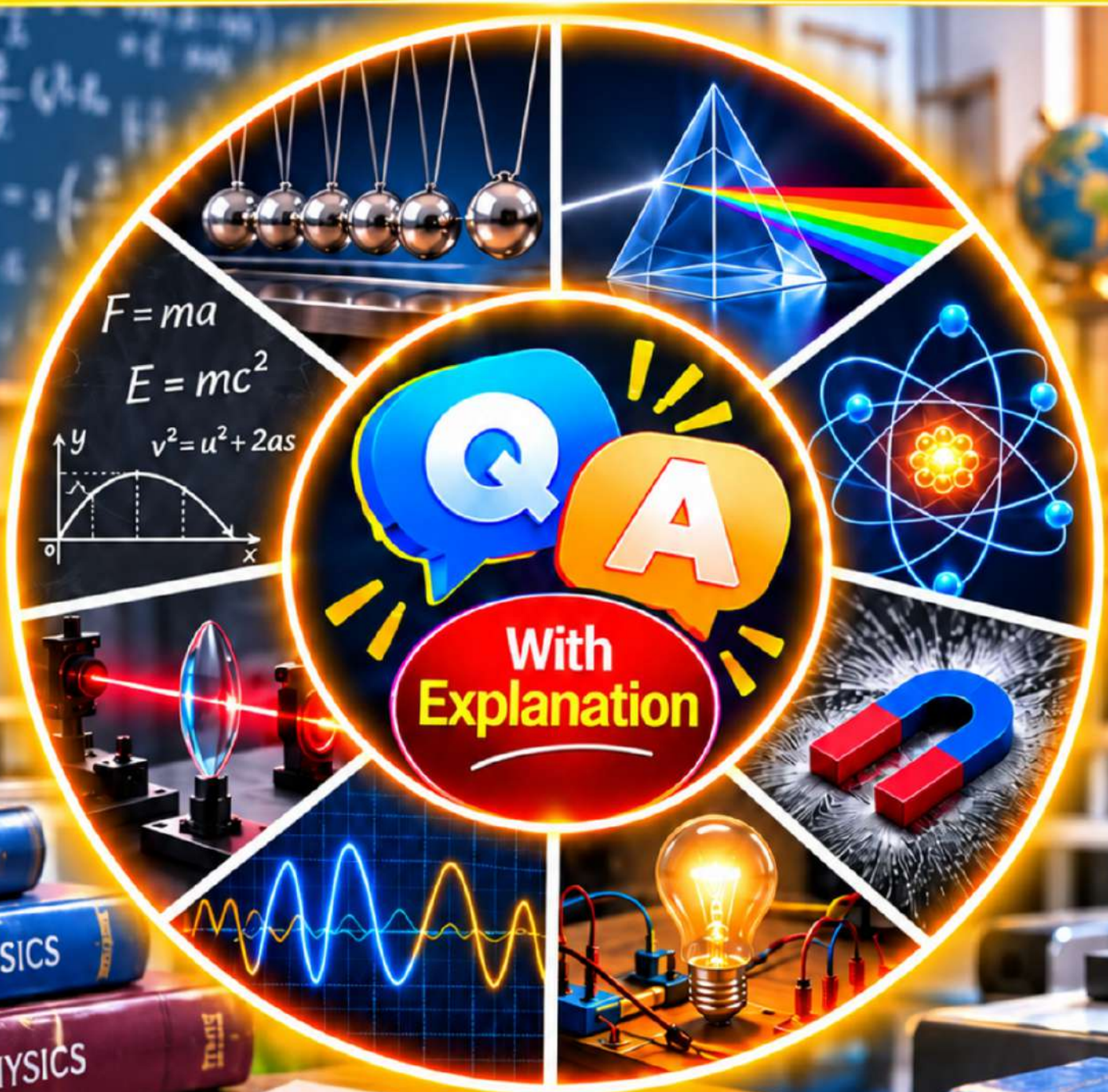
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POLYTECHNIC TRB

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PART - A

1. **The generating function of Hermite polynomial is:**

A. e^{2zx-z^2}

B. e^{z^2}

C. e^{2zx}

D. e^{2zx+z^2}

Answer: (A) e^{2zx-z^2}
Explanation:
The generating function for the Hermite polynomials $H_n(x)$ is

$$e^{2zx-z^2} = \sum_{n=0}^{\infty} H_n(x)\frac{z^n}{n!}.$$

Therefore, e^{2zx-z^2} is the standard generating function of the Hermite polynomials. Hence, option (A) is the correct answer.

2. The Laurent's series of given analytic function f(z) can be put in a uniform form as follows:

A. $\sum_{n=0}^{\infty} A_n (z-z_0)^n$

B. $\sum_{n=-\infty}^{\infty} A_n (z+z_0)^n$

C. $\sum_{n=0}^{\infty} A_n (z-z_n)$

D. $\sum_{n=-\infty}^{\infty} A_n (z-z_0)^n$

Answer: (D) $\sum_{n=-\infty}^{\infty} A_n (z-z_0)^n$

Explanation:
The Laurent series of a function about the point z_0 contains both positive and negative integral powers of $(z-z_0)$. Its general form is

$$f(z) = \sum_{n=-\infty}^{\infty} A_n (z-z_0)^n .$$

The terms corresponding to $n \geq 0$ form the regular or analytic part, while the terms corresponding to $n < 0$ form the principal part of the Laurent series. Therefore, option (D) is the correct answer.

3. The recurrence formula of $\mathbf{J_n'}(x)$ is equal to:

A. $\frac{n}{x}J_n(x) + J_{n-1}(x)$

B. $\frac{n}{x}J_n(x) - J_{n-1}(x)$

C. $-\frac{n}{x}J_n(x) + J_{n+1}(x)$

D. $J_{n-1}(x) - \frac{n}{x}J_n(x)$

Answer: (D) $J_{n-1}(x) - \frac{n}{x}J_n(x)$

Explanation:
For the Bessel function $J_n(x)$, the standard recurrence relation is

$$J_n'(x) = J_{n-1}(x) - \frac{n}{x}J_n(x).$$

Therefore, option (D) is the correct answer.

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4. The equation is of the form

$$\frac{d^2y}{dx^2}+\frac{1}{x}\frac{dy}{dx}+\left(1-\frac{n^2}{x^2}\right)y=0$$

may be solved by the method of series integration as allowed by :

A. Integral theorem

B. Liouville's theorem

C. Fuchs' theorem

D. Contour integration

Answer: (C) Fuchs' theorem

Explanation:
The given differential equation is Bessel's differential equation. The point $x = 0$ is a regular singular point of this equation. The Frobenius series method can be applied around a regular singular point under the conditions associated with Fuchs' theorem. Therefore, the equation can be solved by series integration as allowed by Fuchs' theorem. Hence, option (C) is the correct answer.

5. The Hermite polynomials are specifically useful in analysing the quantum mechanical problem of :

A. Square well potential

B. Harmonic oscillator

C. Rigid rotator

D. Particle in a box

Answer: (B) Harmonic oscillator

Explanation:
Hermite polynomials occur naturally in the solution of the Schrödinger equation for the quantum mechanical harmonic oscillator. After introducing a suitable dimensionless variable and separating the Gaussian factor from the wave function, the remaining differential equation becomes the Hermite differential equation. Its acceptable solutions are Hermite polynomials. Therefore, option (B) is the correct answer.

6. Dyadic tensor is a tensor of rank :

A. Two

B. One

C. Zero

D. Three

Answer: (A) Two

Explanation:
A dyadic is formed from the product of two vectors and has two indices. A tensor with two indices is called a second-rank or rank-two tensor. Therefore, a dyadic tensor is a tensor of rank two. Hence, option (A) is the correct answer.

7. The group of order 3 is :

A. always non-cyclic

B. always cyclic

C. may or may not be cyclic

D. cyclic under some condition

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Answer: (B) always cyclic

Explanation:
The order of the given group is 3, which is a prime number. Every finite group whose order is a prime number is cyclic. If G has order 3, any element other than the identity must have order 3, and that element generates the entire group. Therefore, a group of order 3 is always cyclic. Hence, option (B) is the correct answer.

8. What is the value of $\Gamma(\mathbf{0})$?

A. 0

B. 1

C. π

D. ∞

Answer: (D) ∞

Explanation:
The value of the gamma function at zero, $\Gamma(0)$, is undefined because $\lim_{x\to 0^+}\Gamma(x) = +\infty$. Therefore, the correct option is (D) ∞

9. The operator that relates the dielectric displacement vector with the electric vector of an electromagnetic wave in an isotropic medium is a physical example of :

A. scalar

B. vector

C. dyadic

D. triadic

Answer: (A) scalar

Explanation:
In an isotropic medium, the permittivity is a scalar quantity. Therefore,

$$\mathbf{D} = \varepsilon\mathbf{E}.$$

Hence, the operator relating the electric displacement vector $\mathbf{D}$ and the electric field vector $\mathbf{E}$ is a scalar. Therefore, option (A) is the correct answer.

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10. If $\mathbf{A}^{\mu}$ and $\mathbf{B}_{\mu}$ are the components of a contravariant and covariant tensors, what is the nature of the quantity $\mathbf{A}^{\mu}\mathbf{B}_{\mu}$?

A. scalar (tensor of rank 0)

B. mixed tensor of rank 2

C. covariant tensor of rank 1

D. contravariant tensor of rank 2

Answer: (A) scalar (tensor of rank 0)

Explanation:
Under the Einstein summation convention, the repeated index in the product

$$A^{\mu}B_{\mu}$$

is contracted. Contracting one contravariant index with one covariant index produces a scalar, i.e. a rank-0 tensor. Therefore, option (A) is the correct answer.

11. The Hermite's polynomial of degree n, the value of $\mathbf{H_n(0)}$ =0 if n is an :

A. even integer

B. odd integer

C. zero

D. even or odd integer

Answer: (B) odd integer
Explanation:
Hermite polynomials satisfy the parity property

$$H_n(-x) = (-1)^n H_n(x).$$

When n is an odd integer, $H_n(x)$ is an odd function. The value of every odd function at the origin is zero. Therefore,

$$H_n(0) = 0$$

when n is an odd integer. Hence, the correct answer is odd integer.

12. In the Cauchy's integral formula

$$\mathbf{f\,(z_0) = \frac{1}{2\pi i}\int_C \frac{f(z)}{z - z_0} dz}$$

the value of $\mathbf{z_0}$ is considered :

A. Any point within C

B. At particular points within C

C. At all points within C

D. Any point within C, At particular points within C, At all points within C

Answer: (A) Any point within C
Explanation:
According to Cauchy's integral formula, if $f(z)$ is analytic on and inside a simple closed contour C, then

$$f\,(z_0) = \frac{1}{2\pi i}\int_C \frac{f(z)}{z - z_0} dz$$

for any point z_0 lying inside the contour C. Thus, z_0 can be any point within C, provided the required analyticity conditions are satisfied. Hence, the correct answer is any point within C.

13. The importance of Cauchy Residue theorem is :

A. For evaluating complex integrals

B. For evaluating real integrals

C. For evaluating complex and real integrals

D. For evaluating imaginary integrals

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Answer: (C) For evaluating complex and real integrals
Explanation:
The Cauchy Residue theorem is mainly used to evaluate contour integrals of complex functions by calculating the residues of singularities enclosed by a contour. It can also be applied to evaluate many real definite integrals by extending the real function into the complex plane and selecting a suitable contour. Therefore, the theorem is useful for evaluating both complex and real integrals.

14. A cyclic group is generated by a :

A. Multiple elements

B. Double elements

C. Zero element

D. Single element

Answer: (D) Single element
Explanation:
A cyclic group is a group that can be generated by a single element. If a is a generator of a cyclic group G, then every element of G can be expressed as a power of a. Thus,

$$G = \langle a \rangle.$$

Therefore, only one element is required to generate a cyclic group. Hence, the correct answer is single element.

15. The group D_3 has the following classes :

A. One

B. Four

C. Two

D. Three

Answer: (D) Three
Explanation:
The dihedral group D_3 represents the symmetries of an equilateral triangle and contains six elements. These elements can be divided into three conjugacy classes. They consist of the identity element, the two non-trivial rotations, and the three reflections. These classes can be represented as

$$\{e\},\ \left\{r, r^2\right\},\ \left\{s, sr, sr^2\right\}.$$

Therefore, the group D_3 has three classes.

16. **The orthogonality theorem for the characters of irreducible representation can immediately transform by setting :**

A. $\nu = \mu$ and $\beta = \alpha$

B. $v = \alpha$ and $\beta = \mu$

C. Both $v = \alpha\mu$

D. $v = \alpha\mu$ and $\beta = \alpha\mu$

Answer: (A) $\nu = \mu$ and $\beta = \alpha$
Explanation:
The orthogonality theorem for characters is obtained from the great orthogonality theorem for the matrix elements of irreducible representations. By appropriately equating the corresponding indices and summing over the diagonal matrix elements, the relation can be transformed into the character orthogonality relation.

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In the notation given in the question, the required setting is $\nu = \mu$ and $\beta = \alpha$. Hence, option (A) is correct.

17. **If ϕ and $\bar{\phi}$ is a system of variables of x^μ and $\bar{x}^\mu$. Then $\bar{\phi}$=ϕ is only:**

    A. A tensor of order four

    B. A tensor of order two

    C. A tensor of order one

    D. A tensor of order zero

Answer: (D) A tensor of order zero
Explanation:
If a quantity remains unchanged under a coordinate transformation, it is called a scalar. The given transformation relation is

$$\bar{\phi} = \phi.$$

This shows that the value of ϕ remains invariant when the coordinate system changes from x^μ to $\bar{x}^\mu$. A scalar is defined as a tensor of order zero. Therefore, ϕ is a tensor of order zero.

18. **The total number of independent components of a symmetric second-rank tensor is :**

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

    B. $\frac{n(n-1)}{2}$

    C. $\frac{n\left(n^2+1\right)}{2}$

    D. $\frac{n\left(n^2-1\right)}{2}$

Answer: (A) $\frac{n(n+1)}{2}$
Explanation:
For a symmetric second-rank tensor, the components satisfy

$$T_{ij} = T_{ji}.$$

In n dimensions, a general second-rank tensor has n^2 components. For a symmetric tensor, the n diagonal components are independent, while the off-diagonal components occur in equal pairs. Hence, the number of independent components is

$$n + \frac{n(n-1)}{2} = \frac{n(n+1)}{2}.$$

Therefore, the total number of independent components of a symmetric tensor is $\frac{n(n+1)}{2}$.

19. The fundamental property of a gamma function is :

    A. $\Gamma(n) = (n-1)\Gamma(n-1)$

    B. $\Gamma(n) = (n+1)\Gamma(n-1)$

    C. $\Gamma(n) = (n-1)\Gamma(n+1)$

    D. $\Gamma(n) = (n+1)\Gamma(n+1)$

Answer: (A) $\Gamma(n) = (n-1)\Gamma(n-1)$
Explanation:
The Gamma function satisfies an important recurrence relation given by

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$$\Gamma(n) = (n-1)\Gamma(n-1).$$

More generally,

$$\Gamma(z+1) = z\Gamma(z).$$

For positive integers, this property also gives

$$\Gamma(n) = (n-1)!.$$

Therefore, the fundamental property of the Gamma function is $\Gamma(n) = (n-1)\Gamma(n-1)$.

20. The integral representation of gamma function is given by :

A. $\Gamma(n) = \int_0^{\infty} e^{-x^2} x^{n-1} dx$

B. $\Gamma(n) = \int_0^{\pi} e^{-x^2} x^{n-1} dx$

C. $\Gamma(n) = \int_0^{\infty} e^{-x} x^{n-1} dx$

D. $\Gamma(n) = \int_0^{-\infty} e^{2} x^{n-1} dx$

Answer: (C) $\Gamma(n) = \int_0^{\infty} e^{-x} x^{n-1} dx$
Explanation:
The Gamma function is defined by the improper integral

$$\Gamma(n) = \int_0^{\infty} e^{-x} x^{n-1} dx$$

for $n > 0$. This integral representation extends the factorial function to non-integer and complex values. For a positive integer n,

$$\Gamma(n) = (n-1)!.$$

Therefore, option (C) gives the standard integral representation of the Gamma function.

