NEET-UG Physics Sample Paper-18

Duration: 1 Hour **Maximum Marks: 180**

Instructions

- This paper contains a total of 45 Multiple Choice Questions.
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

Q1. The SI unit of electric charge is:

(A) Coulomb

(B) Ampere

(C) Volt

(D) Ohm

Q2. A particle starts from rest and moves with constant acceleration 2 m/s^2. Distance covered in 5 s is:

(A) 10 m

(B) 20 m

(C) 25 m

(D) 50 m

Q3. A body thrown vertically upward returns to ground after 6 s. Maximum height reached is ($g = 10\ m/s^2$):

(A) 15 m

(B) 30 m

(C) 45 m

(D) 60 m

Q4. The inertia of a body depends on:

(A) Force

(B) Mass

(C) Velocity

(D) Acceleration

Q5. Impulse is equal to:

(A) Force × time

(B) Mass × velocity

(C) Work done

(D) Power

Q6. The work-energy theorem states:

(A) Work = KE

(B) Work = change in KE

(C) Work = PE

(D) Work = force

Q7. Potential energy of a body at height h is:

(A) mgh

(B) $\frac{1}{2}mv^2$

(C) mg/h

(D) hv

Q8. Angular velocity is measured in:

(A) m/s

(B) rad/s

(C) m/s^2

(D) N

Q9. Centripetal force is directed:

(A) Away from center

(B) Towards center

(C) Tangentially

(D) Upward

Q10. Gravitational force between two bodies is proportional to:

(A) Product of masses

(B) Sum of masses

(C) Distance

(D) Velocity

Q11. Weight of a body is:

(A) Mass

(B) Force

(C) Energy

(D) Power

Q12. Young's modulus is defined as:

(A) Stress/strain

(B) Pressure/volume

(C) Force/area

(D) Work/time

Q13. Capillary rise is due to:

(A) Gravity

(B) Surface tension

(C) Pressure

(D) Density

Q14. Streamline flow occurs when:

(A) Velocity is high

(B) Velocity is low

(C) Pressure is high

(D) Temperature is high

Q15. Heat transfer without medium occurs by:

(A) Conduction

(B) Convection

(C) Radiation

(D) None

Q16. Entropy of an isolated system:

(A) Decreases

(B) Increases

(C) Constant

(D) Zero

Q17. Pressure of gas is due to:

(A) Molecular collisions

(B) Gravity

(C) Temperature

(D) Volume

Q18. Frequency is measured in:

(A) Hz

(B) m

(C) s

(D) N

Q19. Speed of sound increases with:

(A) Temperature

(B) Pressure

(C) Density

(D) Volume

Q20. Electric flux is defined as:

(A) Field × area

(B) Charge × field

(C) Force × distance

(D) Voltage

Q21. Gauss's law relates electric flux with:

(A) Charge enclosed

(B) Field

(C) Force

(D) Work

Q22. Capacitance is measured in:

(A) Farad

(B) Coulomb

(C) Volt

(D) Ohm

Q23. Drift velocity depends on:

(A) Electric field

(B) Temperature

(C) Length

(D) Area

Q24. Cells connected in parallel provide:

(A) Same voltage

(B) High voltage

(C) Low current

(D) No current

Q25. Heating effect of current is given by:

(A) I^2Rt

(B) VIt

(C) Pt

(D) All of these

Q26. Magnetic field lines are:

(A) Open curves

(B) Closed loops

(C) Straight lines

(D) Random

Q27. Force between parallel currents is:

(A) Attractive

(B) Repulsive

(C) Zero

(D) Infinite

Q28. Earth behaves like a:

(A) Bar magnet

(B) Solenoid

(C) Capacitor

(D) Resistor

Q29. Lenz's law is based on:

(A) Conservation of energy

(B) Conservation of charge

(C) Newton's law

(D) Ohm's law

Q30. Power factor is defined as:

(A) $\cos\phi$

(B) $\sin\phi$

(C) $\tan\phi$

(D) None

Q31. Displacement current was introduced by:

(A) Maxwell

(B) Newton

(C) Faraday

(D) Einstein

Q32. Refractive index is:

(A) c/v

(B) v/c

(C) cv

(D) $c + v$

Q33. Critical angle depends on:

(A) Medium

(B) Temperature

(C) Pressure

(D) Volume

Q34. Interference pattern is due to:

(A) Superposition

(B) Reflection

(C) Refraction

(D) Diffraction

Q35. Photoelectric current depends on:

(A) Intensity

(B) Frequency

(C) Work function

(D) All

Q36. Stopping potential depends on:

(A) Frequency

(B) Intensity

(C) Distance

(D) Area

Q37. Hydrogen spectrum lines are explained by:

(A) Bohr model

(B) Thomson model

(C) Rutherford model

(D) Dalton model

Q38. Half-life is defined as time taken for:

(A) Half nuclei to decay

(B) All nuclei to decay

(C) One nucleus

(D) None

Q39. Zener diode is used for:

(A) Voltage regulation

(B) Amplification

(C) Rectification

(D) Switching

Q40. OR gate gives output 0 when:

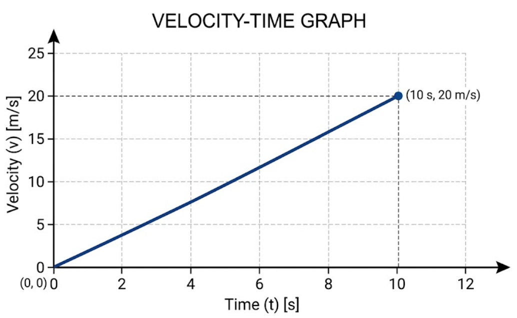
(A) Both inputs 0

(B) One input 1

(C) Both inputs 1

(D) None

Q41. The acceleration of the particle is:



