right)$
   D. $W = \frac{1}{2}mv_o^2\left(\frac{r_o^2}{r^2} + 1\right)$

6. The Probability of finding a moving particle in the n=3 state in a one dimensional box with potential

$$V(x) = \begin{cases} 1 & 0 < x < a \\ \infty & elsewhere \end{cases}$$

in the region $\frac{a}{3} < x < \frac{2a}{3}$ is

A. $\frac{1}{3}$ ✔ B. $\frac{1}{6}$ C. $\frac{2}{3}$ D. 0

7. Complex conjugate of the derivative operator $\frac{d}{dx}$ is

A. $-\frac{d}{dx}$ ✔ B. $i\frac{d}{dx}$ C. $i\hbar\frac{d}{dx}$ D. $-i\hbar\frac{d}{dx}$

8. A particle is moving in a one-dimensional potential **V(x)**. If **V(x)** has an infinite discontinuity at $x = x_n$, the wave function for the particle, at that point

   A. has a finite discontinuity
   B. is continuous but not differentiable ✔
   C. is differentiable
   D. has infinite discontinuity

9. For the normalized wave-function $\psi(x) = Aexp\left(\frac{-x^2}{2\sigma^2}\right)$ the uncertainty in the position is

A. $\frac{\sigma}{\sqrt{2}}$ ✔ B. σ C. $\sigma\sqrt{2}$ D. 2σ

10. A beam of monochromatic light of frequency ν, intensity I and linearly polarized in the vertical plane consists of n photons per unit time. It is passed through a polarizer whose pass angle is 45° to the vertical. The emerging light has

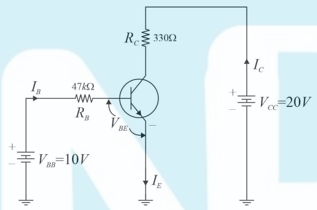
   A. (n/2) photons of frequency ν and polarized along the vertical plane
   B. n photons of frequency $(\nu/2)$ and polarized along the vertical plane
   C. (n/2) photons of frequency ν and polarized along the plane 45° to the vertical. ✔
   D. n photons of frequency ν and polarized along the plane 45° to the vertical.

11. The decimal equivalent of the binary number 10111.0110 is given by

A. $(23.1875)_{10}$ B. $(23.375)_{10}$ C. $(46.375)_{10}$ D. $(46.1875)_{10}$

12. In a npn transistor, 90 % of the emitted electrons reach the collector. If the collector current is 18 mA, the base current (in mA) will be
A. 1.62 B. 1.8 C. 2.0 ✔ D. 2.5

13. Value of the Q point (I_E, V_{CE}) of the following transistor circuit is given by $(Take \beta = 200, V_{BE} = 0.7V)$



A. $I_c = 39.6mA, V_{CE} = 6.93V$ ✔

B. $I_c = 45.5mA, V_{CE} = 4.98V$

C. $I_c = 39.6mA, V_{CE} = 0.693V$

D. $I_c = 4.5mA, V_{CE} = 4.98V$

14. In an amplitude modulated wave with maximum peak-to-peak voltage of 20 mV and minimum peak-to-peak voltage of 4 mV, the percentage modulation is
A. 66.7% ✔ B. 50% C. 15% D. 77%

15. For an applied forward bias of 0.2 V in a germanium diode with reverse saturation current I = 1μA, the static and dynamic resistance at 27 °C, respectively is
A. 88Ω and 11.4Ω ✔ B. 114Ω and 88Ω C. 8.8kΩ and 1.14kΩ D. 8.8Ω and 1.14Ω

16. A 3D isotropic harmonic oscillator has energy levels $\varepsilon_{n_1 n_2 n_3} = \hbar\omega\left(n_1+n_2+n_3+\frac{3}{2}\right)$ where $n_1, n_2, n_3 = 0,1,2,3......$ The number of micro-states corresponding to the energy $\varepsilon = \frac{7}{2}\hbar\omega$ is
A. 6 ✔ B. 3 C. 4 D. 8

17. What will be the solution of the following differential equation:

$$(sinx)\frac{dy}{dx} + (cosx)y = x^2; y(0) = 1$$

A. $y(x) = \frac{x^3}{3sinx}$ ✔
B. $y(x) = \frac{x^3 sinx}{3}$
C. $y(x) = \frac{x^3 cosx}{3}$
D. $y(x) = \frac{x^3}{3cosx}$