21. According to uncertainty relation the minimum uncertainty in the velocity of the electron orbiting around the nucleus of radius r is : ($\hbar$=**h**/**2**π)

A. $\frac{\hbar}{2\pi mr}$

B. $\frac{\hbar}{2mr}$

C. $2hmr$

D. 0

Answer: (B) $\frac{\hbar}{2mr}$
Explanation:
According to Heisenberg's uncertainty principle,

$$\Delta x \Delta p \geq \frac{\hbar}{2}.$$

For an electron confined approximately within a distance r, we take

$$\Delta x \approx r.$$

Since momentum is $p = mv$,

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$$\Delta p = m\Delta v.$$

Therefore,

$$r(m\Delta v) \geq \frac{\hbar}{2}.$$

Hence, the minimum uncertainty in velocity is

$$\Delta v_{\min} = \frac{\hbar}{2mr}.$$

Therefore, option (B) is the correct answer.

22. According to Schrodinger, a particle is equivalent to a :

A. wave packet

B. single wave

C. light wave

D. double wave

Answer: (A) wave packet
Explanation:
In quantum mechanics, a localized particle cannot be represented adequately by a single monochromatic wave because such a wave extends throughout space. A localized particle is represented by a superposition of several waves having different wavelengths and frequencies. This superposition forms a wave packet. The wave packet provides a localized description of the quantum particle. Therefore, a particle is equivalent to a wave packet.

23. **If $\mathbf{E_0}$ is the zero-point energy of a harmonic oscillator of frequency ν and h is Planck's constant then its energy in the n=2 state will be :**

A. $(E_0 + h\nu)$

B. $2E_0$

C. $4E_0$

D. $(E_0 + 2h\nu)$

Answer: (D) $(E_0 + 2h\nu)$
Explanation:
The energy levels of a quantum harmonic oscillator are given by

$$E_n = \left(n + \frac{1}{2}\right) h\nu.$$

The zero-point energy is

$$E_0 = \frac{1}{2}h\nu.$$

For the state $n = 2$,

$$E_2 = \left(2 + \frac{1}{2}\right) h\nu = \frac{5}{2}h\nu.$$

Since $E_0 = \frac{1}{2}h\nu$, this can be written as

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$$E_2 = E_0 + 2h\nu.$$

Therefore, option (D) is the correct answer.

24. **In case of Hydrogen atom the total degeneracy of the state of specified N** (excluding spin) **is given by :**

A. $N = n(2L + 1)$

B. $N = n^2$

C. $N = 1(1 + 1)$

D. $N = (2L + 1)$

Answer: (B) $N = n^2$
Explanation:
For a hydrogen atom, for a specified principal quantum number n, the orbital quantum number can take the values

$$l = 0, 1, 2, \ldots, n - 1.$$

For each value of l, the magnetic quantum number has $2l + 1$ possible values. Therefore, the total degeneracy is

$$\sum_{l=0}^{n-1} (2l + 1) = n^2$$

Thus, when electron spin is not included, the total degeneracy of a hydrogen energy level specified by n is n^2. Therefore, option (B) is the correct answer.

25. The equation representing the Ehrenfest relation is :

A. $\frac{d}{dx}\langle\overrightarrow{p}\rangle = -\langle\nabla V\rangle$

B. $\frac{d}{dt}\langle\overrightarrow{p}\rangle = -\langle\nabla V\rangle$

C. $\frac{d}{dt}\langle\overrightarrow{p}\rangle = -i\hbar\langle\nabla V\rangle$

D. $\frac{d}{dt}\langle\overrightarrow{p}\rangle = i\hbar(\nabla V)$

Answer: (B) $\frac{d}{dt}\langle\overrightarrow{p}\rangle = -\langle\nabla V\rangle$
Explanation:
Ehrenfest's theorem establishes a connection between quantum mechanics and classical mechanics. For the expectation value of momentum, the theorem gives

$$\frac{d}{dt}\langle\overrightarrow{p}\rangle = -\langle\nabla V\rangle.$$

Since the classical force is

$$\overrightarrow{F} = -\nabla V,$$

the rate of change of the expectation value of momentum is equal to the expectation value of the force. Therefore, option (B) represents the Ehrenfest relation.

26. The normalized wave function for a particle in a rectangular box of dimensions a,b,c is :

A. $\psi_n = \left[\sqrt{\frac{abc}{4}}\right] \sin\left(\frac{n_x\pi x}{a}\right) \sin\left(\frac{n_y\pi y}{b}\right) \sin\left(\frac{n_z\pi z}{c}\right)$

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B. $\psi_n = \left[\sqrt{\frac{2}{abc}}\right] \sin\left(\frac{n_x \pi x}{a}\right) \sin\left(\frac{n_y \pi y}{b}\right) \sin\left(\frac{n_z \pi z}{c}\right)$

C. $\psi_n = \left[\sqrt{\frac{4}{abc}}\right] \sin\left(\frac{n_x \pi x}{a}\right) \sin\left(\frac{n_y \pi y}{b}\right) \sin\left(\frac{n_z \pi z}{c}\right)$

D. $\psi_n = \left[\sqrt{\frac{8}{abc}}\right] \sin\left(\frac{n_y \pi y}{b}\right) \sin\left(\frac{n_z \pi z}{c}\right) \sin\left(\frac{n_x \pi x}{a}\right)$

Answer: (D) $\psi_n = \sqrt{\frac{8}{abc}} \sin\left(\frac{n_y \pi y}{b}\right) \sin\left(\frac{n_z \pi z}{c}\right) \sin\left(\frac{n_x \pi x}{a}\right)$
Explanation:
For a particle confined in a three-dimensional rectangular box of dimensions a, b, and c, the wave function is obtained as the product of the normalized wave functions along the three coordinate directions. Thus,

$$\psi_n = \sqrt{\frac{8}{abc}} \sin\left(\frac{n_x \pi x}{a}\right) \sin\left(\frac{n_y \pi y}{b}\right) \sin\left(\frac{n_z \pi z}{c}\right).$$

The normalization constant $\sqrt{8/(abc)}$ ensures that the total probability of finding the particle inside the box is unity. Therefore, option (D) is the correct answer.

27. The rigid rotator wave functions are the spherical harmonics of :

A. $Y_{lm}(\theta, \phi)$

B. $Y_{lm}(r, \phi)$

C. $Y_{lm}(\theta, r)$

D. $Y_{lm}\,(m_s, \phi)$

Answer: (A) $Y_{lm}(\theta, \phi)$
Explanation:
The quantum mechanical rigid rotator describes rotational motion at a fixed radial distance. Therefore, its wave function depends only on the angular coordinates θ and ϕ. The solutions of the angular part of the Schrödinger equation are the spherical harmonics,

$$Y_{lm}(\theta, \phi).$$

Here, l is the orbital angular momentum quantum number and m is the magnetic quantum number. Therefore, option (A) is the correct answer.

28. Which one of the following is the eigen value in this equation

$$\frac{de^{kx}}{dx} = ke^{kx}?$$

A. d

B. x

C. kx

D. k

Answer: (D) k
Explanation:
An eigenvalue equation has the general form

$$\widehat{A}\psi = \lambda\psi,$$

where $\widehat{A}$ is an operator, ψ is an eigenfunction, and λ is the corresponding eigenvalue. Here,

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$$\frac{d}{dx}e^{kx} = ke^{kx}.$$

Thus, e^{kx} is an eigenfunction of the differential operator d/dx, and the constant multiplying the same function after the operation is k. Therefore, k is the eigenvalue.

29. **The spin function of a free particle, in the base S in which S_z is diagonal, can be written as**

$$\begin{pmatrix}\mathbf{1}\\\mathbf{0}\end{pmatrix} \text{ and } \begin{pmatrix}\mathbf{0}\\\mathbf{1}\end{pmatrix}$$

with eigen values $+\hbar/2$ and $-\hbar/2$ respectively. In the given basis, the normalized eigen function of S_y with eigen value $-\hbar/2$.

A. $\frac{1}{\sqrt{2}}\begin{pmatrix}1\\i\end{pmatrix}$

B. $\frac{1}{\sqrt{2}}\begin{pmatrix}0\\i\end{pmatrix}$

C. $\frac{1}{\sqrt{2}}\begin{pmatrix}i\\0\end{pmatrix}$

D. $\frac{1}{\sqrt{2}}\begin{pmatrix}i\\1\end{pmatrix}$

Answer: (D) $\frac{1}{\sqrt{2}}\begin{pmatrix}i\\1\end{pmatrix}$
Explanation:
For a spin- $\frac{1}{2}$ particle, the y-component of the spin operator is

$$S_y = \frac{\hbar}{2}\begin{pmatrix}0 & -i\\ i & 0\end{pmatrix}.$$

For the eigenvalue $-\hbar/2$, the normalized eigenvector can be written as

$$\chi_{-}^{(y)} = \frac{1}{\sqrt{2}}\begin{pmatrix}i\\1\end{pmatrix}.$$

Multiplication of a quantum state by an overall phase factor does not change its physical state. Therefore, the normalized eigenfunction given in option (D) represents the required state.

30. The periodic arrangement of potential cells and potential barriers in Kronig-Penney Model gives the barrier strength V_0b. Which one of the following equation represents the scattering power of the potential barrier ?

A. $P = \frac{mV_0a^2b}{\hbar}$

B. $P = \frac{mV_0a^2b}{\hbar^2}$

C. $P = \frac{mV_0ab}{\hbar^2}$

D. $P = \frac{mV_0^2ab}{\hbar^2}$

Answer: (C) $P = \frac{mV_0ab}{\hbar^2}$
Explanation:
In the Kronig-Penney model, electrons move through a one-dimensional periodic potential consisting of alternating potential wells and barriers. For a narrow barrier of height V_0 and width b, its strength is characterized by the product V_0b. The dimensionless scattering power is expressed as

$$P = \frac{mV_0ab}{\hbar^2},$$

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where m is the mass of the electron, a is the characteristic lattice spacing, and $\hbar$ is the reduced Planck constant. Therefore, option (C) is the correct answer.

31. Which of the following statement is incorrect ?

A. Electric force between two charged particles is directly proportional to the product of their charges

B. Electric force between two charged particles is inversely proportional to the square of the distance between them

C. Electric force between two charged particles is directed along the line joining between them

D. Electric force between two charged particles is attractive for like charges and repulsive for unlike charges

Answer: (D) Electric force between two charged particles is attractive for like charges and repulsive for unlike charges

Explanation:
According to Coulomb's law, the magnitude of the electric force between two point charges is

$$F = \frac{1}{4\pi\varepsilon_0}\frac{|q_1 q_2|}{r^2}.$$

Thus, the force is directly proportional to the product of the charges and inversely proportional to the square of the distance between them. It acts along the line joining the two charges. Like charges repel each other, while unlike charges attract each other. Therefore, the statement in option (D) reverses the actual behaviour and is incorrect.

32. If medium 1 is dielectric and medium 2 is a perfect conductor with charge at surface, then the normal component of the flux density at a dielectric conductor boundary is equal to :
Where ρ_S= Surface charge density.

A. $D_{n1} + D_{n2} = 0$

B. $D_{n1} - D_{n2} = 0$

C. $D_{n1} = \rho_S$

D. $D_{n2} = \rho_S$

Answer: (C) $D_{n1} = \rho_S$
Explanation:
The boundary condition for the normal component of electric flux density is

$$D_{n1} - D_{n2} = \rho_S.$$

Inside a perfect conductor, the electric field and hence the electric flux density are zero. Therefore,

$$D_{n2} = 0.$$

Substituting this into the boundary condition gives

$$D_{n1} = \rho_S.$$

Thus, the normal component of electric flux density immediately outside the conductor is equal to the surface charge density.

33. Ampere's circuital law is :

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A. $\oint_C \overrightarrow{B} \cdot d\overrightarrow{l} = \oint_S \overrightarrow{J} \cdot d\overrightarrow{S}$

B. $\oint_C \overrightarrow{B} \cdot d\overrightarrow{l} = \mu_0 \int_S \overrightarrow{J} \cdot d\overrightarrow{S}$

C. $\oint_C \overrightarrow{H} \cdot d\overrightarrow{l} = \mu_0 \oint_S \overrightarrow{J} \cdot d\overrightarrow{S}$

D. $\oint_C \overrightarrow{H} \cdot d\overrightarrow{l} = 0$

Answer: (B) $\oint_C \overrightarrow{B} \cdot d\overrightarrow{l} = \mu_0 \int_S \overrightarrow{J} \cdot d\overrightarrow{S}$

Explanation:

Ampere's circuital law states that the line integral of the magnetic field around a closed path is proportional to the total current enclosed by that path. In free space,

$$\oint_C \overrightarrow{B} \cdot d\overrightarrow{l} = \mu_0 I_{\text{enclosed}}$$

The enclosed current can be expressed in terms of current density as

$$I_{\text{enclosed}} = \int_S \overrightarrow{J} \cdot d\overrightarrow{S}$$

Therefore,

$$\oint_C \overrightarrow{B} \cdot d\overrightarrow{l} = \mu_0 \int_S \overrightarrow{J} \cdot d\overrightarrow{S}.$$

Hence, option (B) is the correct answer.

34. The electric field outside the conductor having surface charge density s is :

A. $\frac{\sigma}{\varepsilon_0}$

B. $\frac{\sigma}{2\varepsilon_0}$

C. 0

D. $\frac{4\sigma_0}{3}$

Answer: (A) $\frac{\sigma}{\varepsilon_0}$

Explanation:

For a conductor in electrostatic equilibrium, the electric field inside the conductor is zero. Applying Gauss's law to a small Gaussian pillbox across the surface of the conductor gives

$$E_{\text{outside}} - E_{\text{inside}} = \frac{\sigma}{\varepsilon_0}.$$

Since

$$E_{\text{inside}} = 0,$$

we obtain

$$E_{\text{outside}} = \frac{\sigma}{\varepsilon_0}.$$

Therefore, the electric field immediately outside the charged conductor is σ/ε_0.

35. The speed (v) of electromagnetic waves in isotropic dielectrics is :

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A. $[\varepsilon\mu]^{1/2}$

B. $[\varepsilon_0\mu_0]^{-1/2}$

C. $[\varepsilon\mu]^{-1/2}$

D. $[\varepsilon\mu]$

Answer: (C) $[\varepsilon\mu]^{-1/2}$
Explanation:
The velocity of propagation of an electromagnetic wave through an isotropic dielectric medium depends upon the permittivity ε and permeability μ of the medium. It is given by

$$v = \frac{1}{\sqrt{\varepsilon\mu}}.$$

This can also be expressed as

$$v = [\varepsilon\mu]^{-1/2}.$$

Therefore, option (C) is the correct answer.

36. The intrinsic impedance (η) for partially conducting medium is :

A. $\eta = \sqrt{\frac{j\omega\mu}{\sigma+j\omega\varepsilon}}$

B. $\eta = \sqrt{\frac{\mu\omega}{\sigma}}\angle 45°$

C. $\eta = \sqrt{\frac{\mu}{\varepsilon}}$

D. $\eta = \sqrt{\frac{\mu}{\varepsilon_0}}$

Answer: (A) $\eta = \sqrt{\frac{j\omega\mu}{\sigma+j\omega\varepsilon}}$
Explanation:
The intrinsic impedance of a general conducting medium is the ratio of the electric field intensity to the magnetic field intensity. For a medium having conductivity σ, permittivity ε, permeability μ, and angular frequency ω, it is

$$\eta = \sqrt{\frac{j\omega\mu}{\sigma + j\omega\varepsilon}}.$$

This expression is applicable to a partially conducting or lossy dielectric medium. Therefore, option (A) is the correct answer.