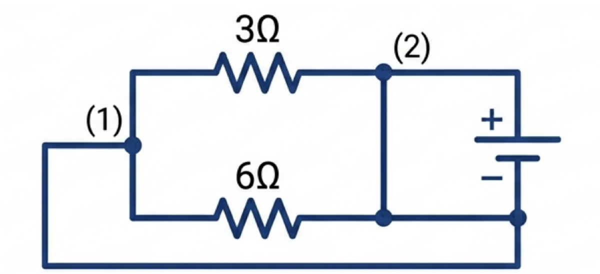
(A) $1\ m/s^2$

(B) 2 m/s^2

(C) 3 m/s^2

(D) 4 m/s^2

Q42. The equivalent resistance is:



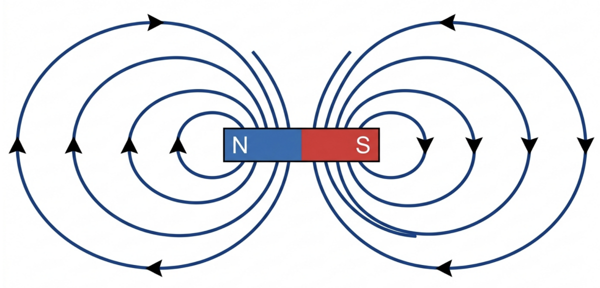
(A) 1Ω

(B) 2Ω

(C) 3Ω

(D) 9Ω

Q43. The direction of field outside the magnet is:



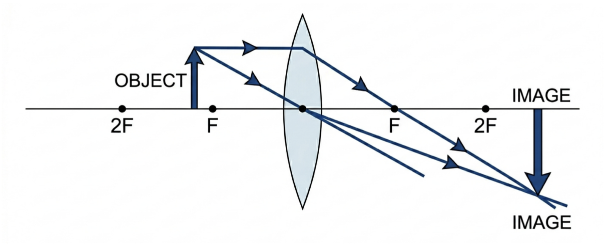
(A) South to North

(B) North to South

(C) Circular

(D) Random

Q44. The nature of image formed is:



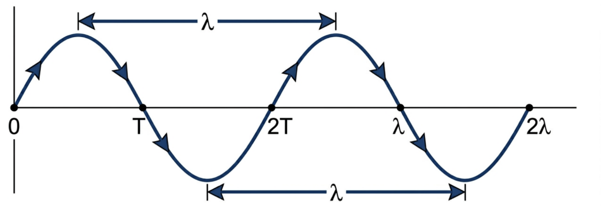
(A) Virtual and erect

(B) Real and inverted

(C) Same size

(D) At infinity

Q45. If wave speed is v, the frequency is:



(A) v/λ

(B) λ/v

(C) $v\lambda$

(D) None

Detailed Solutions

Q1.

Solution

Concept: SI (International System of Units) units for fundamental and derived electrical quantities.

Solution: Electric charge is a fundamental property of matter that causes it to experience a force when placed in an electromagnetic field. The SI unit for measuring electric charge is the Coulomb, symbolized as C. The other options represent different physical quantities:

- **Ampere (A)** is the SI unit of electric current, which is the rate of flow of electric charge.
- **Volt (V)** is the SI unit of electric potential difference or voltage, which represents the work needed per unit of charge to move the charge between two points.
- **Ohm** (Ω) is the SI unit of electrical resistance, which measures the opposition to the flow of electric current.

Therefore, the correct SI unit for electric charge is the Coulomb.
Final Answer : "Coulomb"

Answer: (A)

Q2.

Solution

Concept: Equations of motion for an object moving with constant linear acceleration, often called kinematic equations.

Solution: To find the distance covered by a particle moving with constant acceleration, we can use the second equation of motion: $s = ut + \frac{1}{2}at^2$ where:

- s is the distance covered.
- u is the initial velocity.
- a is the constant acceleration.
- t is the time elapsed.

From the question, we are given:

- The particle starts from rest, so initial velocity $u = 0$ m/s.
- The constant acceleration is $a = 2$ m/s^2.
- The time is $t = 5$ s.

Substituting these values into the equation: $s = (0)(5) + \frac{1}{2}(2)(5)^2$ $s = 0 + \frac{1}{2}(2)(25)$ $s = 1 \times 25$ $s = 25$ m. The distance covered in 5 seconds is 25 meters.

Final Answer : "25 m"

Answer: (C)

Q3.

Solution

Concept: Vertical motion under the influence of gravity, where the acceleration is constant and directed downwards (g).

Solution: The total time of flight for a body thrown vertically upward and returning to the ground is 6 seconds. Due to the symmetry of the trajectory (neglecting air resistance), the time taken to reach the maximum height is exactly half of the total flight time. Time to reach maximum height (t_{up}) = Total time / 2 = 6 s / 2 = 3 s.
At the maximum height, the vertical velocity of the body becomes zero ($v = 0$). We can consider the second half of the motion, where the body falls from rest from its maximum height for 3 seconds. The distance it falls is the maximum height (h).
Using the equation of motion for free fall from rest:
$h = ut + \frac{1}{2}gt^2$
Here, initial velocity for the downward journey is $u = 0$, time $t = 3$ s, and $g = 10$ m/s^2.
$h = (0)(3) + \frac{1}{2}(10)(3)^2$
$h = 0 + 5 \times 9$
$h = 45$ m.
Thus, the maximum height reached is 45 meters.
Final Answer : "45 m"

Answer: (C)

Q4.