18. What is the series expansion and region of convergence of the function $f(z) = \frac{1}{z+1}$ about $z_o = \frac{1}{2}$

A. $f(z) = \frac{1}{2}\sum_{n=0}^{\infty}\left[-\frac{1}{2}\left(z-\frac{1}{2}\right)\right]^n; |z-\frac{1}{2}| < \frac{1}{2}$
B. $f(z) = \sum_{n=0}^{\infty}[-z]^n; |z| < 1$
C. $f(z) = \frac{2}{3}\sum_{n=0}^{\infty}\left[-\frac{2}{3}\left(z+\frac{1}{2}\right)\right]^n; |z-\frac{1}{2}| < \frac{3}{2}$ ✔
D. $f(z) = 2\sum_{n=0}^{\infty}\left[-2\left(z+\frac{1}{2}\right)\right]^n; |z-\frac{1}{2}| < \frac{1}{2}$

19. Evaluate the Integral $I = \int_0^{2\pi}\frac{d\theta}{2+cos\theta}$
A. $\frac{2\pi\sqrt{3}}{3}$ ✔ B. 0 C. $\frac{2\pi\sqrt{3}}{2}$ D. $\frac{\pi\sqrt{3}}{2}$

20. What is the expectation value of the linear momentum squared i.e. $\langle p_x^2\rangle$ for the wave function $\psi(x) = \sqrt{k}x^{-k|x|}$; k being a real constant
A. $< p_x^2 >= \hbar^2 k^2$ B. $< p_x^2 >= -\hbar^2 k^2$ ✔ C. $< p_x^2 >= 2\hbar^2 k^2$ D. $< p_x^2 >= -2\hbar^2 k^2$

21. A sphere of radius R carries a volume charge density $\rho = kr$ where k is a constant and 0<r<R. The energy of the configuration (in S.I. units) is given by A. $\frac{\pi k^2 R^7}{7\varepsilon_o}$ ✔ B. $\frac{k^2 R^8}{16\varepsilon_o^2}$ C. $\frac{k^2 R^7}{7\varepsilon_o}$ D. $\frac{\pi k^2 R^8}{16\varepsilon_o}$

22. A point charge q is embedded at the center of a sphere of linear dielectric material with susceptibility χ_e and radius R. The electric field and polarisation at a point r < R in S.I. units would then be
A. 1 ✔ B. 2 C. 3 D. 4

23. A linearly polarized electromagnetic wave $\vec{E} = E_o exp(-i(\vec{k}.\vec{r} - \omega t))$ is travelling in vacuum. The root mean square value of the displacement current density for $|E_o| = 5.1\times 10^{-3}Vm^{-1}$ at a frequency $\omega = 1GHz$ is A. $2\times 10^{-4}Am^{-2}$ ✔ B. $2.8\times 10^{-4}Am^{-2}$ C. $2\times 10^{4}Am^{-2}$ D. $2.8\times 10^{4}Am^{-2}$

24. Consider a sphere carrying an electric polarization $\vec{P} = 3\varepsilon_o r^2 \hat{r}$, where r denotes the radial distance from the center. The electric field inside the sphere is
A. $\vec{E} = -4r^2\hat{3}$ ✔ B. $\vec{E} = -3r^3\hat{3}$ C. $\vec{E} = -\frac{2}{3}r^2\hat{3}$ D. $\vec{E} = -\frac{4}{3}r^3\hat{3}$

25. Let the electric field due to a spherical distribution of charge be given by $\vec{E} = E_o(1-3e^{-\alpha r}\frac{\hat{r}}{r^2})$, Where E_o and α are constants, and r denotes the radial distance from the center of the sphere. The corresponding charge density would be minimum
A. $r = 2/\alpha$ ✔ B. $r = 2\alpha/\sqrt{3}$ C. $r = \sqrt{3}\alpha$ D. $r = 1/\alpha$

26. A finite conductor is made up of a metal of permittivity ε . For a uniform conductivity σ , the volume charge density would evolve with time as
A. $\rho \propto e^{\sigma t/\varepsilon}$ ✔ B. $\rho \propto e^{t\varepsilon/\sigma}$ C. $\rho \propto e^{\sigma t^2/\varepsilon}$ D. $\rho \propto e^{t^2\varepsilon/\sigma}$