37. The radiation resistance of a linear antenna [Half wave antenna] is:

A. 78.1 Ohms

B. 73.1 Ohms

C. 36.5 Ohms

D. 219.3 Ohms

Answer: (B) 73.1 Ohms
Explanation:
A half-wave dipole is a linear antenna whose total length is approximately one-half of the operating wavelength. The radiation resistance at its feed point for an ideal thin half-wave dipole in free space is approximately

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$$R_r = 73.1\Omega.$$

Radiation resistance represents the equivalent resistance through which the same amount of power would be dissipated as the power actually radiated by the antenna. Therefore, option (B) is the correct answer.

38. The relationship between magnetic field $\overrightarrow{\mathbf{B}}$ and magnetic scalar potential $\phi_{\mathbf{m}}$ is :

A. $\overrightarrow{H} = \nabla \cdot \phi_m$

B. $\overrightarrow{H} = -\nabla \cdot \phi_m$

C. $\overrightarrow{H} = -\nabla\phi_m$

D. $\overrightarrow{H} = \nabla\phi_m$

Answer: (C) $\overrightarrow{H} = -\nabla\phi_m$
Explanation:
In a region where the magnetic field can be represented using a magnetic scalar potential, the field is obtained from the negative gradient of the scalar potential. Thus,

$$\overrightarrow{H} = -\nabla\phi_m.$$

The negative sign indicates that the magnetic field is directed toward decreasing values of the magnetic scalar potential. Therefore, according to the notation used in the question, option (C) is the correct answer.

39. For steady (direct current), which of the following is incorrect ?

A. $\overrightarrow{\nabla} \cdot \overrightarrow{J} = 0$

B. $\Sigma I = 0$

C. $\oint_S \overrightarrow{J} \cdot d\overrightarrow{S} \neq 0$

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

Answer: (C) $\oint_S \overrightarrow{J} \cdot d\overrightarrow{S} \neq 0$
Explanation:
The continuity equation for electric current is

$$\nabla \cdot \overrightarrow{J} = -\frac{\partial \rho}{\partial t}.$$

For steady direct current, the charge density does not change with time. Therefore,

$$\frac{\partial \rho}{\partial t} = 0$$

and consequently

$$\nabla \cdot \overrightarrow{J} = 0.$$

Using the divergence theorem, this also gives

$$\oint_S \overrightarrow{J} \cdot d\overrightarrow{S} = 0.$$

Hence, the statement that this closed surface integral is not equal to zero is incorrect. Therefore, option (C) is the correct answer.

40. The skin depth ' δ ' or depth of penetration in a conducting medium is :

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A. $\delta = [\pi F \mu \sigma]^{1/2}$

B. $\delta = [\pi F \mu \sigma]^{-1/2}$

C. $\delta = \frac{1}{\sqrt{2\pi F \mu \sigma}}$

D. $\delta = \sqrt{\frac{2}{\mu \sigma F}}$

Answer: (B) $\delta = [\pi F \mu \sigma]^{-1/2}$

Explanation:

Skin depth is the distance inside a conductor at which the amplitude of an electromagnetic field falls to $1/e$ of its value at the surface. For a good conductor,

$$\delta = \sqrt{\frac{2}{\omega \mu \sigma}}.$$

Since

$$\omega = 2\pi F,$$

we obtain

$$\delta = \sqrt{\frac{2}{2\pi F \mu \sigma}} = \frac{1}{\sqrt{\pi F \mu \sigma}}.$$

Therefore,

$$\delta = [\pi F \mu \sigma]^{-1/2}.$$

Hence, option (B) is the correct answer.

41. The system is found all the time in an equilibrium state is called :

A. Quasi-static process

B. Cyclical process

C. Isobaric process

D. Isentropic process

Answer: (A) Quasi-static process

Explanation:

A quasi-static process is a thermodynamic process that takes place extremely slowly, so that the system remains nearly in thermodynamic equilibrium at every stage. During such a process, variables such as pressure, volume and temperature have well-defined values throughout. Therefore, a system found all the time in an equilibrium state is said to undergo a quasi-static process.

42. **The S.I. unit of specific heat of a gas is :**

A. $JkgK^{-1}$

B. $Jkg^{-1}\ K^{-1}$

C. JkgK

D. $Jkg^{-1}\ K$

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Answer: (B) $Jkg^{-1}\ K^{-1}$
Explanation:
Specific heat capacity is the amount of heat required to raise the temperature of unit mass of a substance by one kelvin. It is expressed as

$$c = \frac{Q}{m\Delta T}.$$

Here, Q is measured in joules, m in kilograms and temperature in kelvin. Therefore, the S.I. unit of specific heat is

$$J\ kg^{-1}\ K^{-1}.$$

Hence, option (B) is the correct answer.

43. **Entropy of an isolated system during an irreversible process:**

    A. decreases

    B. constant

    C. increases

    D. no change

Answer: (C) increases
Explanation:
According to the second law of thermodynamics, an irreversible process involves entropy generation. For an irreversible process, the entropy generated within the system is positive. Thus,

$$S_{\text{gen}} > 0.$$

For an isolated system this directly means that its entropy increases. Hence, the characteristic entropy change associated with an irreversible process is an increase in entropy, making option (C) the correct answer.

44. **The total change in entropy of the working substance in a complete reversible process is :**

    A. 0

    B. 100

    C. 1

    D. 10

Answer: (A) 0
Explanation:
Entropy is a thermodynamic state function. In a complete reversible cyclic process, the working substance eventually returns to its initial thermodynamic state. Since the initial and final states are identical, the total change in entropy over the complete cycle is

$$\Delta S = 0.$$

Therefore, the total change in entropy of the working substance in a complete reversible process is zero.

45. **The value of Joule per calorie is :**

    A. 4.186 Joules/Calorie

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B. 4.523 Joules/Calorie

C. 5.210 Joules/Calorie

D. 2.100 Joules/Calorie

Answer: (A) 4.186 Joules/Calorie
Explanation:
The joule and calorie are both units of energy. The mechanical equivalent of heat establishes the relation between these two units. One calorie is approximately equivalent to

$$1cal = 4.186\ J.$$

Therefore, the value of Joule per calorie is approximately 4.186 Joules/Calorie. Hence, option (A) is the correct answer.

46. **The absorptive power of a perfect black body is :**

A. 1

B. 0

C. ∞

D. 0.97

Answer: (A) 1
Explanation:
The absorptive power of a body is defined as the ratio of the radiant energy absorbed by the body to the total radiant energy incident on it. A perfect black body absorbs all the radiation falling on it. Therefore,

$$a = \frac{\text{energy absorbed}}{\text{energy incident}} = 1.$$

Hence, the absorptive power of a perfect black body is unity, making option (A) the correct answer.

47. By the equipartition theorem, the molar specific heat of a diatomic gas at constant volume is given by :

A. $\frac{3}{2}R$

B. $\frac{1}{2}R$

C. $\frac{7}{2}R$

D. $\frac{5}{2}R$

Answer: (D) $\frac{5}{2}R$
Explanation:
At ordinary temperatures, a diatomic gas possesses three translational and two rotational degrees of freedom. Thus, the total number of active degrees of freedom is

$$f = 3 + 2 = 5.$$

According to the equipartition theorem, the molar specific heat at constant volume is

$$C_V = \frac{f}{2}R.$$

Therefore,

$$C_V = \frac{5}{2}R.$$

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Hence, option (D) is the correct answer.

48. When does Fermi dirac and Maxwell Boltzmann distribution functions becomes virtually the same ?

A. at high temperatures

B. at low temperatures

C. at room temperatures

D. at absolute temperature

Answer: (A) at high temperatures

Explanation:
The Fermi-Dirac distribution describes the statistical behaviour of fermions, whereas the Maxwell-Boltzmann distribution describes particles in the classical limit. At sufficiently high temperatures and low particle densities, quantum effects become negligible. Under these conditions, the Fermi-Dirac distribution approaches the Maxwell-Boltzmann distribution. Therefore, the two distribution functions become virtually the same at high temperatures.

49. **Among the following gases given below which one will exert the highest pressure at same N,V,T?**

A. a fermion gas

B. a boson gas

C. photon gas

D. phonon gas

Answer: (A) a fermion gas
Explanation:
Fermions obey the Pauli exclusion principle, which prevents identical fermions from occupying the same quantum state simultaneously. As particles are added, they must occupy progressively higher energy states. This produces an additional pressure known as degeneracy pressure. Consequently, under comparable quantum statistical conditions, a fermion gas exerts a higher pressure than a boson gas. Hence, option (A) is the correct answer.

50. **The specific heat of an ideal Fermi gas in three dimensions, at a very low temperature varies as :**

A. T

B. $T^{3/2}$

C. T^2

D. T^3

Answer: (A) T
Explanation:
At very low temperatures, only fermions lying close to the Fermi energy can be thermally excited. For a three-dimensional ideal Fermi gas in the low-temperature limit, the specific heat is proportional to the absolute temperature. Thus,

$$C_V \propto T.$$

More specifically,

$$C_V = \frac{\pi^2}{2} N k_B \frac{T}{T_F},$$

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for $T \ll T_F$, where T_F is the Fermi temperature. Therefore, the specific heat varies as T, making option (A) the correct answer.

51. Ultraviolet is the spectral region associated with absorption phenomena of :

A. Nuclear zeeman transitions

B. Vibrational transitions

C. Innercore electron transitions

D. Valence electron transitions

Answer: (D) Valence electron transitions
Explanation:
Ultraviolet spectroscopy mainly involves electronic transitions of valence electrons in atoms and molecules. When ultraviolet radiation is absorbed, valence electrons are promoted from lower energy orbitals to higher energy orbitals. Typical electronic transitions include

$$\sigma \rightarrow \sigma^*,\ n \rightarrow \sigma^*,\ \pi \rightarrow \pi^*,\ n \rightarrow \pi^*.$$

Therefore, ultraviolet absorption phenomena are mainly associated with valence electron transitions.

52. For an individual atom or molecule, the Doppler shifted absorption frequency is given by :

A. $\nu = \frac{1}{2\pi\tau}$

B. $\nu = \nu_0 \left(1 \pm \frac{v}{c}\right)$

C. $\nu = \frac{1}{\nu_0} \left(1 \pm \frac{v}{c}\right)$

D. $\nu = 2\nu_0 \left(1 \pm \frac{v}{c}\right)$

Answer: (B) $\nu = \nu_0 \left(1 \pm \frac{v}{c}\right)$
Explanation:
Due to the Doppler effect, the frequency of radiation observed by an atom or molecule depends upon its motion relative to the source. For velocities much smaller than the speed of light, the Doppler shifted frequency is approximately

$$\nu = \nu_0 \left(1 \pm \frac{v}{c}\right),$$

where ν_0 is the natural frequency, v is the relative velocity and c is the velocity of light. The sign depends upon whether the atom or molecule moves toward or away from the radiation source. Therefore, option (B) is the correct answer.

53. The frequency of the light emitted by the moving (move towards as well as far from the observer) atom is related to the natural frequency ν_0 by :

A. $\nu = \frac{1}{\nu_0} \left(1 \pm \frac{v}{c}\right)$

B. $\nu = \left(1 - \frac{v}{c}\right)$

C. $\nu = \left(1 + \frac{v}{c}\right)$

D. $\nu = \nu_0 \left(1 \pm \frac{v}{c}\right)$

Answer: (D) $\nu = \nu_0 \left(1 \pm \frac{v}{c}\right)$
Explanation:
When a light-emitting atom moves relative to an observer, the observed frequency changes because of the Doppler effect. For a velocity v much smaller than the speed of light c, the shifted frequency can be written approximately as

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$$\nu = \nu_0 \left(1 \pm \frac{v}{c}\right).$$

The observed frequency increases when the atom moves toward the observer and decreases when it moves away. Therefore, option (D) is the correct answer.

54. The irregular doublet law states that the difference between the square roots of the term values is :

A. not a constant and depends on the atomic number Z

B. a constant and independent of the atomic number Z

C. a constant and independent of the mass number A

D. a constant

Answer: (B) a constant and independent of the atomic number Z
Explanation:
The irregular doublet law is an empirical relation associated with the spectra of atoms and ions. It states that, for corresponding spectral terms, the difference between the square roots of the term values remains approximately constant and is independent of the atomic number Z. This relation is useful in comparing corresponding terms in related atomic spectra. Therefore, option (B) is the correct answer.

55. When the electron jumps any P-level to the lowest S-level (3s) it emits a line of :

A. Sharp series

B. Principal series

C. Diffuse series

D. Fundamental series

Answer: (B) Principal series
Explanation:
In the spectra of alkali atoms, different spectral series correspond to transitions between particular orbital states. The principal series is produced when an electron makes a transition from a higher P-state to the lowest S-state. Thus, transitions of the type

$$nP \to 3S$$

produce lines belonging to the principal series when $3S$ is the lowest S-level under consideration. Therefore, option (B) is the correct answer.

56. Rotational energy of a classical rotator is given by :

A. $\frac{1}{2}I\omega^3$

B. $\frac{1}{2}I\omega$

C. $\frac{1}{2}I\omega^2$

D. $\frac{h^2}{8\pi^2 I}J(J+1)$

Answer: (C) $\frac{1}{2}I\omega^2$
Explanation:
The rotational kinetic energy of a classical rigid body is analogous to the translational kinetic energy. For rotational motion, the moment of inertia I corresponds to mass and the angular velocity ω corresponds to linear velocity. Therefore, the rotational energy is

$$E_{rot} = \frac{1}{2}I\omega^2.$$

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The expression involving $J(J+1)$ represents the quantized rotational energy rather than the classical rotational energy. Hence, option (C) is the correct answer.

57. The term value corresponding to the zero-point energy of a harmonic oscillator is given by :

A. $\varepsilon_0 = \frac{1}{3}\bar{\nu}_0$

B. $\varepsilon_0 = \frac{1}{2}\bar{\nu}_0^2$

C. $\varepsilon_0 = \frac{1}{2}\bar{\nu}_0^3$

D. $\varepsilon_0 = \frac{1}{2}\bar{\nu}_0$

Answer: (D) $\varepsilon_0 = \frac{1}{2}\bar{\nu}_0$

Explanation:

For a quantum harmonic oscillator, the allowed vibrational energy levels are

$$E_v = \left(v + \frac{1}{2}\right) h\nu_0.$$

For the lowest state, $v = 0$, and therefore

$$E_0 = \frac{1}{2} h\nu_0.$$

When the energy is expressed in spectroscopic wavenumber units, the corresponding term value is

$$\varepsilon_0 = \frac{1}{2}\bar{\nu}_0.$$

Thus, even in its lowest state, the oscillator possesses a finite amount of energy called zero-point energy. Therefore, option (D) is the correct answer.

58. A normal vibration is defined as a molecular motion in which all the atoms move :

A. with the same frequency and fixed relative phase relationships

B. with different frequencies and arbitrary phase relationships

C. with the same amplitude but different frequencies

D. randomly with no fixed phase relationship

Answer: (A) with the same frequency and fixed relative phase relationships

Explanation:

A normal mode is a characteristic molecular motion in which all atoms oscillate with the same normal frequency. Their relative amplitudes and phase relationships remain fixed; the atoms need not all be in phase. Therefore, option (A) is the correct answer.

59. When radiation of frequency ν_0 is allowed to fall on molecule experience a varying electric field :

A. $E = E_0 cos\pi\nu_0 t$

B. $E = E_0 cos\pi\nu t$

C. $E = E_0 cos2\pi\nu_0 t$

D. $E = 2E_0 cos2\pi\nu_0 t$

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Answer: (C) $E = E_0 cos 2\pi\nu_0 t$

Explanation:

Electromagnetic radiation produces an oscillating electric field. If the radiation has frequency ν_0, its angular frequency is

$$\omega = 2\pi\nu_0.$$

The time-dependent electric field can therefore be represented as

$$E = E_0 cos(\omega t).$$

Substituting $\omega = 2\pi\nu_0$, we obtain

$$E = E_0 cos\left(2\pi\nu_0 t\right).$$

Therefore, option (C) is the correct answer.