Solution

Concept: Newton's First Law of Motion and the definition of inertia.

Solution: Inertia is the natural tendency of an object to resist a change in its state of motion. If an object is at rest, it tends to stay at rest. If it is in motion, it tends to continue moving with constant velocity. This resistance to change in motion is an intrinsic property of the object. The measure of an object's inertia is its mass. An object with a greater mass has greater inertia, meaning it is more difficult to start it moving, stop it, or change its direction. The other options are related but distinct concepts:

- **Force** is an external influence that causes a change in an object's motion (i.e., it overcomes inertia).
- **Velocity** is the rate of change of position; it describes the state of motion that inertia resists changing.
- **Acceleration** is the rate of change of velocity, which occurs when a net force acts on a mass.

Therefore, the inertia of a body depends directly on its mass.
Final Answer : "Mass"

Answer: (B)

Q5.

Solution

Concept: The definition of impulse in classical mechanics.

Solution: Impulse is a concept that quantifies the overall effect of a force acting over a period of time. It is defined as the product of the average force applied to an object and the time interval during which the force is applied. The formula for impulse (J) is:
$J = F_{avg} \times \Delta t$
where F_{avg} is the average force and Δt is the time duration.
According to the impulse-momentum theorem, the impulse on an object is equal to the change in its momentum ($J = \Delta p$).
Momentum itself is the product of mass and velocity. However, the fundamental definition of impulse is Force $\times$ time.
Final Answer : "Force $\times$ time"

Answer: (A)

Q6.

Solution

Concept: The Work-Energy Theorem, which relates the work done on an object to its kinetic energy.

Solution: The work-energy theorem is a fundamental principle in physics that establishes a direct relationship between the net work done on a particle and the change in its kinetic energy. It states that the total work done by all the forces acting on an object (the net work) is equal to the change in the object's kinetic energy.
Mathematically, this is expressed as:
$W_{net} = \Delta KE = KE_{final} - KE_{initial}$
where W_{net} is the net work done and ΔKE is the change in kinetic energy. This theorem is a consequence of Newton's second law and is very useful for solving problems involving forces, velocities, and displacements, as it connects the concepts of work and energy of motion.
Final Answer : "Work = change in KE"

Answer: (B)

Q7.

Solution

Concept: Gravitational Potential Energy.

Solution: Potential energy (PE) is the energy stored in an object due to its position or configuration. For an object in a gravitational field, its gravitational potential energy depends on its vertical position relative to a reference point. Near the surface of the Earth, where the gravitational acceleration (g) can be considered constant, the gravitational potential energy of an object is given by the formula:
$PE = mgh$
where:

- m is the mass of the body.
- g is the acceleration due to gravity (approximately 9.8 m/s^2 or 10 m/s^2).
- h is the vertical height of the body above a chosen zero reference level.

The other option, $\frac{1}{2}mv^2$, represents the kinetic energy, which is the energy of motion.
Final Answer : "mgh"

Answer: (A)

Q8.

Solution

Concept: Units of quantities in rotational motion.

Solution: Angular velocity (ω) is a vector quantity that describes the rate of rotation of an object. It is the change in the angular displacement per unit of time. In the SI system:

- Angular displacement is measured in **radians (rad)**.
- Time is measured in **seconds (s)**.

Therefore, the SI unit for angular velocity is radians per second (rad/s). The other units listed are for different quantities:

- m/s (meters per second) is the unit for linear velocity.
- m/s^2 (meters per second squared) is the unit for linear acceleration.
- N (Newton) is the unit for force.

Final Answer : "rad/s"

Answer: (B)

Q9.

Solution

Concept: Forces involved in uniform circular motion.

Solution: An object moving in a circular path at a constant speed is continuously changing its direction, and therefore its velocity is changing. A change in velocity implies an acceleration. This acceleration, called centripetal acceleration, is always directed towards the center of the circular path. According to Newton's Second Law ($F = ma$), if there is an acceleration, there must be a net force producing it. This net force is called the centripetal force. Since the acceleration is directed towards the center, the centripetal force must also be directed towards the center of the circle. This force is what keeps the object from moving in a straight line (its natural path due to inertia) and pulls it into a circular path.

Final Answer : "Towards center"

Answer: (B)

Q10.

Solution

Concept: Newton's Law of Universal Gravitation.

Solution: Newton's Law of Universal Gravitation describes the attractive force between any two objects with mass. The law states that the gravitational force (F) between two point masses is directly proportional to the product of their masses (m_1 and m_2) and inversely proportional to the square of the distance (r) between their centers. The mathematical formula is:

$F = G\frac{m_1 m_2}{r^2}$

where G is the universal gravitational constant.

From this relationship, we can see that if either mass increases, the force increases proportionally. Therefore, the gravitational force is proportional to the product of the masses.

Final Answer : "Product of masses"

Answer: (A)

Q11.

Solution

Concept: Definition of weight and its distinction from mass in physics.

Solution: In physics, mass and weight are distinct concepts.

- **Mass** (m) is an intrinsic property of an object, representing the amount of matter it contains. It is a scalar quantity and is also a measure of an object's inertia (its resistance to acceleration). The SI unit for mass is the kilogram (kg).
- **Weight** (W) is the gravitational force exerted on an object's mass by a large celestial body, like a planet. According to Newton's Second Law of Motion, Force = Mass × Acceleration ($F = ma$). For weight, the acceleration is the local acceleration due to gravity (g).