27. Consider a simple cubic lattice with (latice constant=a) in an xray diffraction experiment. Suppose the wavelength of the incident X-ray is related to the lattice constant as $\lambda\frac{a}{2\sqrt{3}}$. The second order Bragg diffraction from (111) planes appears at θ. Any small changes in the lattice constant Δa would result in a small change in the Bragg angle $\Delta\theta.\frac{\Delta\theta}{\Delta n}$
A. $\frac{-1}{a\sqrt{2}}$ B. $\frac{1}{a\sqrt{3}}$ C. $\frac{-1}{a\sqrt{3}}$ ✔ D. $\frac{-2}{a\sqrt{15}}$

28. An ionic solid is in thermal equilibrium at temperature T. In order to maintain the charge neutrality, vacancy defects are created in pairs (+ and - ions). N is the number of molecules (each containing a pair of oppositely charged ions) per unit volume and n is the number of vacancies per unit volume. Which statement is true about the plot of $ln\left(\frac{n}{N}\right)$ as a function of T.
A. It is a straight line. B. It is a hyperbolic curve. ✔ C. It is a logarithmic curve. D. It is an exponential curve.

29. Consider a two-dimensional sheet of metal in thermal equilibrium at room temperature (300 K). The sheet resistivity is 3.55 ohm and the surface density of electrons is $10^{21}/m^2$. Following Drude's theory for the collisions of electrons in the metal, the mean free path of an electron would be close to [Given $K_B = 1.38\times10^{-23}J/K, m = 9.11\times10^{-31}Kg, e = 1.6\times10^{-19}C$]
A. 95Å B. 9.5Å ✔ C. 950Å D. 0.95Å

30. For a doped semiconductor, μ_H and μ_e represent the hole and electron mobilities respectively. If n_i represents the intrinsic carrier density, then at a given temperature the required electron concentration at which the resistivity becomes maximum is given by,
A. n_i B. $n_i\frac{\mu_e}{\mu_H}$ C. $n_i\sqrt{\frac{\mu_H}{\mu_e}}$ ✔ D. $n_i\sqrt{\frac{\mu_e}{\mu_H}}$

31. What will be the proton separation energy of ^{197}Au? (Given mass of ^{197}Au= 196.966552 amu, mass of ^{196}Pt = 195.9649 amu)

A. 4.22 MeV B. 5.44 MeV ✔ C. 7.28 Mev D. 3.66 MeV

32. What will be the Q-value (energy release) when a particle decays to a proton and a pion ($\Lambda \to p\pi^-$) (rest mass of Λ = 1115.6 MeV/c). [Take π^- rest mass = 139.6 MeV/c].

A. 32.5 MeV B. 37.7 MeV ✔ C. 42.5 meV D. 39.8 MeV

33. Any nucleus emitting an alpha particle followed by two beta negative decays is

A. an isotope of the original one. ✔
B. an isotone of the original one.
C. an isobar of the original one.
D. an isomer of the original one.

34. The strong nuclear force between the nucleons present inside the nucleus is

A. charge dependent.
B. spin-dependent.
C. both charge and spin-dependent.
D. spin-dependent but not charge independent. ✔

35. A scalar meson decays into three pseudo scalar mesons. The decay happens through

A. weak interaction ✔
B. gravitational interaction
C. electromagnetic interaction
D. strong interaction

36. Which of the following statements about the reaction $p + p \to p + p + p + \bar{p}$ is wrong?

A. Baryon number is conserved.
B. Electric charge is conserved.

C. The reaction is allowed only if the incident protons have energy greater than a particular threshold. ✔

D. The reaction is not allowed because the conservation of (rest) mass is violated.

37. A string AB of length $2l$ is tied between two rigid supports. The tension in the string is T and mass per unit length is μ. A knife edge is placed at the position K at a distance x ($x \gg l$) from the midpoint C of AB. The two segments of the string now vibrate in their respective fundamental modes. The beat frequency listened by the observer is
A. $(1/l^2)(T/\mu)^{1/2}$ B. $(x/l^2)(T/\mu)^{1/2}$ ✔ C. $(T/\mu)^{3/2}$ D. $(1/x)(T/\mu)^{3/2}$

38. Two light waves of same wavelength 628nm in air have same initial phase difference. One travels through a glass layer of thickness 'a'. The refractive indices of the glass and plastic are 1.65 and 1.45 respectively. If the waves end up with the phase difference of 5.0 rad, the least value of thickness should be
A. 628nm B. 2500nm ✔ C. 5000nm D. 6280nm