60. The Nuclear magneton is defined by :

A. $\mu_N = \frac{e\hbar}{2m_P}$

B. $\mu_N = \frac{\hbar}{2m_p}$

C. $\mu_N = \frac{e\hbar}{3m_p}$

D. $\mu_N = \frac{e^2\hbar}{2m_p}$

Answer: (A) $\mu_N = \frac{e\hbar}{2m_P}$

Explanation:

The nuclear magneton is the standard unit used to express magnetic moments of atomic nuclei and nuclear particles. It is defined in terms of the elementary charge e, the reduced Planck constant $\hbar$, and the proton mass m_p as

$$\mu_N = \frac{e\hbar}{2m_p}.$$

Its value is approximately

$$\mu_N \approx 5.05 \times 10^{-27}\ J\ T^{-1}.$$

Therefore, option (A) is the correct answer.

61. In a crystal, the Miller indices of a plane are (hkl) = (233). The given plane intercepts the crystallographic axes at which of the following points ? (a,b,c are the cell dimensions along the three crystallographic axes).

A. $\frac{a}{2}, \frac{b}{3}, \frac{c}{3}$

B. $3a, 2b, 2c$

C. $2a, 3b, 3c$

D. $\frac{a}{3}, \frac{b}{2}, \frac{c}{2}$

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Answer: (A) $\frac{a}{2}, \frac{b}{3}, \frac{c}{3}$

Explanation:

The Miller indices of a crystal plane are obtained by taking the reciprocals of its intercepts along the crystallographic axes and reducing them to the smallest integers. For the plane (233), the standard intercepts corresponding directly to the Miller indices are proportional to

$$\frac{a}{2}, \frac{b}{3}, \frac{c}{3}.$$

Therefore, option (A) gives the correct intercepts.

62. If $\vec{a}_1, \vec{a}_2$ and $\vec{a}_3$ are the primitive vectors of a crystal lattice, then, the primitive vectors of the reciprocal lattice are given by:

A. $\vec{b}_1 = \frac{\pi}{2}\frac{\vec{a}_1 \times \vec{a}_2}{a_3}, \ \vec{b}_2 = \frac{\pi}{2}\frac{\vec{a}_2 \times \vec{a}_3}{a_1}, \ \vec{b}_3 = \frac{\pi}{2}\frac{\vec{a}_3 \times \vec{a}_1}{a_2}$

B. $\vec{b}_1 = \frac{\vec{a}_2 \times \vec{a}_3}{2}, \ \vec{b}_2 = \frac{\vec{a}_3 \times \vec{a}_1}{2}, \ \vec{b}_3 = \frac{\vec{a}_1 \times \vec{a}_2}{2}$

C. $\vec{b}_1 = \frac{\vec{a}_1 \times (\vec{a}_2 \times \vec{a}_3)}{\pi}, \ \vec{b}_2 = \frac{\vec{a}_2 \times (\vec{a}_3 \times \vec{a}_1)}{\pi}, \ \vec{b}_3 = \frac{\vec{a}_3 \times (\vec{a}_1 \times \vec{a}_2)}{\pi}$

D. $\vec{b}_1 = 2\pi\frac{\vec{a}_2 \times \vec{a}_3}{\vec{a}_1 \cdot (\vec{a}_2 \times \vec{a}_3)}, \ \vec{b}_2 = 2\pi\frac{\vec{a}_3 \times \vec{a}_1}{\vec{a}_1 \cdot (\vec{a}_2 \times \vec{a}_3)}, \ \vec{b}_3 = 2\pi\frac{\vec{a}_1 \times \vec{a}_2}{\vec{a}_1 \cdot (\vec{a}_2 \times \vec{a}_3)}$

Answer: (D) $\vec{b}_1 = 2\pi\frac{\vec{a}_2 \times \vec{a}_3}{\vec{a}_1 \cdot (\vec{a}_2 \times \vec{a}_3)}, \ \vec{b}_2 = 2\pi\frac{\vec{a}_3 \times \vec{a}_1}{\vec{a}_1 \cdot (\vec{a}_2 \times \vec{a}_3)}, \ \vec{b}_3 = 2\pi\frac{\vec{a}_1 \times \vec{a}_2}{\vec{a}_1 \cdot (\vec{a}_2 \times \vec{a}_3)}$

Explanation:

The reciprocal lattice vectors are defined so that

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

If the volume of the primitive unit cell is

$$V = \vec{a}_1 \cdot (\vec{a}_2 \times \vec{a}_3),$$

then the reciprocal lattice vectors are

$$\vec{b}_1 = 2\pi\frac{\vec{a}_2 \times \vec{a}_3}{V}, \ \vec{b}_2 = 2\pi\frac{\vec{a}_3 \times \vec{a}_1}{V}, \ \vec{b}_3 = 2\pi\frac{\vec{a}_1 \times \vec{a}_2}{V}.$$

Therefore, option (D) is the correct answer.

63. In a cubic crystal of lattice dimension a, a set of parallel planes have miller indices (110). The distance between two adjacent planes having miller indices (110) is given by :

A. $\frac{a}{\sqrt{2}}$

B. $\frac{a}{\sqrt{3}}$

C. $\sqrt{2}a$

D. $\sqrt{3}a$

Answer: (A) $\frac{a}{\sqrt{2}}$

Explanation:

For a cubic crystal, the interplanar spacing for planes having Miller indices (hkl) is

$$d_{hkl} = \frac{a}{\sqrt{h^2 + k^2 + l^2}}.$$

For the (110) planes,

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$$h = 1,\ k = 1,\ l = 0.$$

Therefore,

$$d_{110} = \frac{a}{\sqrt{1^2 + 1^2 + 0^2}} = \frac{a}{\sqrt{2}}.$$

Hence, option (A) is the correct answer.

64. Which of the following statements are correct about a ferromagnetic materials ?

(i) All ferromagnetic materials have spontaneous magnetization below Curie temperature.

(ii) All ferromagnetic materials can be converted into paramagnetic materials by heating above Curie temperature.

(iii) All ferromagnetic materials possess diamagnetism and paramagnetism at all temperatures.

A. (i) and (ii)

B. (ii) and (iii)

C. (i) and (iii)

D. (i) (ii) and (iii)

Answer: (A) (i) and (ii)

Explanation:

Ferromagnetic materials possess spontaneous magnetization below their Curie temperature because the atomic magnetic moments tend to align parallel to one another. When a ferromagnetic material is heated above its Curie temperature, thermal agitation destroys the long-range magnetic ordering and the material becomes paramagnetic. Statement (iii) is not correct because ferromagnetism is not simply simultaneous diamagnetism and paramagnetism at all temperatures. Therefore, statements (i) and (ii) are correct.

65. The value of Heisenberg exchange integral for an antiferromagnetic substance is given by :

A. $J = 0$

B. $J > 0$

C. $J < 0$

D. $J = 1$

Answer: (C) $J < 0$

Explanation:

In the conventional Heisenberg exchange Hamiltonian, the sign of the exchange integral J determines the preferred orientation of neighboring magnetic moments. A positive value favors parallel alignment and hence ferromagnetism, whereas a negative value favors antiparallel alignment. Antiferromagnetic substances are characterized by antiparallel ordering of neighbouring magnetic moments. Therefore,

$$J < 0.$$

Hence, option (C) is the correct answer.

66. Which of the following statements are correct about a ferroelectric material ?

(i) A ferroelectric material has an electric dipole moment when there is no electric field.

(ii) The positive and negative charge centres coincide with each other.

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(iii) It exhibits a hysteresis loop.

A. (i) and (ii)

B. (i) and (iii)

C. (ii) and (iii)

D. (i), (ii) and (iii)

Answer: (B) (i) and (iii)
Explanation:
A ferroelectric material possesses spontaneous electric polarization even in the absence of an externally applied electric field. Therefore, statement (i) is correct. In a polarized ferroelectric material, the centres of positive and negative charges do not coincide, so statement (ii) is incorrect. Ferroelectric materials also exhibit a characteristic polarization-electric field hysteresis loop. Hence, statement (iii) is correct. Therefore, statements (i) and (iii) are correct.

67. In a three dimensional lattice, a,b and c represent the dimensions of the unit cell. α,β and γ represent the angles between the cell axes. Which of the following have a=b=c and α=β=γ.

(i) Cubic and tetragonal

(ii) Cubic and trigonal

(iii) Cubic and hexagonal

A. (i) only

B. (i) and (ii)

C. (ii) only

D. (ii) and (iii)

Answer: (C) (ii) only
Explanation:
For the cubic crystal system,

$$a = b = c,\ \alpha = \beta = \gamma = 90^\circ.$$

For the trigonal or rhombohedral crystal system,

$$a = b = c,\ \alpha = \beta = \gamma \neq 90^\circ.$$

Thus, both cubic and trigonal systems satisfy the general conditions $a = b = c$ and $\alpha = \beta = \gamma$. Tetragonal and hexagonal systems do not have all three lattice parameters equal. Therefore, statement (ii) only is correct.

68. Which of the following statements are correct ?

(i) In Laue method, single crystal is used to study its structure.

(ii) In Powder crystal method, powdered crystal is used to study its structure.

(iii) In rotating crystal method, single crystal is used to study its structure.

A. (i) and (ii)

B. (ii) and (iii)

C. (i) and (iii)

D. (i), (ii) and (iii)

Professor Academy

Answer: (D) (i), (ii) and (iii)
Explanation:
In the Laue method, a stationary single crystal is exposed to polychromatic X-rays to investigate crystal symmetry and orientation. In the powder crystal method, a finely powdered crystalline specimen is used, providing many randomly oriented crystallites. In the rotating crystal method, a single crystal is rotated in a monochromatic X-ray beam. Therefore, all three statements are correct, making option (D) the scientifically correct answer.

69. In a cubic crystal, how many symmetry elements are present?

A. 10

B. 14

C. 22

D. 23

Answer: (D) 23
Explanation:
The cubic crystal system possesses a high degree of symmetry. In the conventional
counting of symmetry elements for the cubic system, there are a total of 23 symmetry elements, including axes of rotational symmetry, mirror planes and the centre of symmetry. This high symmetry is a characteristic feature of cubic crystals. Therefore, option (D), 23, is the correct answer.

70. Magnetic susceptibility of a ferromagnetic material is :

A. small and positive

B. small and negative

C. very large and positive

D. very large and negative

Answer: (C) very large and positive
Explanation:
Magnetic susceptibility χ measures the degree to which a material becomes magnetized when an external magnetic field is applied. In ferromagnetic materials, magnetic domains can align strongly with an applied field, producing a very large magnetization. Consequently,

$$\chi = \frac{M}{H}$$

is very large and positive for a ferromagnetic material. Therefore, option (C) is the correct answer.

71. A free neutron decays to a proton. But a free proton does not decay to a neutron. This is because :

A. neutron has larger rest mass than the proton

B. neutron is a composite particle made up of a proton and an electron, whereas proton is a fundamental particle

C. neutron is an uncharged particle whereas proton is a charged particle

D. weak forces can operate in a neutron but not in a proton

Answer: (A) neutron has larger rest mass than the proton
Explanation:
A free neutron undergoes beta decay according to

$$n \to p + e^{-} + \bar{\nu}_e.$$

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The rest mass of a neutron is greater than the combined rest mass of the proton and electron, so this decay is energetically possible. A free proton cannot spontaneously decay into a neutron because the neutron has a greater rest mass, and such a process would require additional energy. Therefore, option (A) is the correct answer.

72. The significance of liquid drop model is :

A. gives atomic masses and binding energies

B. predicts α and β emission properties and fission

C. gives atomic masses and binding energies and also predicts α and β emission properties

D. predicts α and β absorption properties

Answer: (C) gives atomic masses and binding energies and also predicts α and β emission properties

Explanation:
The liquid drop model treats the nucleus as a collection of interacting nucleons analogous to molecules in a liquid drop. It provides the basis for the semi-empirical mass formula and helps explain nuclear masses and binding energies. The model also provides useful insight into various nuclear decay and emission processes. Therefore, according to the given alternatives, option (C) is the correct answer.

73. A Lepton is a particle that :

A. exhibit a strong nuclear force

B. exhibit a strong gravitational force

C. does not exhibit strong nuclear force

D. does not exhibit a strong gravitational force

Answer: (C) does not exhibit strong nuclear force
Explanation:
Leptons are elementary particles that do not participate in the strong nuclear interaction. Examples of leptons include electrons, muons, tau particles and their corresponding neutrinos. They participate in the weak interaction, and charged leptons also participate in electromagnetic interactions. Like all particles with energy, leptons are also subject to gravity. Therefore, the defining property among the given choices is that a lepton does not exhibit strong nuclear force.

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74. During a negative beta decay :

A. an atomic electron is ejected

B. an electron which is already present within the nucleus is ejected

C. a neutron in the nucleus decays emitting an electron

D. a proton in the nucleus decays emitting an electron

Answer: (C) a neutron in the nucleus decays emitting an electron
Explanation:
During negative beta decay, a neutron inside the nucleus is transformed into a proton
through the weak interaction. An electron and an electron antineutrino are simultaneously emitted. The process is

$$n \to p + e^- + \bar{\nu}_e.$$

The emitted electron is created during the decay process and is not an electron that was already present inside the nucleus. Therefore, option (C) is the correct answer.

75. The radius of carbon nucleus is about 3×10^{-15} m and its mass is 12u. The average density of the nuclear material is :

A. $1.2 \times 10^{17}\ kg/m^3$

B. $1.4 \times 10^{17}\ kg/m^3$

C. $1.8 \times 10^{17}\ kg/m^3$

D. $2.1 \times 10^{17}\ kg/m^3$

Answer: (C) $1.8 \times 10^{17}\ kg/m^3$
Explanation:
The average density of a nucleus is given by

$$\rho = \frac{M}{V}.$$

The mass of the carbon nucleus is approximately

$$M = 12\left(1.66 \times 10^{-27}\right) = 1.992 \times 10^{-26}\ kg.$$

The volume of the nucleus is

$$V = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi\left(3 \times 10^{-15}\right)^3.$$

Thus,

$$V \approx 1.13 \times 10^{-43}\ m^3.$$

Therefore,

$$\rho \approx \frac{1.992 \times 10^{-26}}{1.13 \times 10^{-43}} \approx 1.76 \times 10^{17}\ kg/m^3.$$

This is approximately $1.8 \times 10^{17}\ kg/m^3$. Hence, option (C) is the correct answer.

76. Calculate the energy released in the (α,n) reaction for $^{9}_{4}$Be. The equation for the nuclear reaction is,

$$^{9}_{4}\mathbf{Be} + {}^{4}_{2}\mathbf{He} \rightarrow {}^{12}_{6}\mathbf{C} + {}^{1}_{0}\mathbf{n} + \mathbf{Q}$$

The mass of $^{9}_{4}$Be is 9.012183u, Mass of $^{12}_{6}$C is 12.000000u, Mass of $^{4}_{2}$He is 4.002603u and Mass of $^{1}_{0}$n is 1.008665u.

A. 5.30 MeV

B. 5.50 MeV

C. 5.70 MeV

D. 5.90 MeV

Answer: (C) 5.70 MeV
Explanation:
The Q-value of the nuclear reaction is obtained from the mass difference,

$$Q = \left(m_i - m_f\right)c^2.$$

The initial mass is

$$m_i = 9.012183 + 4.002603 = 13.014786u.$$

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The final mass is

$$m_f = 12.000000 + 1.008665 = 13.008665u.$$

Therefore,

$$\Delta m = 13.014786 - 13.008665 = 0.006121u.$$

Using

$$1u = 931.5MeV/c^2,$$

we obtain

$$Q = 0.006121 \times 931.5 \approx 5.70MeV.$$

Therefore, option (C) is the correct answer.