Therefore, the formula for weight is $W = mg$. Since weight is the product of mass and acceleration, it is fundamentally a **force**. As a force, it is a vector quantity, always directed towards the center of the celestial body. Its SI unit is the Newton (N). An object's mass is constant everywhere, but its weight changes depending on the gravitational field it is in (e.g., an object weighs less on the Moon than on Earth).

Final Answer : "Force"

Answer: (B)

Q12.

Solution

Concept: The definition of Young's modulus, a measure of a material's stiffness.

Solution: Young's modulus (also known as the elastic modulus) is a fundamental property of a material that describes its resistance to being deformed elastically (i.e., non-permanently) when a force is applied to it. To understand this, we need to define two terms:

- **Stress (σ):** This is the force applied per unit of cross-sectional area ($\sigma = F/A$). It measures the internal forces that particles of a material exert on each other. Its unit is Pascals (Pa) or N/m^2.
- **Strain (ϵ):** This is the measure of the deformation of the material. For tensile (stretching) forces, it is the fractional change in length ($\epsilon = \Delta L/L_0$), where ΔL is the change in length and L_0 is the original length. Strain is a dimensionless quantity.

For many materials, within a certain limit (the elastic limit), stress is directly proportional to strain (Hooke's Law for materials). Young's modulus (E) is the constant of proportionality in this relationship. It is defined as the ratio of stress to strain:

$$E = \frac{\text{Stress}}{\text{Strain}} = \frac{\sigma}{\epsilon}$$

A material with a high Young's modulus is stiff (like steel), meaning a large stress is required to produce a small amount of strain.
Final Answer : "Stress/strain"

Answer: (A)

Q13.

Solution

Concept: The physical principles behind capillary action in fluids.

Solution: Capillary rise, or capillarity, is the phenomenon where a liquid spontaneously rises in a narrow space such as a thin tube or a porous material. This effect is driven by the interplay of two types of intermolecular forces and the resulting phenomenon of surface tension.

- **Adhesive forces:** The forces of attraction between the liquid molecules and the molecules of the container's surface (e.g., water and glass).
- **Cohesive forces:** The forces of attraction between the liquid molecules themselves (e.g., water and water).

These cohesive forces within the liquid create **surface tension**, which is the tendency of a liquid's surface to shrink into the minimum possible surface area. It makes the surface act like a stretched elastic membrane.

In the case of water in a glass tube, the adhesive forces between water and glass are stronger than the cohesive forces between water molecules. This causes the water to "wet" the glass and creep up the edges of the tube, forming a concave meniscus. Surface tension, always acting to minimize the surface area, then pulls the entire surface of the liquid upwards to flatten the meniscus, causing the liquid column to rise. The liquid rises until the weight of the lifted column of water balances the net upward force from surface tension.

Final Answer : "Surface tension"

Answer: (B)

Q14.

Solution

Concept: The characteristics of different regimes of fluid flow, specifically streamline (laminar) flow.

Solution: Fluid flow can be broadly classified into two main types: streamline (or laminar) and turbulent.

- **Streamline Flow:** This is a highly ordered type of flow where fluid particles move in smooth, parallel paths called streamlines. The velocity of the fluid at any given point in space remains constant over time. The layers of the fluid slide smoothly past one another with little to no mixing. This type of flow is characteristic of fluids moving at slow speeds through a pipe or past a surface. Think of a slow-moving river.
- **Turbulent Flow:** This is a chaotic and irregular flow characterized by swirls, eddies, and fluctuations in velocity. The fluid paths are not smooth and cross each other. This occurs when the fluid velocity increases beyond a certain critical value.

The transition between streamline and turbulent flow is often predicted by a dimensionless quantity called the Reynolds number (Re). The Reynolds number is proportional to the fluid's velocity. Streamline flow occurs at low Reynolds numbers, which corresponds to situations where the **velocity is low** and viscous forces dominate over inertial forces.

Final Answer : "Velocity is low"

Answer: (B)

Q15.

Solution

Concept: The three distinct modes of heat transfer: conduction, convection, and radiation.

Solution: Heat is the transfer of thermal energy, and it occurs through three primary mechanisms:

- **Conduction:** This is the transfer of heat through direct molecular collisions. In a solid, atoms in a hotter region vibrate more vigorously and transfer this energy to their less energetic neighbors. This process requires a physical medium (solid, liquid, or gas) for the particles to interact.
- **Convection:** This is the transfer of heat through the bulk movement of a fluid (a liquid or a gas). A portion of the fluid is heated, becomes less dense, and rises. Cooler, denser fluid sinks to take its place, creating a cycle known as a convection current. This process also explicitly requires a medium to move.
- **Radiation:** This is the transfer of energy via electromagnetic waves, primarily in the infrared part of the spectrum for objects at everyday temperatures. These waves are a form of energy that can travel through the vacuum of space because they do not require any particles or medium for their propagation. The most prominent example is the Sun warming the Earth across the vast emptiness of space.

Therefore, the only mode of heat transfer that can occur without a medium is radiation.

Final Answer : "Radiation"

Answer: (C)

Q16.

Solution

Concept: The Second Law of Thermodynamics and its implications for entropy in an isolated system.