39. Two points are seen as white dots are 1 mm apart on black paper. They are viewed by an eye of a pupil having a diameter of 3.0 mm. The maximum distance at which these dots can be resolved by the eye is: A. 5 m ✔ B. 1 m C. 6 m D. 3 m

40. A parallel beam of light of wavelength falls on a uniformly thick soap film making an angle of 30^o with the normal to the surface of the film. If a constructive second-order interference pattern is observed with the reflected light, then the thickness of the soap film is A. 0.426 nm ✔ B. 0.5 nm C. 0.0426 nm D. 4.26nm

41. The isothermal compressibility and expansivity of a substance are respectively given by ($\beta_T = aT^2/P^2$) and ($\alpha = bT/P$), where 'a' and 'b' are constants, T and P and temperature and pressure respectively. The equation of state for the system under consideration is

A. $V = V_o\left(\frac{\left(a+\frac{b}{2}\right)T^2}{P}\right)$ ✔

B. $V = V_o\left(\frac{(a+b)T^2}{P}\right)$

C. $V = V_o\left(\frac{(a+b)T}{P}\right)$

D. $V = V_o\left(\frac{(a+b)T^2}{P^2}\right)$

42. A thermally insulated container contains n moles of gas molecules having gas constant R molar mass M and the ratio of specific heats $\gamma = \frac{C_P}{C_V}$ if the temperature inside the container suddenly increases by ΔT, the velocity of the gas molecules would be

A. $v = \{[2r]/M(\gamma+1)\}^{1/2}$

B. $v = \{[2r]/M(\gamma-1)\}^{1/2}$ ✔

C. $v = \{[2r]/M(\gamma+1)^{(}1/2)\}^{1/2}$

D. unchanged

43. A Carnot engine operates at an efficiency of 60 %. If the sink temperature is 100 °C, the source temperature is closest to

A. 165 °C B. 250 °C C. 660 °C ✔ D. 930 °C

44. A collection of 3-dimensional isotropic simple harmonic oscillators is in equilibrium with a heat bath of temperature. The number of oscillators in the first excited state to that in the ground state is

A. $e^{\frac{0.5\hbar\omega}{K_BT}}$ B. $e^{\frac{\hbar\omega}{K_BT}}$ C. $3e^{\frac{\hbar\omega}{K_BT}}$ ✔ D. $\frac{1}{3}e^{\frac{\hbar\omega}{K_BT}}$

45. Suppose that the potential energy of a hypothetical atom consisting of a proton and electron is given by $U = -\frac{ke^2}{3r^3}$. Then if Bohr's postulates are applied to this atom, then the radius of the orbit will be proportional to

A. n^2 B. $\frac{1}{n^2}$ ✔ C. n^3 D. $\frac{1}{n^3}$

46. A moving hydrogen atom makes a head-on collision with a stationary hydrogen atom. Before collision both the atoms are in the ground state and after the collision, they stick and move together. What is the minimum value of the kinetic energy of the moving hydrogen atom, such that one of the atoms reaches one of the excited states?

A. 10.2eV B. 12.08eV C. 20.4eV ✔ D. 5.1eV

47. The mean momentum p of a nucleon in a nucleus of mass number A and atomic number Z depends on A,Z as

A. $p \propto A^{1/3}$ B. $p \propto A^{-1/3}$ ✔ C. $p \propto Z^{1/3}$ D. $p \propto AZ$

48. A system of 8 non interacting electron is confined by a three dimensional potential $V(r) = \frac{1}{2}mr^2\omega^2$. The ground state energy of the system in units of $\hbar\omega$

A. 18 ✔ B. 8 C. 16 D. 24

49. Which of the following is an acceptable spin-orbital for a two-electron system? ("α" and "β" represent spin-up and spin-down states respectively and labels "1" and "2" represent the two electrons)

A. $(1/\sqrt{2})[\alpha(1)\beta(2)+\alpha(2)\beta(1)]$ ✔
B. $(1/\sqrt{2})[\alpha(1)\beta(2)-\alpha(2)\beta(1)]$
C. $(1/\sqrt{2})[\alpha(1)+\beta(2)]$
D. $(1/\sqrt{2})[\alpha(1)\beta(2)]$

50. A photon of initial wavelength 0.4 Å suffers two successive collisions with two electrons. The deflection in the first collision is 90° and the deflection in the second collision is 60°. The final wavelength of the photon is:
A. 0.024 Å B. 0.012 Å C. 0.4 Å D. 0.436 Å ✔