77. **Find the Q value (Q= Δm_0= ΔKE) of the nuclear reaction**

$$^4_2\mathbf{He} + ^{14}_7\mathbf{N} \rightarrow ^{17}_8\mathbf{O} + ^1_1\mathbf{H}.$$

The rest masses of the neutral atoms $^4_2$He, $^{14}_7$N and $^{17}_8$O are 4.002603U, 14.003074U and 16.999133U respectively. The mass of $^1_1$H is 1.007825U.

A. -1.39 MeV

B. -1.29 MeV

C. -1.19 MeV

D. -1.09 MeV

Answer: (C) -1.19 MeV
Explanation:
The Q-value is calculated using

$$Q = (m_i - m_f)\, c^2.$$

The initial mass is

$$m_i = 4.002603 + 14.003074 = 18.005677U.$$

The final mass is

$$m_f = 16.999133 + 1.007825 = 18.006958U.$$

Hence,

$$\Delta m = 18.005677 - 18.006958 = -0.001281U.$$

Using

$$1U = 931.5MeV/c^2,$$

we obtain

Professor Academy

$$Q = (-0.001281)(931.5) \approx -1.19MeV.$$

The negative value indicates that the reaction is endoergic and requires energy. Therefore, option (C) is the correct answer.

78. Which of the following process is forbidden by the law of conservation of strangeness?

A. $\pi^- + P \rightarrow \Sigma^- + K^+$

B. $K^- + P \rightarrow \Omega^- + K^+ + K^\circ$

C. $\pi^- + P \rightarrow \Sigma^+ + K^-$

D. $\pi^- + P \rightarrow K^+ + K^- + n$

Answer: (C) $\pi^- + P \rightarrow \Sigma^+ + K^-$
Explanation:
Strangeness must be conserved in reactions governed by the strong interaction. The initial particles $\pi^-$and proton have zero total strangeness. In the reaction

$$\pi^- + P \rightarrow \Sigma^+ + K^-,$$

the Σ^+has strangeness -1, while K^-also carries strangeness -1. Thus, the final total strangeness is -2, whereas the initial total strangeness is zero. Therefore, strangeness is not conserved, and this process is forbidden by the law of conservation of strangeness.

79. The nuclear radius is expressed by the relation :

A. $R = R_0 A^{4/3}$

B. $R = R_0 A^{2/3}$

C. $R = R_0 A^{1/3}$

D. $R = R_0^{1/4}$

Answer: (C) $R = R_0 A^{1/3}$
Explanation:
Experimental measurements show that the nuclear radius increases approximately as the cube root of the mass number A. The empirical relation for nuclear radius is

$$R = R_0 A^{1/3},$$

where R_0 is approximately

$$R_0 \approx 1.2 \times 10^{-15}\ m.$$

Since the nuclear volume is proportional to R^3, this relation also implies that nuclear volume is proportional to the number of nucleons. Therefore, option (C) is the correct answer.

80. Neutrinos are particles which have :

A. Positive charge, -1/2 spin and zero rest mass

B. Negative charge, -1/2 spin and zero rest mass

C. zero charge, 1/2 spin and a very small non-zero rest mass

D. Positive charge, 1/2 spin and zero rest mass

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Answer: (C) zero charge, 1/2 spin and a very small non-zero rest mass
Explanation:
A neutrino is an electrically neutral elementary particle belonging to the lepton family. It has intrinsic spin

$$s = \frac{1}{2},$$

and therefore it is classified as a fermion. Neutrinos are electrically neutral and have very small but non-zero masses. Therefore, option (C) is the correct answer.

81. Increase in current in tunnel diode from 0 to its peak value $\mathbf{I_P}$ at a forward voltage $\mathbf{V_P}$, is due to the phenomena called :

A. negative resistance

B. flow of electrons in reverse

C. tunneling

D. breakdown

Answer: (C) tunneling
Explanation:
A tunnel diode is a heavily doped semiconductor diode having an extremely thin depletion region. At small forward voltages, electrons can pass through the thin potential barrier by the quantum mechanical phenomenon known as tunneling. As the forward voltage increases from zero to the peak voltage V_P, the tunneling current increases and reaches the peak current I_P. Therefore, the increase in current up to the peak value is due to tunneling.

82. For sustained oscillations in a transistor RC phase-shift oscillator with $R = R_C$, the minimum forward current gain h_{fe} of the transistor should be:

A. 38

B. 56

C. 46

D. 66

Answer: (B) 56
Explanation:
A phase shift oscillator normally uses three RC sections to provide the required phase shift of 180°, while the transistor amplifier provides an additional 180°. The RC feedback network introduces considerable attenuation. Hence, the transistor must provide sufficient gain to satisfy the Barkhausen criterion for sustained oscillations. For the standard transistor phase shift oscillator, the minimum forward current gain ratio required is approximately 56. Therefore, option (B) is the correct answer.

83. If $\mathbf{C_1R_2}$ is the time constant, the width of the output pulse T in monostable vibrator :

A. $T = 0.59C_1R_2$

B. $T = 0.69C_1R_2$

C. $T = 0.79C_1R_2$

D. $T = 0.89C_1R_2$

Answer: (B) $T = 0.69C_1R_2$
Explanation:
A monostable multivibrator has one stable state and one quasi-stable state. When a triggering pulse is applied, the circuit changes temporarily to the quasi-stable state and returns to its stable state after a time determined by the RC network. For the circuit considered here, the pulse width is approximately

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$$T = 0.69 C_1 R_2.$$

Thus, the duration of the output pulse depends directly on the time constant $C_1 R_2$. Therefore, option (B) is the correct answer.

84. Convert $(25)_{10}$ into binary numbers :

A. $(11101)_2$

B. $(1011)_2$

C. $(11001)_2$

D. $(0110)_2$

Answer: (C) $(11001)_2$
Explanation:
To convert decimal 25 into binary, express it as a sum of powers of 2:

$$25 = 16 + 8 + 1.$$

Therefore,

$$25 = 1\left(2^4\right) + 1\left(2^3\right) + 0\left(2^2\right) + 0\left(2^1\right) + 1\left(2^0\right).$$

Hence,

$$(25)_{10} = (11001)_2.$$

Therefore, option (C) is the correct answer.

85. The expression for De Morgan's theorem is :

A. $AB = \bar{A} + \bar{B}$

B. $\overline{AB} = \bar{A} + \bar{B}$

C. $\overline{AB} = \bar{A} \cdot \bar{B}$

D. $\overline{AB} = \bar{A} + B$

Answer: (B) $\overline{AB} = \bar{A} + \bar{B}$
Explanation:
De Morgan's theorem provides important rules for complementing Boolean expressions. One of the two De Morgan's laws states that the complement of the product of two Boolean variables is equal to the sum of their individual complements. Thus,

$$\overline{AB} = \bar{A} + \bar{B}.$$

The other form is

$$\overline{A + B} = \bar{A}\bar{B}.$$

Therefore, option (B) is the correct answer.

86. A logic gate whose output is in '1' state if and only if all the inputs are in '1' state is :

A. OR gate

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B. AND gate

C. NOT gate

D. NAND gate

Answer: (B) AND gate
Explanation:
An AND gate performs the logical multiplication operation. For a two-input AND gate with inputs A and B, its output is

$$Y = A \cdot B.$$

The output becomes logic 1 only when both inputs are logic 1. More generally, for an AND gate having several inputs, every input must be in the 1 state for its output to become 1. Therefore, option (B) is the correct answer.

87. An ideal operational amplifier has :

A. finite bandwidth

B. zero input impedance

C. infinite input impedance

D. finite input impedance

Answer: (C) infinite input impedance
Explanation:
An ideal operational amplifier is assumed to have infinite open-loop voltage gain, infinite input impedance, zero output impedance and infinite bandwidth. Infinite input impedance means that no current is drawn by either input terminal of the operational amplifier. Mathematically,

$$I_+ = I_- = 0.$$

Therefore, among the given alternatives, infinite input impedance is a fundamental characteristic of an ideal operational amplifier. Hence, option (C) is the correct answer.

88. In an Op-amp the input terminal marked as ' - ' (minus sign) is called as :

A. inverting input terminal

B. inverting output terminal

C. non-inverting terminal

D. phase change terminal

Answer: (A) inverting input terminal
Explanation:
An operational amplifier has two input terminals. The terminal marked with a minus sign (-) is known as the inverting input terminal, while the terminal marked with a plus sign (+) is called the non-inverting input terminal. A signal applied to the inverting input produces an output that is 180° out of phase with the input signal. Therefore, option (A) is the correct answer.

89. If the tunnel diode is reverse-biased, it acts like a :

A. Insulator

B. Semiconductor

C. Conductor

D. Superconductor

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Answer: (C) Conductor
Explanation:
A tunnel diode is very heavily doped and therefore possesses an extremely thin depletion region. Under reverse bias, electrons can tunnel through the narrow potential barrier even at relatively small reverse voltages. Consequently, a significant reverse current flows through the tunnel diode. Because of this high current conduction under reverse bias, it behaves approximately like a conductor. Therefore, option (C) is the correct answer.

90. **In a phase shift oscillator, a ladder network of three RC section is used each section will produce a phase shift of :**

    A. 70°

    B. 40°

    C. 60°

    D. 90°

Answer: (C) 60°
Explanation:
For sustained oscillations, the total phase shift around the feedback loop must be 360° or 0°. In a transistor RC phase shift oscillator, the transistor amplifier contributes a phase shift of 180°. Therefore, the three-section RC feedback network must provide another 180° phase shift. If this phase shift is distributed equally among the three RC sections, each section contributes

$$\frac{180^\circ}{3} = 60^\circ.$$

Therefore, each RC section produces a phase shift of 60°, making option (C) the correct answer.

91. **The measurement of energy and time using electronic signals are done by using the concepts of :**

    A. Sampling theorem

    B. Norton's theorem

    C. Fourier transformation

    D. Gaussian distribution

Answer: (A) Sampling theorem
Explanation:
The sampling theorem is fundamental in converting continuous electronic signals into discrete samples for measurement and analysis. It states that a band-limited signal can be reconstructed correctly when the sampling frequency is at least twice the highest frequency present in the signal. Electronic measurements of quantities such as energy and time make use of signal sampling and processing techniques. Therefore, option (A) is the correct answer.

92. **Multichannel analyzers are very important laboratory instruments used for measuring distributions of signals consisting of :**

    A. sine waves

    B. square waves

    C. saw tooth waves

    D. pulses

Answer: (D) pulses
Explanation:
A multichannel analyzer is an electronic instrument used to analyze and sort incoming pulses according

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to their amplitudes. Each pulse is assigned to an appropriate channel corresponding to its amplitude or energy. The resulting distribution provides information about the energy spectrum of detected radiation or other pulsed signals. Therefore, multichannel analyzers are primarily used for measuring distributions of signals consisting of pulses.

93. **The technique used for detection of simultaneous emission of two photons is called as :**

    A. simulation measurement

    B. coincidence measurement

    C. synchronous measurement

    D. simultaneous measurement

Answer: (B) coincidence measurement
Explanation:
Coincidence measurement is a technique used in nuclear and radiation experiments to determine whether two detected events occur within a very short specified time interval. When two photons are emitted simultaneously and detected by separate detectors, the corresponding signals are passed through a coincidence circuit. Only events occurring within the coincidence resolving time are recorded. Therefore, the technique is called coincidence measurement.

94. **The standard deviation σ is the square root of the average of the squares minus the square of the average. The above statement is :**

    A. False

    B. Partially True

    C. Partially False

    D. True

Answer: (D) True
Explanation:
The variance of a quantity x can be expressed as

$$\sigma^2 = \langle x^2 \rangle - \langle x \rangle^2,$$

where $\langle x^2 \rangle$ represents the average of the squares and $\langle x \rangle^2$ represents the square of the average. Therefore, the standard deviation is

$$\sigma = \sqrt{\langle x^2 \rangle - \langle x \rangle^2}.$$

Hence, the given statement is true and option (D) is the correct answer.

95. **While using the statistical distribution functions when the number of samples are more, but the probability of a result is small the following distribution function is used :**

    A. Binomial distribution

    B. Gaussian distribution

    C. Poisson distribution

    D. Parent distribution

Answer: (C) Poisson distribution
Explanation:
The Poisson distribution is particularly useful for describing rare events when the number of possible

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trials is very large but the probability of occurrence in each individual trial is very small. It can be obtained as a limiting case of the binomial distribution when

$$n \to \infty,\ p \to 0,$$

while the product np remains finite. Therefore, the appropriate distribution under the stated conditions is the Poisson distribution.

96. **The simplest bridge circuit used for measurement of resistance is:**

    A. Megohm bridge

    B. Anderson's bridge

    C. De Sauty's bridge

    D. Wheatstone's bridge

Answer: (D) Wheatstone's bridge
Explanation:
The Wheatstone bridge is one of the simplest and most widely used bridge circuits for accurately measuring an unknown electrical resistance. It consists of four resistive arms arranged in a bridge configuration. At the balanced condition,

$$\frac{R_1}{R_2} = \frac{R_3}{R_x},$$

where R_x is the unknown resistance. By using the known resistances, the unknown resistance can be determined accurately. Therefore, option (D) is the correct answer.

97. **The advanced level of X-ray detectors used for material characterization use doped semiconductors. This method is called as :**

    A. Non-Destructive Testing (NDT)

    B. Energy Dispersive X-ray spectroscopy (EDX)

    C. Scanning Electron Microscopy (SEM)

    D. Atomic Force Microscopy (AFM)

Answer: (B) Energy Dispersive X-ray spectroscopy (EDX)
Explanation:
Energy Dispersive X-ray spectroscopy is an analytical technique used for elemental and chemical characterization of materials. In EDX, characteristic X-rays emitted from a specimen are detected and their energies are measured. Semiconductor detectors are commonly employed because the energy of an incident X-ray photon can be converted into an electrical signal proportional to the photon energy. Therefore, option (B) is the correct answer.

98. **Geiger-Muller Counters cannot be used for detecting :**

    A. alpha rays

    B. gamma radiation

    C. beta rays

    D. neutrons

Answer: (D) neutrons
Explanation:
A Geiger-Muller counter detects alpha and beta radiation directly through ionization of the fill gas, and gamma radiation can be detected indirectly through secondary charged particles. Neutrons are uncharged and require a suitable converter to produce detectable charged particles. Therefore, an

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ordinary Geiger-Muller counter cannot directly detect neutrons.

99. **In the working of the Pirani gauge the resistance of the wire placed in the vacuum chamber is calibrated as a function of :**

    A. temperature

    B. volume

    C. pressure

    D. time

Answer: (C) pressure
Explanation:
A Pirani gauge measures low gas pressures using the dependence of thermal conductivity on pressure. A heated wire is placed inside the vacuum chamber, and the rate at which it loses heat to the surrounding gas depends on the gas pressure. Changes in the wire temperature cause corresponding changes in its electrical resistance. The resistance is therefore calibrated against pressure, allowing the pressure inside the vacuum chamber to be determined.

100. **The diffusion pumps are used for creating vacuum of the order of :**

    A. 10^{-3} to 10^{-10} torr

    B. upto 10^{-2} torr

    C. 10^{-11} to 10^{-13} torr

    D. greater than 10^{-10} torr

Answer: (A) 10^{-3} to 10^{-10} torr
Explanation:
A diffusion pump is a high-vacuum pump that uses a high-speed jet of vaporized working fluid to transport gas molecules from the high-vacuum region toward the outlet. It does not normally operate directly from atmospheric pressure and therefore requires a backing pump. Diffusion pumps can produce very high vacuum conditions, typically extending from approximately

$$10^{-3} \text{ torr to } 10^{-10} \text{ torr},$$

Depending on the system and operating conditions. Therefore, option (A) is the correct answer.