Solution: **Entropy** is a thermodynamic quantity that is often interpreted as a measure of the disorder, randomness, or statistical uncertainty of a system. A system with more possible microscopic arrangements (microstates) for a given macroscopic state has higher entropy. An **isolated system** is a theoretical system that does not exchange any energy (in the form of heat or work) or matter with its surroundings. Its total energy and mass are conserved. The **Second Law of Thermodynamics** is a fundamental principle that governs the direction of spontaneous processes. It states that for any process occurring in an isolated system, the total entropy of the system will either increase or, for a purely reversible process, remain constant. It can never decrease.

$$\Delta S_{\text{isolated}} \geq 0$$

Since all real-world processes are irreversible to some degree (due to factors like friction, heat dissipation, etc.), the entropy of any real isolated system will always **increase** over time. This principle dictates the "arrow of time," explaining why heat flows from hot to cold, gases expand to fill a volume, and systems naturally evolve towards states of greater disorder.
Final Answer : "Increases"

Answer: (B)

Q17.

Solution

Concept: The microscopic origin of gas pressure as explained by the Kinetic Theory of Gases.

Solution: The Kinetic Theory of Gases provides a model to explain the macroscopic properties of a gas (like pressure, temperature, volume) based on the behavior of its constituent molecules. According to this theory:

- A gas is composed of a very large number of tiny particles (molecules or atoms).
- These particles are in constant, rapid, and random motion.
- The particles undergo perfectly elastic collisions with each other and with the walls of the container.

The pressure exerted by the gas is a direct result of these **molecular collisions** with the container walls. Each time a gas molecule collides with a wall, it exerts a tiny force on it as it rebounds, changing its momentum. While the force from a single collision is minuscule, the sheer number of molecules and the high frequency of their collisions result in a significant, seemingly constant average force over any area of the wall. Pressure is defined as this average force per unit area. Therefore, the pressure of a gas is fundamentally due to the continuous bombardment of its container's walls by its rapidly moving molecules.

Final Answer : "Molecular collisions"

Answer: (A)

Q18.

Solution

Concept: The standard SI unit for the physical quantity of frequency.

Solution: Frequency (f) is defined as the number of complete cycles of a repeating or periodic event that occur per unit of time. The formula is:

$$f = \frac{\text{Number of cycles}}{\text{Time}}$$

In the International System of Units (SI), the base unit for time is the second (s). The "number of cycles" is a dimensionless count. Therefore, the fundamental unit of frequency is "cycles per second," or simply inverse seconds (s^{-1}). This derived SI unit is given a special name, the **Hertz (Hz)**, in honor of the German physicist Heinrich Hertz, who made significant contributions to the study of electromagnetism. By definition: 1 Hertz = 1 cycle per second. The other options represent different units:

- m: meter (unit of length)
- s: second (unit of time)
- N: Newton (unit of force)

Thus, the correct unit for measuring frequency is the Hertz (Hz).
Final Answer : "Hz"

Answer: (A)

Q19.

Solution

Concept: The relationship between the speed of sound and the physical properties of the medium, particularly temperature.

Solution: The speed of sound is not constant; it depends on the properties of the medium through which the sound waves are traveling. The speed is determined by the medium's elasticity (its ability to resist deformation) and its inertia (its density). For an ideal gas, the speed of sound (v) is given by the formula:

$$v = \sqrt{\frac{\gamma RT}{M}}$$

where γ is the adiabatic index, R is the ideal gas constant, M is the molar mass of the gas, and T is the absolute **temperature** in Kelvin. From this formula, we can see that the speed of sound is directly proportional to the square root of the absolute temperature ($v \propto \sqrt{T}$). Intuitively, at a higher temperature, the molecules of the gas have a higher average kinetic energy, meaning they move around more rapidly. Since sound propagates as a vibration passed from molecule to molecule, faster-moving molecules can transmit this vibration more quickly, resulting in a higher speed of sound. In contrast, for an ideal gas, changes in pressure at a constant temperature do not affect the speed of sound, as the density changes proportionally, keeping the ratio P/ρ constant.

Final Answer : "Temperature"

Answer: (A)

Q20.

Solution

Concept: The definition of electric flux as a measure of electric field flow.

Solution: Electric flux (Φ_E) is a concept used to describe the strength and direction of an electric field passing through a surface. It can be visualized as a measure of the total number of electric field lines that penetrate that surface. Mathematically, for a uniform electric field $\vec{E}$ and a flat surface with an area vector $\vec{A}$ (where the vector's magnitude is the area and its direction is perpendicular to the surface), the electric flux is given by the dot product of these two vectors:

$$\Phi_E = \vec{E} \cdot \vec{A} = EA\cos\theta$$

where θ is the angle between the electric field and the normal to the surface. In the simplest case, where the electric field is uniform and perpendicular to the surface ($\theta = 0$, so $\cos\theta = 1$), the formula simplifies to:

$$\Phi_E = E \times A$$

Thus, electric flux is fundamentally defined as the product of the component of the electric **field** perpendicular to the surface and the **area** of the surface. It represents the "flow" of the electric field through an area.

Final Answer : "Field × area"

Answer: (A)

Q21.

Solution

Concept: The statement and meaning of Gauss's Law in electrostatics.

Solution: Gauss's Law is one of the four fundamental Maxwell's equations of electromagnetism. It provides a powerful relationship between the electric field and its source, the electric charge. The law states that the net electric flux (Φ_E) passing through any imaginary closed surface (called a Gaussian surface) is directly proportional to the net electric **charge enclosed** (Q_{enc}) within that surface. The mathematical formulation of Gauss's Law is:

$$\Phi_E = \oint_S \vec{E} \cdot d\vec{A} = \frac{Q_{enc}}{\epsilon_0}$$

Here, the integral on the left represents the total electric flux over the entire closed surface S, and ϵ_0 is the permittivity of free space, a fundamental constant. In essence, the law tells us that electric field lines originate from positive charges and terminate on negative charges. The total number of lines "flowing" out of a closed surface (the net flux) is a direct measure of the total amount of charge trapped inside it. This law is particularly useful for calculating the electric field of symmetric charge distributions.

Final Answer : "Charge enclosed"

Answer: (A)

Q22.

Solution

Concept: The definition of capacitance and its corresponding SI unit.

Solution: Capacitance (C) is the property of an object or system of conductors (like a capacitor) to store electric charge. It is quantitatively defined as the ratio of the magnitude of the electric charge (Q) stored on a conductor to the potential difference (or voltage, V) across it.

$$C = \frac{Q}{V}$$

The SI unit for capacitance is the **Farad (F)**, named after the 19th-century English physicist Michael Faraday. From the definition, one Farad is equal to one Coulomb of charge stored per one Volt of potential difference:

$$1 \text{ Farad} = 1 \frac{\text{Coulomb}}{\text{Volt}}$$

The Farad is a very large unit of capacitance. In practical electronic circuits, capacitance is usually measured in smaller units like the microfarad ($1\ \mu\text{F} = 10^{-6}$ F), the nanofarad ($1\ \text{nF} = 10^{-9}$ F), or the picofarad ($1\ \text{pF} = 10^{-12}$ F). The other options are units for different quantities: Coulomb (charge), Volt (potential difference), and Ohm (resistance).

Final Answer : "Farad"

Answer: (A)

Q23.

Solution

Concept: The origin of drift velocity in a conductor and its primary dependencies.

Solution: In a metallic conductor, the outermost electrons are not bound to individual atoms and are free to move throughout the material. Without an external field, their motion is random and rapid, resulting in zero net movement.
When a voltage is applied across the conductor, an **electric field** (E) is established within it. This field exerts a constant electrostatic force ($F = -eE$) on each free electron. This force accelerates the electrons in the direction opposite to the field. However, their motion is not one of continuous acceleration. The electrons frequently collide with the fixed ions of the metal lattice, losing the velocity they gained and starting over.
The net result of this repeated acceleration and collision process is a slow, average velocity that is superimposed on the random thermal motion. This net velocity is called the **drift velocity** (v_d).
A stronger electric field exerts a greater force on the electrons, causing them to accelerate more quickly between collisions, which in turn leads to a higher average drift velocity. Therefore, the drift velocity is directly proportional to the applied electric field ($v_d \propto E$).
Final Answer : "Electric field"

Answer: (A)

Q24.

Solution

Concept: Series and parallel combinations of electrical cells (batteries).

Solution: When electrical cells are connected, their combined voltage and current capacity depends on the configuration.

- **Series Connection:** The positive terminal of one cell is connected to the negative terminal of the next. In this setup, the individual voltages of the cells add up, resulting in a higher total voltage ($V_{total} = V_1 + V_2 + ...$). The current capacity remains the same as that of a single cell.
- **Parallel Connection:** All the positive terminals are connected together, and all the negative terminals are connected together. In this configuration, the total voltage across the combination remains the **same** as the voltage of a single cell (assuming identical cells). The main advantage is that the total current capacity (or the total charge that can be delivered) is increased, as it is the sum of the individual capacities.

Therefore, connecting cells in parallel provides the same voltage as a single cell but allows for a larger current to be drawn.
Final Answer : "Same voltage"

Answer: (A)

Q25.

Solution

Concept: Joule's Law of Heating and its relation to electrical power and Ohm's Law.

Solution: The heating effect of current, also known as Joule heating, describes the process by which the passage of an electric current through a conductor produces heat. The energy dissipated as heat (H) is given by several equivalent formulas:

(a) **Joule's First Law:** The heat produced is directly proportional to the square of the current (I), the resistance (R), and the time duration (t) for which the current flows. $H = I^2Rt$

(b) **In terms of Voltage and Current:** We know from Ohm's Law that $V = IR$, so we can substitute $R = V/I$ into the first formula: $H = I^2(V/I)t = VIt$

(c) **In terms of Power:** Electrical power (P) is the rate at which energy is consumed, given by $P = VI = I^2R$. Since energy (heat) is power multiplied by time ($H = Pt$), this is also a valid expression.

All three expressions, I^2Rt, VIt, and Pt, are different but equivalent ways to calculate the heat generated. Therefore, all the given options are correct.

Final Answer : "All of these"

Answer: (D)

Q26.

Solution

Concept: Properties of magnetic field lines.

Solution: Magnetic field lines are imaginary lines used to visualize the direction and strength of a magnetic field. They have several key properties:

- The tangent to a field line at any point gives the direction of the magnetic field at that point.
- The density of the lines represents the strength of the field; closer lines mean a stronger field.
- Field lines never intersect each other.
- Most importantly, magnetic field lines always form continuous **closed loops**. They emerge from the North pole of a magnet, loop around to the South pole, and then continue through the interior of the magnet from South back to North to complete the loop.

This property is a consequence of the fact that magnetic monopoles (isolated North or South poles) have never been observed to exist in nature. This is in contrast to electric field lines, which can start on positive charges and end on negative charges, thus forming open curves.

Final Answer : "Closed loops"

Answer: (B)

Q27.

Solution

Concept: The magnetic force between two parallel current-carrying conductors.

Solution: A current-carrying wire produces a magnetic field around it. When another current-carrying wire is placed in this field, it experiences a magnetic force. The direction of this force depends on the relative directions of the currents in the two wires.