101. What will be ratio compounded of the 3 ratios 2 : 3, 6 : 11 and 11 : 2 ?

    A. 2 : 1

    B. 2 : 3

    C. 1 : 2

    D. 3:2

Answer: (A) 2 : 1
Explanation:
The compound ratio of two or more ratios is obtained by multiplying all the antecedents together and all the consequents together. Therefore, the compound ratio is

$$(2 \times 6 \times 11) : (3 \times 11 \times 2).$$

Simplifying,

$$132 : 66 = 2 : 1.$$

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Hence, the compounded ratio of the three given ratios is 2 : 1. Therefore, option (A) is the correct answer.

102. Who is called as 'the Master of the Seven notes of Music' ?

A. Pandiya Nedunchezhiyan

B. Cheran Senguttuvan

C. Karikalan

D. Mahendiran I

Answer: (C) Karikalan
Explanation:
Karikalan was one of the most prominent rulers of the early Chola dynasty and occupies an important place in the history and literature of ancient Tamil Nadu. He is traditionally associated with achievements in administration, warfare, irrigation and cultural patronage. In the context of the given question, Karikalan is referred to as 'the Master of the Seven notes of Music'. Therefore, option (C) is the correct answer.

103. Impulse is expressed _____.

A. Force × Time

B. Mass × Acceleration

C. momentum / time

D. Mass × Velocity

Answer: (A) Force × Time
Explanation:
Impulse is defined as the product of the force acting on an object and the time interval for which the force acts. For a constant force,

$$J = F\Delta t.$$

According to the impulse-momentum theorem, impulse is also equal to the change in momentum,

$$J = \Delta p.$$

Therefore, impulse is expressed as Force × Time. Hence, option (A) is the correct answer.

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104. Which one of the following is a Vat dye ?

A. Alizarin

B. Bismarck brown

C. Indigo

D. Malachite green

Answer: (C) Indigo
Explanation:
Vat dyes are water-insoluble dyes that are converted into a soluble reduced form before being applied to textile fibres. After application, oxidation converts the dye back into its insoluble form inside the fibre. Indigo is a classic example of a vat dye and has been extensively used for dyeing cotton, particularly denim. Therefore, option (C) Indigo is the correct answer.

105. **A concentric arrangement of bundle sheath cells of the leaves of C-4 plants is called** _____

A. anomalous thickening

B. kranz anatomy

C. cystolith

D. quantosome

Answer: (B) kranz anatomy
Explanation:
C-4 plants possess a characteristic leaf structure known as Kranz anatomy. In this arrangement, each vascular bundle is surrounded by a prominent ring of bundle sheath cells, which is further surrounded by mesophyll cells. The word 'Kranz' means wreath or ring and describes this concentric arrangement. This anatomical specialization plays an important role in the C-4 pathway of photosynthesis. Therefore, option (B) is the correct answer.

106. **Who organised green turbaned peasants agitation in 1972 ?**

A. E.V.R. Periyar

B. Narayanaswami

C. Nallakannu

D. K. Kamaraj

Answer: (B) Narayanaswami
Explanation:
The green turbaned peasants agitation was associated with agrarian mobilization and the assertion of farmers' demands. The participants used the green turban as a symbol representing the agricultural community and its interests. According to the historical context referred to in the question, the agitation in 1972 was organised by Narayanaswami. Therefore, option (B) is the correct answer.

107. **Who was the First Nayak Ruler of Madurai ?**

A. Krishnappa Nayak

B. Visvanatha Nayak

C. Tirumalai Nayak

D. Chokkanatha Nayak

Answer: (B) Visvanatha Nayak
Explanation:
Visvanatha Nayak is regarded as the founder and first ruler of the Madurai Nayak dynasty. He established Nayak rule at Madurai during the sixteenth century under the
broader political influence of the Vijayanagara Empire. He is also associated with the development of the Palayakkarar or Poligar administrative system. Therefore, Visvanatha Nayak was the first Nayak ruler of Madurai, making option (B) the correct answer.

108. Annie Besant established the Home Rule League at :

A. Bombay

B. Calcutta

C. Madras

D. Lucknow

Answer: (C) Madras
Explanation:
Annie Besant played an important role in the Indian Home Rule Movement. In 1916, she established her Home Rule League with its headquarters at Madras. The movement demanded self-government for India within the British Empire and helped create greater political awareness throughout the country.

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Therefore, Annie Besant established the Home Rule League at Madras. Hence, option (C) is the correct answer.

109. 'Fathom' is a unit to measure the :

A. Salinity

B. Volcanic activity

C. Mass movement

D. Sea water depth

Answer: (D) Sea water depth
Explanation:
A fathom is a traditional unit of length commonly used in nautical measurements, particularly for measuring the depth of water. One fathom is equal to six feet, or approximately

$$1 \text{ fathom} = 1.8288 \text{ metres.}$$

It has historically been used by sailors and navigators to indicate the depth of seas and other bodies of water. Therefore, option (D) Sea water depth is the correct answer.

110. In which Tamil literature, the word 'Sangam' is used?

A. Agathiyam

B. Tholkappiyam

C. Thirukural

D. Iraiyanar Ahapporul Urai

Answer: (D) Iraiyanar Ahapporul Urai
Explanation:
The Sangam tradition is recorded in Iraiyanar Ahapporul Urai (the commentary on Iraiyanar's Ahapporul). Therefore, option (D) is the correct answer.

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PART-B

111. **The value of the function $J_{1/2}(x)$ is :**

A. $\sqrt{\frac{2}{\pi x}}sinx$

B. $\sqrt{\frac{2}{\pi x}}cosx$

C. $tanx$

D. $\sqrt{\frac{2}{\pi x}}$

Answer: (A) $\sqrt{\frac{2}{\pi x}}sinx$
Explanation:
For Bessel functions of half-integral order, the functions can be expressed in terms of elementary trigonometric functions. In particular, the Bessel function of the first kind of order 1/2 is

$$J_{1/2}(x) = \sqrt{\frac{2}{\pi x}}sinx.$$

Similarly, the Bessel function of order -1/2 involves the cosine function. Therefore, the value of $J_{1/2}(x)$ is $\sqrt{2/(\pi x)}sinx$, making option (A) the correct answer.

112. Apply Calculus of residues, evaluate the integral,

$$\int_0^{2\pi} \frac{d\theta}{2+cos\theta}$$

A. $\frac{2\pi}{\sqrt{3}}$

B. 0

C. $\frac{4\pi}{\sqrt{3}}$

D. 4π

Answer: (A) $\frac{2\pi}{\sqrt{3}}$
Explanation:
Using the standard result

$$\int_0^{2\pi} \frac{d\theta}{a+bcos\theta} = \frac{2\pi}{\sqrt{a^2-b^2}},\ a > |b|$$

and taking

$$a = 2,\ b = 1,$$

we obtain

$$\int_0^{2\pi} \frac{d\theta}{2+cos\theta} = \frac{2\pi}{\sqrt{2^2-1^2}} = \frac{2\pi}{\sqrt{3}}.$$

Therefore, option (A) is the correct answer.

113. If f(z) =u(x,y)+iv(x,y) is analytic in a domain D, then u and v satisfy the Laplace equation is :

A. $u_x + u_y = 0, v_x + v_y = 0$

B. $u_y + v_y = 0$

C. $u_{xx} = 0, v_{yy} = 0$

D. $u_{xx} + u_{yy} = 0, v_{xx} + v_{yy} = 0$

Answer: (D) $u_{xx} + u_{yy} = 0, v_{xx} + v_{yy} = 0$
Explanation:
If $f(z) = u + iv$ is analytic, its real and imaginary parts satisfy the Cauchy-Riemann equations

$$u_x = v_y,\ u_y = -v_x.$$

Differentiating these relations and using equality of mixed partial derivatives gives

$$u_{xx} + u_{yy} = 0$$

and

$$v_{xx} + v_{yy} = 0.$$

Thus, both u and v are harmonic functions and satisfy Laplace's equation. Therefore, option (D) is the correct answer.

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114. The value at x = 0 of $\mathbf{H_{2n}(x)}$ is :

A. $2n$

B. $(-1)^n \frac{(2n)!}{n!}$

C. $(-1)^n 2^{2n+1} \frac{n}{2}$

D. $2^{2n} \frac{n}{2}$

Answer: (B) $(-1)^n \frac{(2n)!}{n!}$
Explanation:
Hermite polynomials possess definite parity, with even-order Hermite polynomials being even functions and odd-order Hermite polynomials being odd functions. A standard special value for even-order Hermite polynomials is

$$H_{2n}(0) = (-1)^n \frac{(2n)!}{n!}.$$

Therefore, option (B) is the correct answer.

115. **Using the fundamental Poisson brackets find the values of α and β for which the equations**

$$\mathbf{Q{=}q^{\alpha}cos\beta p}$$

and

$$\mathbf{P{=}q^{\alpha}sin\beta p}$$

represent a canonical transformation.

A. $\alpha = \frac{1}{2},\ \beta = 2$

B. $\alpha = -\frac{1}{2}, \beta = -1$

C. $\alpha = 0, \beta = 1$

D. $\alpha = \frac{1}{2}, \beta = 1$

Answer: (A) $\alpha = \frac{1}{2},\ \beta = 2$
Explanation:
For a transformation to be canonical, the fundamental Poisson bracket must satisfy

$$\{Q, P\} = 1.$$

Using

$$\{Q, P\} = \frac{\partial Q}{\partial q}\frac{\partial P}{\partial p} - \frac{\partial Q}{\partial p}\frac{\partial P}{\partial q},$$

we have

$$\frac{\partial Q}{\partial q} = \alpha q^{\alpha-1} cos\beta p,\ \frac{\partial Q}{\partial p} = -\beta q^{\alpha} sin\beta p,$$

and

$$\frac{\partial P}{\partial q} = \alpha q^{\alpha-1} sin\beta p,\ \frac{\partial P}{\partial p} = \beta q^{\alpha} cos\beta p.$$

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Therefore,

$$\{Q, P\} = \alpha\beta q^{2\alpha-1}$$

For this to be unity for every q,

$$2\alpha - 1 = 0,\ \alpha\beta = 1.$$

This gives

$$\alpha = \frac{1}{2},\ \beta = 2.$$

Therefore, option (A) is the correct answer.

116. In a rigid body, the trace of a rotational matrix is :

A. $2 + cos\phi$

B. $2 - cos\phi$

C. $1 - 2cos\phi$

D. $1 + 2cos\phi$

Answer: (D) $1 + 2cos\phi$
Explanation:
For a three-dimensional rotation through an angle ϕ, the rotation matrix has eigenvalues

$$1,\ e^{i\phi},\ e^{-i\phi}.$$

The trace of a matrix is equal to the sum of its eigenvalues. Therefore,

$$Tr(R) = 1 + e^{i\phi} + e^{-i\phi}.$$

Using

$$e^{i\phi} + e^{-i\phi} = 2cos\phi,$$

we obtain

$$Tr(R) = 1 + 2cos\phi.$$

Therefore, option (D) is the correct answer.

117. Euler-Lagrange equation for a simple pendulum under the small-angle approximation is :

A. $\ddot{\theta} - \frac{g}{l}\theta = 0$

B. $\ddot{\theta} + \frac{g}{l}\theta = 0$

C. $\ddot{\theta} - \frac{l}{g}\theta = 0$

D. $\ddot{\theta} + \frac{l}{g}\theta = 0$

Professor Academy

Answer: (B) $\ddot{\theta} + \frac{g}{l}\theta = 0$
Explanation:
For a simple pendulum of length l, the exact equation of motion obtained from the Euler-Lagrange equation is

$$\ddot{\theta} + \frac{g}{l}\sin\theta = 0.$$

For small angular displacements,

$$sin\theta \approx \theta.$$

Therefore, the equation becomes

$$\ddot{\theta} + \frac{g}{l}\theta = 0.$$

This is the equation of simple harmonic motion for a simple pendulum under the small-angle approximation. Therefore, option (B) is the correct answer.

118. Calculate the rest energy of an electron in MeV.

A. 0.152 MeV

B. 0.511 MeV

C. 0.914 MeV

D. 9.14 MeV

Answer: (B) 0.511 MeV
Explanation:
The rest energy of an electron is obtained using Einstein's mass-energy relation

$$E_0 = m_e c^2.$$

Using

$$m_e = 9.11 \times 10^{-31}\ kg$$

and

$$c = 3 \times 10^8\ m\ s^{-1},$$

we get

$$E_0 = \left(9.11 \times 10^{-31}\right)\left(3 \times 10^8\right)^2 \approx 8.19 \times 10^{-14}\ J.$$

In electron-volt units,

$$E_0 \approx 0.511 MeV.$$

Thus, the rest energy of an electron is 0.511 MeV. Therefore, option (B) is the correct answer.

119. The radial wave function of the Hydrogen atom for 1s state is :

A. $\Psi_{1s} = \frac{1}{\sqrt{24}}\left(\frac{1}{a}\right)^{5/2} re^{-r/2a}$

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B. $\Psi_{1s} = \frac{1}{\sqrt{2}} \left(\frac{1}{a}\right)^{3/2} \left(1 - \frac{r}{2a}\right) e^{-r/2a}$

C. $\Psi_{1s} = \frac{2}{a^{3/2}} e^{-r/a}$

D. $\Psi_{1s} = e^{r}$

Answer: (C) $\Psi_{1s} = \frac{2}{a^{3/2}} e^{-r/a}$
Explanation:
For the hydrogen atom, the normalized radial wave function is determined by the principal quantum number n and orbital quantum number l. For the ground state,

$$n = 1,\ l = 0.$$

The corresponding radial wave function is

$$R_{10}(r) = \frac{2}{a^{3/2}} e^{-r/a},$$

where a is the Bohr radius. The exponential factor shows that the radial wave function decreases as the distance from the nucleus increases. Therefore, option (C) is the correct answer.

120. The period of a linear harmonic oscillator is 1 second. Its zero point energy is :

A. $3.3 \times 10^{-27}\ J$

B. $3.3 \times 10^{-13}\ J$

C. $3.3 \times 10^{-41}\ J$

D. $3.3 \times 10^{-34}\ J$

Answer: (D) $3.3 \times 10^{-34}\ J$
Explanation:
The zero-point energy of a quantum harmonic oscillator is

$$E_0 = \frac{1}{2} h\nu.$$

The period is given as

$$T = 1\ s.$$

Therefore, the frequency is

$$\nu = \frac{1}{T} = 1\ Hz.$$

Using Planck's constant

$$h = 6.626 \times 10^{-34}\ J\ s,$$

the zero-point energy is

$$E_0 = \frac{1}{2} \left(6.626 \times 10^{-34}\right) (1) = 3.313 \times 10^{-34}\ J.$$

Thus,

$$E_0 \approx 3.3 \times 10^{-34}\ J.$$

Therefore, option (D) is the correct answer.

Professor Academy

121. The total elastic scattering cross-section for a spherically symmetric potential is :

A. $\sigma = \frac{4\pi^2}{K^2} \sum_{L=0}^{\infty} (2L+1) \sin^2 \delta_L$

B. $\sigma = \frac{\pi}{K} \sum_{L=0}^{\infty} (2L-1) \sin^2 \delta_L$

C. $\sigma = \frac{\pi^2}{K^2} \sum_{L=0}^{\infty} (2L+1) \sin^2 \delta_L$

D. $\sigma = \frac{4\pi}{K^2} \sum_{L=0}^{\infty} (2L+1) \sin^2 \delta_L$

Answer: (D) $\sigma = \frac{4\pi}{K^2} \sum_{L=0}^{\infty} (2L+1) \sin^2 \delta_L$
Explanation:
For elastic scattering by a spherically symmetric potential, the scattering amplitude can be expanded in terms of partial waves. Each partial wave is characterized by the phase shift δ_L. The total elastic scattering cross-section is

$$\sigma = \frac{4\pi}{K^2} \sum_{L} (2L+1) \sin^2 \delta_L.$$

Here, K is the wave number and L is the angular momentum quantum number. Therefore, option (D) gives the required relation.