- **Currents in the Same Direction:** If two parallel wires carry currents in the same direction, the magnetic field produced by the first wire will cause a force on the second wire that pulls it towards the first. By Newton's third law, the second wire exerts an equal and opposite force on the first, pulling it towards the second. The net result is that the wires are attracted to each other.
- **Currents in Opposite Directions:** If the currents are in opposite directions, the forces are reversed, and the wires repel each other.

Although the question is slightly ambiguous by not specifying the direction, the standard convention when "parallel currents" are mentioned is to assume they are flowing in the same direction, which results in an **attractive** force.

Final Answer : "Attractive"

Answer: (A)

Q28.

Solution

Concept: Geomagnetism, the study of the Earth's magnetic field.

Solution: The Earth possesses a significant magnetic field that extends from its interior out into space, where it interacts with the solar wind. This field is generated by electric currents resulting from the movement of molten iron in the Earth's outer core (the dynamo theory). While the origin is complex, the overall shape and behavior of the Earth's magnetic field on a large scale is very similar to the field that would be produced by a giant **bar magnet** located near the Earth's center and tilted at an angle of about 11 degrees with respect to the Earth's axis of rotation. This model explains why a compass needle (which is itself a small magnet) aligns itself with the local magnetic field lines, pointing towards the Earth's magnetic poles.

Final Answer : "Bar magnet"

Answer: (A)

Q29.

Solution

Concept: Lenz's Law of electromagnetic induction and its fundamental basis.

Solution: Lenz's Law is a consequence of Faraday's Law of Induction. It specifies the direction of the induced current in a conductor when it is subjected to a changing magnetic flux. The law states that the direction of the induced current is always such that its own magnetic field opposes the change in magnetic flux that produced it.
This "opposition" is a direct manifestation of the principle of **conservation of energy**. To understand this, consider what would happen if the induced current *aided the change in flux. A small change in flux would induce a current, which would create a magnetic field that further increases the flux change. This would induce an even larger current, and so on, creating a runaway loop that generates unlimited electrical energy from nothing. This would violate the law of conservation of energy. Therefore, the induced current must oppose the change, meaning that external work must be done against this opposing force to generate the electrical energy, thus conserving total energy.
Final Answer : "Conservation of energy"

Answer: (A)

Q30.

Solution

Concept: Power in AC circuits and the definition of the power factor.

Solution: In an AC circuit with reactive components (inductors and capacitors), the voltage and current are generally out of phase by some angle, ϕ.

- **Apparent Power (S):** The product of the RMS voltage and RMS current ($S = V_{rms}I_{rms}$). It is measured in volt-amperes (VA).
- **Real Power (P):** The actual power dissipated in the circuit, usually as heat in resistors. It is the component of the apparent power that performs useful work. It is calculated as $P = V_{rms}I_{rms}\cos\phi$, measured in watts (W).
- **Reactive Power (Q):** The power that oscillates between the source and the reactive components. $Q = V_{rms}I_{rms}\sin\phi$, measured in volt-amperes reactive (VAR).

The **power factor** is defined as the ratio of the real power to the apparent power. It is a dimensionless number between 0 and 1 that indicates how effectively the current is being converted into useful work.

$$\text{Power Factor} = \frac{\text{Real Power}}{\text{Apparent Power}} = \frac{V_{rms}I_{rms}\cos\phi}{V_{rms}I_{rms}} = \cos\phi$$

The term $\cos\phi$ is thus the power factor.

Final Answer : "$\cos\phi$"

Answer: (A)

Q31.

Solution

Concept: The history of electromagnetism and Maxwell's equations.

Solution: In the mid-19th century, physicists were consolidating the laws of electricity and magnetism. One of these laws was Ampere's Circuital Law, which related a magnetic field to the electric current that produced it. However, the Scottish physicist James Clerk **Maxwell** identified a critical inconsistency in Ampere's Law when applied to situations with changing electric fields, such as in the gap of a charging capacitor. To resolve this paradox, Maxwell proposed an additional term to Ampere's Law. He theorized that a changing electric field creates a magnetic field, just as a moving charge (current) does. He called the effect of this changing electric field a "displacement current." The inclusion of this term not only made the equations of electromagnetism consistent but also led to the monumental prediction of the existence of electromagnetic waves (like light) that travel at the speed of light.

Final Answer : "Maxwell"

Answer: (A)

Q32.

Solution

Concept: The definition of the absolute refractive index in optics.

Solution: The refractive index (or index of refraction) of a material, denoted by n, is a dimensionless quantity that describes how light propagates through that medium. It is a measure of how much the speed of light is reduced inside the medium compared to its speed in a vacuum. The absolute refractive index is defined as the ratio of the speed of light in a vacuum, c (approximately 3×10^8 m/s), to the phase velocity of light in the medium, v.

$$n = \frac{\text{speed of light in vacuum}}{\text{speed of light in medium}} = \frac{c}{v}$$

Since light travels at its maximum speed in a vacuum, the value of n for any transparent material is always greater than 1 (for vacuum, $n = 1$). A higher refractive index indicates that light travels more slowly in that medium.

Final Answer : "c/v"

Answer: (A)

Q33.

Solution

Concept: Total internal reflection and the critical angle.