122. If a and $\mathbf{a}^+$be the ladder operators then $\mathbf{a}^+\mathbf{a}|\mathbf{n}\rangle$ is :

A. $n^2|n\rangle$

B. $\sqrt{n}|n\rangle$

C. $n|n\rangle$

D. $(n-1)n|n\rangle$

Answer: (C) $n|n\rangle$
Explanation:
For the quantum harmonic oscillator, the annihilation operator acts on the number state as

$$a|n\rangle = \sqrt{n}|n-1\rangle.$$

The creation operator then gives

$$a^+|n-1\rangle = \sqrt{n}|n\rangle.$$

Therefore,

$$a^+a|n\rangle = \sqrt{n}\sqrt{n}|n\rangle = n|n\rangle.$$

Thus, a^+a is the number operator and $|n\rangle$ is its eigenstate with eigenvalue n. Therefore, option (C) is the correct answer.

123. In a source-free region, if the scalar potential $V = 0$ and the magnetic vector potential is

$$\vec{A} = \hat{\mathbf{i}}x^4 + \hat{\mathbf{k}}z^2t^2,$$

then the electric field vector $\vec{E}$ is:

A. $2z^2\hat{\mathbf{k}}$

B. $4z^2\hat{\mathbf{k}}$

C. $-4z^2\hat{\mathbf{k}}$

Professor Academy

D. $-2z^2t\hat{\mathbf{k}}$

Answer: (D)

$$-2z^2t\hat{\mathbf{k}}$$

Explanation:
The electric field in terms of the electric scalar potential V and magnetic vector potential $\vec{A}$ is

$$\vec{E} = -\nabla V - \frac{\partial \vec{A}}{\partial t}.$$

Since $V = 0$,

$$\nabla V = 0.$$

$$\vec{E} = -\frac{\partial \vec{A}}{\partial t}.$$

Given

$$\vec{A} = \hat{\mathbf{i}}x^4 + \hat{\mathbf{k}}z^2t^2,$$

we have

$$\frac{\partial \vec{A}}{\partial t} = 2z^2t\hat{\mathbf{k}}.$$

$$\vec{E} = -2z^2t\hat{\mathbf{k}}.$$

Therefore, option (D) is the correct answer.

124. If $\vec{A}$ is the magnetic vector potential and V is the electric scalar potential, then the Coulomb gauge and Lorenz gauge conditions, respectively, are:

A. $\nabla \cdot \vec{A} = 0$ and $\nabla \cdot \vec{A} = -\mu_0\varepsilon_0 \frac{\partial V}{\partial t}$

B. $\nabla \cdot \vec{A} = \rho$ and $\nabla \cdot \vec{A} = -\mu_0\varepsilon_0 \frac{\partial V}{\partial t}$

C. $\nabla \cdot \vec{A} = 0$ and $\nabla \cdot \vec{A} = \mu_0\varepsilon_0 \frac{\partial V}{\partial t}$

D. $\nabla \cdot \vec{A} = \rho$ and $\nabla \cdot \vec{A} = \mu_0\varepsilon_0 \frac{\partial V}{\partial t}$

Answer: (A) $\nabla \cdot \vec{A} = 0$ $\nabla \cdot \vec{A} = -\mu_0\varepsilon_0 \frac{\partial V}{\partial t}$

Explanation:
The Coulomb gauge condition is

$$\nabla \cdot \vec{A} = 0.$$

The Lorenz gauge condition is

$$\nabla \cdot \vec{A} + \mu_0\varepsilon_0 \frac{\partial V}{\partial t} = 0.$$

$\nabla \cdot \vec{A} = -\mu_0\varepsilon_0 \frac{\partial V}{\partial t}$ Hence, option (A) correctly represents the Coulomb gauge and Lorenz gauge conditions, respectively.

125. Which of the following statements is not correct?

A. The Lorenz gauge condition is

$$\nabla \cdot \vec{A} + \mu_0\varepsilon_0 \frac{\partial V}{\partial t} = 0.$$

B. The Lorenz gauge makes the equations for the scalar potential V and vector potential $\vec{A}$ coupled to each other.

Professor Academy

C. The Coulomb gauge is defined by

$$\nabla \cdot \vec{A} = 0$$

and is also called the transverse gauge.

D. A gauge transformation changes the scalar and vector potentials but does not change the physical electric and magnetic fields.

Answer: (B) The Lorenz gauge makes the equations for the scalar potential V and vector potential $\vec{A}$ coupled to each other.

Explanation:
The Lorenz gauge condition is

$$\nabla \cdot \vec{A} + \mu_0 \varepsilon_0 \frac{\partial V}{\partial t} = 0.$$

Using this gauge, the equations for the scalar potential V and vector potential $\vec{A}$ can be written as separate wave equations. Thus, the Lorenz gauge helps to decouple the equations for the two potentials.

The Coulomb gauge is

$$\nabla \cdot \vec{A} = 0,$$

and is also known as the transverse gauge.

Gauge transformations may change V and $\vec{A}$, but the physical fields $\vec{E}$ and $\vec{B}$ remain unchanged.

Therefore, statement (B) is not correct.

126. Given

$$\overrightarrow{\mathbf{H}}=\mathbf{H_m e^{i(\omega t+\beta z)}\hat{x}}$$

in free space, find $\overrightarrow{\mathbf{E}}$.

A. $-\frac{\beta H_m}{\varepsilon_0 \omega} e^{i(\omega t+\beta z)} \widehat{y}$

B. $\frac{\beta H_m}{\varepsilon_0 \omega} e^{i(\omega t+\beta z)} \widehat{x}$

C. $\frac{\beta H_m}{\varepsilon_0 \omega} e^{i(\omega t+\beta z)} \widehat{y}$

D. $\frac{\beta H_m}{\varepsilon_0 \omega}$

Answer: (C) $\frac{\beta H_m}{\varepsilon_0 \omega} e^{i(\omega t+\beta z)} \widehat{y}$
Explanation:
For an electromagnetic wave in free space, Maxwell's equation gives

$$\nabla \times \overrightarrow{H} = \varepsilon_0 \frac{\partial \overrightarrow{E}}{\partial t}.$$

For

$$\overrightarrow{H} = H_m e^{i(\omega t+\beta z)} \widehat{x},$$

the spatial variation occurs along the z-direction. Evaluating the curl and comparing it with the time derivative of the electric field gives

$$\overrightarrow{E} = \frac{\beta H_m}{\varepsilon_0 \omega} e^{i(\omega t+\beta z)} \widehat{y}.$$

Professor Academy

Thus, the electric field is perpendicular to both the magnetic field and the direction of propagation. Therefore, option (C) is the correct answer.

127. A quantity of air at 27°C and at atmospheric pressure is suddenly compressed to half of its original volume. Find the pressure at the end of compression using equation PV^{γ}= constant.

A. 1 atmosphere

B. 1.4 atmosphere

C. 2.8 atmosphere

D. 2.636 atmosphere

Answer: (D) 2.636 atmosphere
Explanation:
For sudden adiabatic compression of air,

$$P_1 V_1^{\gamma} = P_2 V_2^{\gamma}.$$

For air,

$$\gamma \approx 1.4.$$

Since the final volume is half the original volume,

$$V_2 = \frac{V_1}{2}.$$

Therefore,

$$P_2 = P_1 \left(\frac{V_1}{V_2}\right)^{\gamma} = 1 \times (2)^{1.4}.$$

Thus,

$$P_2 \approx 2.639 \text{ atmosphere},$$

which is approximately 2.636 atmosphere as given in the alternatives. Therefore, option (D) is the correct answer.

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128. All natural processes taking place in the universe are irreversible. Therefore the entropy of the universe is continuously :

A. increasing

B. decreasing

C. remains constant

D. increases and decreases alternately

Answer: (A) increasing
Explanation:
According to the second law of thermodynamics, the total entropy of an isolated system cannot decrease. The universe can be considered as an isolated system for thermodynamic considerations. For irreversible natural processes, entropy is generated, so

$$\Delta S_{\text{universe}} > 0.$$

Since natural processes are generally irreversible, the entropy of the universe continuously increases. Therefore, option (A) is the correct answer.

129. A reversible heat engine can be 100% efficient if the temperature of the sink is :

A. equal to that of source

B. less than that of source

C. at $0K$

D. at $0°C$

Answer: (C) at $0K$
Explanation:
The maximum efficiency of a reversible Carnot heat engine operating between a source at temperature T_H and a sink at temperature T_C is

$$\eta = 1 - \frac{T_C}{T_H}.$$

For 100% efficiency,

$$\eta = 1.$$

Therefore,

$$1 - \frac{T_C}{T_H} = 1,$$

which requires

$$T_C = 0K.$$

Thus, theoretically a reversible heat engine could have 100% efficiency only if the sink were at absolute zero. Therefore, option (C) is the correct answer.

130. According to which statistics the energy at absolute zero cannot be equal to zero ?

A. Maxwell - Boltzmann Statistics

B. Bose - Einstein Statistics

C. Fermi - Dirac Statistics

D. Planck's Radiation Theory

Answer: (C) Fermi - Dirac Statistics
Explanation:
Particles obeying Fermi-Dirac statistics are fermions and are subject to the Pauli exclusion principle. At absolute zero, fermions cannot all occupy the lowest energy state. Instead, they fill the available quantum states successively from the lowest energy up to the Fermi energy. Consequently, the system retains a finite total energy even at

$$T = 0K.$$

Therefore, according to Fermi-Dirac statistics, the energy at absolute zero cannot be zero. Hence, option (C) is the correct answer.

Professor Academy

131. HCl molecule has a rotational constant B value of 1059.3 $\mathbf{m^{-1}}$ and a centrifugal distortion constant D of 5.3×10^{-2} $\mathbf{m^{-1}}$. Estimate the vibrational frequency of the molecule.

A. 299516.3 m^{-2}

B. 299516.3 m^{-1}

C. 4.4321 m^{-2}

D. 44321 m $^{-2}$

Answer: (B) 299516.3 m^{-1}
Explanation:
For a diatomic molecule, the centrifugal distortion constant D, rotational constant B, and vibrational wavenumber $\bar{\nu}$ are related approximately by

$$D = \frac{4B^3}{\bar{\nu}^2}.$$

Therefore,

$$\bar{\nu} = \sqrt{\frac{4B^3}{D}}.$$

Substituting the given values,

$$\bar{\nu} = \sqrt{\frac{4(1059.3)^3}{5.3 \times 10^{-2}}}.$$

Thus,

$$\bar{\nu} \approx 2.995 \times 10^5 \ m^{-1}.$$

Hence, the vibrational frequency expressed as a wavenumber is approximately 299516.3 m^{-1}. Therefore, option (B) is the correct answer.

132. Evaluate the ratio of the rate of stimulated emission to that of spontaneous emission at 1000K. If the wavelength of radiation is 5000Å.

A. 3.107×10^{-13}

B. 3.107×10^{-10}

C. 3.107×10^{-5}

D. 4.105×10^{-13}

Answer: (A) 3.107×10^{-13}
Explanation:
The ratio of stimulated emission to spontaneous emission is obtained from Einstein's coefficients and Planck's radiation law. It is

$$\frac{R_{stim}}{R_{sp}} = \frac{1}{e^{h\nu/kT} - 1}.$$

Since

$$\nu = \frac{c}{\lambda},$$

the ratio becomes

Professor Academy

$$\frac{1}{e^{hc/\lambda kT}-1}.$$

For

$$\lambda = 5000\text{Å} = 5 \times 10^{-7}\ m$$

and $T = 1000K$, the exponential factor is very large. The resulting ratio is approximately

$$3.1 \times 10^{-13}.$$

Therefore, option (A) is the correct answer.

133. Calculate the strength of the magnetic field required to give a precessional frequency of 100 MHz for ^{17}O nucleus, $g_N = -0.757$; $\mu_N = 5.051 \times 10^{-27}$ J T^{-1}; I= 5/2.

A. 17.33 Tesla

B. 17.33 Hz

C. 17.41 Tesla

D. 15.44 Tesla

Answer: (A) 17.33 Tesla
Explanation:
The Larmor precessional frequency of a nucleus in an external magnetic field is related to the magnetic field by

$$\nu = \frac{|g_N|\,\mu_N B}{h}.$$

Therefore,

$$B = \frac{h\nu}{|g_N|\,\mu_N}.$$

Using

$$h = 6.626 \times 10^{-34} Js,\ \nu = 100 \times 10^6\ Hz,$$

we obtain

$$B = \frac{\left(6.626 \times 10^{-34}\right)\left(100 \times 10^6\right)}{(0.757)\,(5.051 \times 10^{-27})}.$$

Hence,

$$B \approx 17.33\ T.$$

Therefore, option (A) is the correct answer.

134. In the NMR spectrum of ^{14} N with I= 1, how many spectral lines will be observed? Calculate the frequency required for the NMR line at an external field of 1.4T.

A. Only one line; 4.331 MHz

B. Two line; 4.331 MHz

Professor Academy

C. Only one line; 2.331 MHz

D. Only one line; 1.331 MHz

Answer: (A) Only one line; 4.331 MHz
Explanation:
For a nucleus with spin $I = 1$, the magnetic quantum numbers are

$$m_I = +1, 0, -1.$$

The allowed NMR transitions obey the selection rule

$$\Delta m_I = \pm 1.$$

In a simple magnetic field, adjacent energy levels are equally spaced, so the allowed transitions occur at the same resonance frequency and give a single NMR line. The resonance frequency is determined by

$$\nu = \frac{\gamma B_0}{2\pi}.$$

For ^{14}N at an external field of $1.4T$, the corresponding resonance frequency is approximately

$$\nu = 4.331MHz.$$

Therefore, option (A) is the correct answer.

135. Which of the following statements are correct about the Miller indices of a crystal plane?

(i) If Miller indices of two planes are equal, the two planes are parallel.

(ii) If a plane is parallel to one of the coordinate axes, one of its Miller indices is zero.

(iii) If (hkl) is the Miller indices of a plane, then, the plane cuts the coordinate axes into h, k and l equal segments.

A. (i) and (ii)

B. (i) and (iii)

C. (ii) and (iii)

D. (i), (ii) and (iii)

Answer: (A) (i) and (ii)
Explanation:
Miller indices specify the orientation of crystal planes. Planes belonging to the same family with the same Miller indices are parallel. The intercepts associated with a plane having Miller indices (hkl) are proportional to

$$\frac{a}{h}, \frac{b}{k}, \frac{c}{l}.$$

Therefore, statement (iii), which says that the axes are directly divided into h, k, l equal segments, is not the standard definition. For a plane parallel to an axis, its intercept on that axis is infinite and the corresponding Miller index is zero. Therefore, statements (i) and (ii) are correct, so option (A) is the correct answer.

Professor Academy

136. In an isotropic dielectric material, $\overrightarrow{\mathbf{E}}$,$\overrightarrow{\mathbf{D}}$ and $\overrightarrow{\mathbf{P}}$ represent the intensity of electric field, electric displacement vector and polarization vector respectively. Which of the following are correct ? ($\varepsilon_{\mathbf{r}}$ is the relative permittivity of the dielectrics)

(i) $\overrightarrow{D} = \varepsilon_0 \varepsilon_r \overrightarrow{E}$

(ii) $\overrightarrow{D} = \varepsilon_0 \overrightarrow{E} + \overrightarrow{P}$

(iii) $\overrightarrow{D} = \varepsilon_0 (1 + \chi_e) \overrightarrow{E}$

(iv) $\overrightarrow{D} = \varepsilon_0 (1 - \chi_e) \overrightarrow{E}$

A. (i), (ii) and (iii) only

B. (i), (ii) and (iv) only

C. (i) and (iii) only

D. (ii) and (iv) only

Answer: (A) (i), (ii) and (iii) only
Explanation:
For a linear isotropic dielectric,

$$\overrightarrow{P} = \varepsilon_0 \chi_e \overrightarrow{E}.$$

The electric displacement vector is

$$\overrightarrow{D} = \varepsilon_0 \overrightarrow{E} + \overrightarrow{P}.$$

Substituting the expression for polarization,

$$\overrightarrow{D} = \varepsilon_0 (1 + \chi_e) \overrightarrow{E}.$$

Since

$$\varepsilon_r = 1 + \chi_e,$$

we also obtain

$$\overrightarrow{D} = \varepsilon_0 \varepsilon_r \overrightarrow{E}.$$

Thus, statements (i), (ii) and (iii) are correct, while statement (iv) is incorrect. Therefore, option (A) is the correct answer.

Professor Academy

137. Match the following:

(a)	Diamagnetism	(i)	Rare earth metals
(b)	Paramagnetism	(ii)	Salts of transition elements
(c)	Ferromagnetism	(iii)	Temperature independent susceptibility
(d)	Antiferromagnetism	(iv)	Temperature dependent susceptibility

A. (a)-(iv), (b)-(iii), (c)-(ii), (d)-(i)
B. (a)-(iii), (b)-(iv), (c)-(i), (d)-(ii)
C. (a)-(iii), (b)-(iv), (c)-(ii), (d)-(i)
D. (a)-(iv), (b)-(iii), (c)-(i), (d)-(ii)

Answer: (B) (a)-(iii), (b)-(iv), (c)-(i), (d)-(ii)
Explanation:
Diamagnetic susceptibility is generally small, negative and nearly independent of temperature, so diamagnetism corresponds to (iii). Paramagnetic susceptibility normally varies with temperature according to Curie's or Curie-Weiss law, so paramagnetism corresponds to (iv). Rare earth metals can exhibit ferromagnetic behaviour, giving the association (c)-(i), while salts of certain transition elements may exhibit antiferromagnetic ordering, giving (d)-(ii). Therefore, the matching given in option (B) is the intended answer.

138. **Match the following :**

(a) Ferroelectricity (i) Lead zirconate

(b) Antiferroelectricity (ii) Quartz

(c) Piezo electricity (iii) Hysteresis

(d) Ferromagnetism (iv) Rochelle salt

A. (a)-(iii), (b)-(ii), (c)-(i), (d)-(iv)

B. (a)-(iii), (b)-(i), (c)-(ii), (d)-(iv)

C. (a)-(iv), (b)-(i), (c)-(ii), (d)-(iii)

D. (a)-(iv), (b)-(ii), (c)-(i), (d)-(iii)

Answer: (C) (a)-(iv), (b)-(i), (c)-(ii), (d)-(iii)
Explanation:
Rochelle salt is a well-known example of a ferroelectric material, so ferroelectricity corresponds to (iv). Lead zirconate is associated with antiferroelectric behaviour, giving (b)-(i). Quartz is a standard example of a piezoelectric material and therefore corresponds to (ii). Ferromagnetic substances exhibit a characteristic magnetic hysteresis loop, so ferromagnetism corresponds to (iii). Hence, the correct matching is

$$(a)-(iv),\ (b)-(i),\ (c)-(ii),\ (d)-(iii).$$

Therefore, option (C) is the correct answer.

139. **Given $\mathbf{m_{He}}$= 4.002643amu,$\mathbf{m_p}$= 1.007825amu, and $\mathbf{m_n}$= 1.008665amu. The average binding energy per nucleon of $\mathbf{^4_2He}$ nucleon is :**

A. 7.06 MeV

B. 4.03 MeV

C. 14.12 MeV

D. 28.24 MeV

Answer: (A) 7.06 MeV
Explanation:
The helium nucleus contains two protons and two neutrons. The mass defect is

$$\Delta m = 2m_p + 2m_n - m_{He}.$$

Substituting the values,

$$\Delta m = 2(1.007825) + 2(1.008665) - 4.002643.$$

Thus,

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$$\Delta m \approx 0.030337 \text{ amu.}$$

The total binding energy is approximately

$$B = \Delta m(931.5) \approx 28.26 MeV.$$

Since there are four nucleons, the average binding energy per nucleon is

$$\frac{B}{A} = \frac{28.26}{4} \approx 7.06 MeV.$$

Therefore, option (A) is the correct answer.

140. The magnitude of a nuclear reaction cross-section depends upon :

A. Kinetic energy and nature of incident particle, independent of nature of target nuclei.

B. Potential energy and nature of incident particle, nature of target nuclei.

C. Kinetic energy and nature of incident particle, nature of target nuclei.

D. Potential energy and nature of incident particle, independent of nature of target nuclei.

Answer: (C) Kinetic energy and nature of incident particle, nature of target nuclei.
Explanation:
The nuclear reaction cross-section represents the probability that a particular nuclear reaction will occur. Its magnitude depends strongly on the kinetic energy of the incident particle because the interaction probability changes with incident energy. It also depends on the nature of the incident particle, such as whether it is a neutron, proton or alpha particle, and on the nuclear properties of the target. Therefore, the cross-section depends on the kinetic energy and nature of the incident particle as well as the nature of the target nucleus. Hence, option (C) is the correct answer.

141. The energy released per reaction when Li^7 is converted into $_2He^4$ by proton bombardment is approximately:
(Given atomic masses $_3Li^7 = 7.0183$amu, $_2He^4 = 4.0040$amu, $_1H^1 = 1.0081$amu)

A. 1.7 MeV

B. 17 MeV

C. 170 MeV

D. 0.17 MeV

Answer: (B) 17 MeV
Explanation:
The nuclear reaction involved is

$$^7_3Li + \ ^1_1H \rightarrow 2\ ^4_2He + Q.$$

The total mass before the reaction is

$$m_i = 7.0183 + 1.0081 = 8.0264 \text{ amu.}$$

The total mass after the reaction is

$$m_f = 2(4.0040) = 8.0080 amu.$$

Therefore, the mass defect is

Professor Academy

$$\Delta m = 8.0264 - 8.0080 = 0.0184 \text{ amu.}$$

Using

$$1amu = 931.5MeV/c^2,$$

the energy released per reaction is

$$Q = 0.0184 \times 931.5 \approx 17.14MeV.$$

Hence, the energy released is approximately of the order of 17 MeV. Therefore, option (B) is the correct answer.

142. In liquid drop model, according to Bohr and Wheeler's theory :

A. Volume of the drop changes, oscillations of the excited nucleus will deform the surface only, axis of symmetry changes.

B. Volume of the drop remains constant, oscillations of the excited nucleus will deform the surface only, axis of symmetry retained as same.

C. Volume of the drop remains constant, oscillations of the excited nucleus will deform the surface only, axis of symmetry changes.

D. Volume of the drop changes, oscillations of the excited nucleus will deform the entire nucleus, axis of symmetry changes.

Answer: (B) Volume of the drop remains constant, oscillations of the excited nucleus will deform the surface only, axis of symmetry retained as same.

Explanation:
In the liquid drop model, the nucleus is treated approximately like an incompressible drop of nuclear fluid. According to the Bohr and Wheeler description, excitation can produce oscillations and deformation of the nuclear surface while the total volume of the nuclear drop remains essentially constant. During the assumed deformation, the axis of symmetry is retained. Therefore, option (B) correctly describes the assumptions associated with the liquid drop model.

143. The resistivity of intrinsic silicon is (Given that $\mathbf{n_i = 1.5 \times 10^{10}/cm^3}$, μ_n= 1300 $\mathbf{cm^2/V - s}$, μ_p= 500 $\mathbf{cm^2/V - s}$)

A. $4.32 \times 10^{-6}\ S/cm$

B. $5.21 \times 10^5 \Omega - cm$

C. $2.3 \times 10^5 \Omega - cm$

D. $1.92 \times 10^{-6}\ S/cm$

Answer: (C) $2.3 \times 10^5 \Omega - cm$
Explanation:
For an intrinsic semiconductor,

$$n = p = n_i.$$

The conductivity is

$$\sigma = qn_i \left(\mu_n + \mu_p\right).$$

Substituting the given values,

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$$\sigma = \left(1.6 \times 10^{-19}\right)\left(1.5 \times 10^{10}\right)(1300 + 500).$$

Therefore,

$$\sigma = \left(1.6 \times 10^{-19}\right)\left(1.5 \times 10^{10}\right)(1800) = 4.32 \times 10^{-6}\ S/cm.$$

Resistivity is the reciprocal of conductivity:

$$\rho = \frac{1}{\sigma}.$$

Hence,

$$\rho = \frac{1}{4.32 \times 10^{-6}} \approx 2.31 \times 10^{5}\Omega - cm.$$

Thus, the resistivity is approximately $2.3 \times 10^{5}\Omega - cm$. Therefore, option (C) is the correct answer.

144. A 5-variable K-map has :

A. 16 cells

B. 32 cells

C. 64 cells

D. 5 cells

Answer: (B) 32 cells
Explanation:
A Karnaugh map containing n Boolean variables requires

$$2^n$$

cells because each cell represents one possible combination of the Boolean variables. For a 5-variable K-map,

$$\text{Number of cells } = 2^5.$$

Therefore,

$$2^5 = 32.$$

Hence, a 5-variable K-map contains 32 cells. Therefore, option (B) is the correct answer.

145. **Simplify using K-map**

$$\mathbf{Y{=}F(A,B,C,D) = \Sigma(3,4,5,7,9,13,14,15)}.$$

A. $Y = \bar{A}B\bar{C} + \bar{A}CD + A\bar{C}D + ABC$

B. $Y = \bar{A}B\bar{C} + \bar{A}CD + A\bar{C}D + ABC + BD$

C. $Y = AB\bar{C} + A\bar{C}D + \bar{A}\bar{C}D + \bar{A}\bar{B}\bar{C}$

D. $Y = \bar{A}\bar{B}C + \bar{A}C\bar{D} + \bar{A}\bar{C}D + \bar{A}BC$

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Answer: (A) $Y = \bar{A}B\bar{C} + \bar{A}CD + A\bar{C}D + ABC$
Explanation:
The given Boolean function is

$$Y = \Sigma(3, 4, 5, 7, 9, 13, 14, 15).$$

These minterms are entered into the corresponding cells of a four-variable K-map. Adjacent 1's are then combined into the largest possible groups. The required groupings produce the implicants

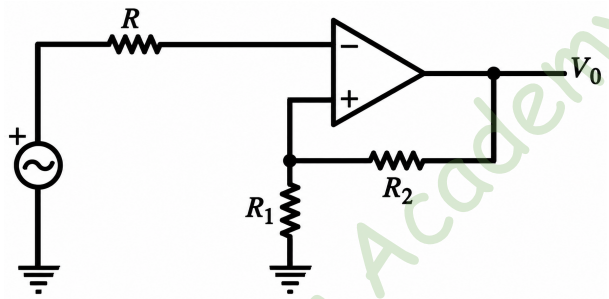
$$\bar{A}B\bar{C},\ \bar{A}CD,\ A\bar{C}D,\ ABC.$$

Combining these terms gives

$$Y = \bar{A}B\bar{C} + \bar{A}CD + A\bar{C}D + ABC.$$

Therefore, option (A) is the correct answer.

146. **Identify the following circuit :**



A. Schmitt trigger

B. sine wave generator

C. triangular wave generator

D. integrator

Answer: (A) Schmitt trigger
Explanation:
The given operational amplifier circuit is a Schmitt trigger. The input signal is applied to the inverting terminal through the resistor R, while a fraction of the output voltage is fed back to the non-inverting terminal through the resistors R_1 and R_2.

The presence of this positive feedback is the main characteristic of a Schmitt trigger. The feedback creates two different threshold voltages, namely the upper threshold voltage and the lower threshold voltage. When the input crosses these threshold levels, the output switches rapidly between its positive and negative saturation levels.

The feedback voltage is determined by the voltage divider R_1 and R_2 and can be written as

$$V_+ = \frac{R_1}{R_1 + R_2} V_0.$$

Thus, the circuit exhibits hysteresis and acts as a Schmitt trigger. Therefore, option (A) is the correct answer.

147. The signal received from a source is given as input to a CRO and the frequency of the sine wave shown is measured as 500 Hz . The time period of the signal is :

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A. 0.5 ms

B. 20 ms

C. 2 ms

D. 500 ms

Answer: (C) 2 ms

Explanation:

The frequency and time period of a periodic signal are related by

$$T = \frac{1}{f}.$$

Given the frequency,

$$f = 500\ Hz.$$

Therefore,

$$T = \frac{1}{500}\ s = 0.002\ s.$$

Since

$$1\ s = 1000\ ms,$$

we get

$$T = 0.002 \times 1000 = 2\ ms.$$

Hence, the time period of the signal is 2 ms. Therefore, option (C) is the correct answer.

148. If a light signal of wavelength 600 nm is propagated from a source then the frequency of the signal is :

A. $2.055 \times 10^{14}\ Hz$

B. $5.00 \times 10^{14}\ Hz$

C. $9.05 \times 10^{14}\ Hz$

D. $3.02 \times 10^{14}\ Hz$

Answer: (B) $5.00 \times 10^{14}\ Hz$

Explanation:

The frequency f, wavelength λ, and speed of light c are related by

$$c = f\lambda.$$

Therefore,

$$f = \frac{c}{\lambda}.$$

Given,

$$c = 3 \times 10^{8}\ m/s$$

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and

$$\lambda = 600\ nm = 600 \times 10^{-9}\ m.$$

Substituting,

$$f = \frac{3 \times 10^8}{600 \times 10^{-9}}.$$

Thus,

$$f = 5.00 \times 10^{14}\ Hz.$$

Therefore, option (B) is the correct answer.

149. In an experiment an LED which emits light of wavelength 560 nm is used to determine Planck's constant. If the threshold voltage measured is 2.216 Volts then the value of the Planck's constant measured is :

A. $3.021 \times 10^8\ m/s$

B. $6.626 \times 10^{-34} Js$

C. $1.602 \times 10^{-19} C$

D. 6.022×10^{23}

Answer: (B) $6.626 \times 10^{-34} Js$
Explanation:
For an LED, the electrical energy supplied to an electron at the threshold voltage is approximately equal to the energy of the emitted photon. Therefore,

$$eV = \frac{hc}{\lambda}.$$

Rearranging for Planck's constant,

$$h = \frac{eV\lambda}{c}.$$

Using V = 2.216 V and wavelength 560 nm gives an experimental estimate of Planck's constant very close to the accepted value:

$$h = 6.626 \times 10^{-34}\ J\ s.$$

Among the given alternatives, this value is represented by option (B). Therefore, option (B) is the correct answer.

150. **A Geiger Muller counter wire collects 10^8 electrons per discharge.When the counting rate is 500 counts/min,find the total number of electrons counted in one minute.**

A. $5 \times 10^{-10} electrons$

B. $1.6 \times 10^{-19} electrons$

C. $5 \times 10^8 electrons$

D. $5 \times 10^{10} electrons$

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Answer:(D) 5×10^{10}*electrons*
Explanation:
The number of electrons collected in each discharge is

$$N = 10^8.$$

The counting rate of the Geiger-Müller counter is

$$500 \text{ counts/min.}$$

Therefore, the total number of electrons collected in one minute is

$$N_{\text{total}} = 10^8 \times 500.$$

Since

$$500 = 5 \times 10^2,$$

we obtain

$$N_{\text{total}} = 10^8 \times 5 \times 10^2 = 5 \times 10^{10}.$$

The total number of electrons counted in one minute is

$$5 \times 10^{10} electrons$$

Therefore, option(D)is the correct answer.

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