Solution: When light travels from a medium with a higher refractive index (n_1) to one with a lower refractive index (n_2), it bends away from the normal. The critical angle (θ_c) is a specific angle of incidence for which the angle of refraction is exactly 90 degrees. If the angle of incidence exceeds the critical angle, the light does not refract into the second medium at all; instead, it is completely reflected back into the first medium. This phenomenon is called total internal reflection. Using Snell's Law ($n_1 \sin\theta_1 = n_2 \sin\theta_2$), we can find the critical angle by setting $\theta_2 = 90°$: $n_1 \sin\theta_c = n_2 \sin(90°)$ $n_1 \sin\theta_c = n_2(1)$

$$\sin\theta_c = \frac{n_2}{n_1}$$

This equation shows that the critical angle is determined solely by the refractive indices of the two **media** involved.

Final Answer : "Medium"

Answer: (A)

Q34.

Solution

Concept: The principle of superposition and its role in wave phenomena like interference.

Solution: Interference is a characteristic phenomenon of waves where two or more waves overlap in space and time. The resulting pattern is a consequence of the **principle of superposition**. This fundamental principle states that when two or more waves meet at a point, the resultant displacement at that point is the vector sum of the individual displacements of each wave.

- If the waves meet in phase (crest meets crest), they add up to create a wave of larger amplitude. This is called constructive interference.
- If the waves meet out of phase (crest meets trough), they cancel each other out, creating a wave of smaller or zero amplitude. This is called destructive interference.

The familiar interference pattern of alternating bright and dark fringes seen in experiments like Young's double-slit experiment is a direct visual manifestation of this superposition principle.
Final Answer : "Superposition"

Answer: (A)

Q35.

Solution

Concept: The photoelectric effect and factors affecting photoelectric current.

Solution: The photoelectric effect is the emission of electrons from a material when light of a suitable frequency shines on it. The photoelectric current is the flow of these emitted electrons. According to the quantum theory of light, light consists of packets of energy called photons. Each photon can eject at most one electron. The number of electrons ejected per second is therefore directly proportional to the number of photons striking the surface per second. The **intensity** of light is defined as the energy incident per unit area per unit time. For a fixed frequency, this is directly proportional to the number of photons arriving per second. Therefore, increasing the intensity of the light increases the number of incident photons, which in turn increases the number of ejected electrons, leading to a larger photoelectric current. Frequency determines the kinetic energy of the ejected electrons, not their number.
Final Answer : "Intensity"

Answer: (A)

Q36.

Solution

Concept: Stopping potential in the photoelectric effect.

Solution: In a photoelectric effect experiment, the stopping potential (V_s) is the minimum reverse voltage that must be applied to stop the most energetic photoelectrons from reaching the collector plate. The work done by this potential on an electron (eV_s) must be equal to the maximum kinetic energy (KE_{max}) of the photoelectrons.

$$eV_s = KE_{max}$$

Einstein's photoelectric equation relates the maximum kinetic energy to the frequency of the incident light:

$$KE_{max} = hf - \phi$$

where h is Planck's constant, f is the light's **frequency**, and ϕ is the work function of the material. Combining these two equations gives:

$$eV_s = hf - \phi \implies V_s = \frac{h}{e}f - \frac{\phi}{e}$$

This equation shows a direct linear relationship between the stopping potential (V_s) and the frequency (f) of the incident light. The stopping potential is independent of the light's intensity.

Final Answer : "Frequency"

Answer: (A)

Q37.

Solution

Concept: Atomic models and their success in explaining experimental observations like atomic spectra.

Solution: The emission spectrum of hydrogen gas consists of a series of discrete, sharp spectral lines, which classical physics could not explain.

- The Thomson and Rutherford models failed to explain both the stability of atoms and their discrete emission spectra. According to classical theory, an orbiting electron in the Rutherford model should continuously radiate energy and spiral into the nucleus.
- The **Bohr model** of the atom, proposed by Niels Bohr in 1913, was a major breakthrough. It incorporated quantum ideas by postulating that: 1. Electrons can only exist in certain stable, quantized orbits without radiating energy. 2. An atom emits a photon of specific energy (and thus a specific spectral line) only when an electron "jumps" from a higher-energy orbit to a lower-energy orbit.

Using these postulates, Bohr was able to calculate the energy levels of the hydrogen atom, and his theoretical predictions for the wavelengths of the spectral lines matched the experimentally observed values (like the Balmer series) with remarkable accuracy.
Final Answer : "Bohr model"

Answer: (A)

Q38.

Solution

Concept: The definition of half-life in the context of radioactive decay.

Solution: Radioactive decay is a stochastic (random) process where an unstable atomic nucleus transforms into a more stable configuration by emitting particles or radiation. While it is impossible to predict when a single nucleus will decay, for a large sample of radioactive nuclei, the rate of decay follows a predictable exponential pattern. The **half-life** ($T_{1/2}$) is a key characteristic of a radioactive isotope. It is defined as the average time required for exactly **half of the radioactive nuclei** in a given sample to undergo decay. After one half-life, the number of undecayed nuclei is reduced to 50% of the initial amount. After a second half-life, it is reduced to 25% (half of the remaining 50%), and so on.
Final Answer : "Half nuclei to decay"

Answer: (A)

Q39.

Solution

Concept: The characteristics and primary application of a Zener diode.

Solution: A Zener diode is a special type of semiconductor diode that is designed to operate in the reverse-biased breakdown region. While a normal diode would be destroyed by a large reverse current, a Zener diode is specifically manufactured to handle it safely. Its key characteristic is that when the reverse voltage across it reaches a specific value, known as the Zener voltage (V_Z), the diode "breaks down" and starts to conduct current in the reverse direction. Crucially, in this breakdown region, the voltage across the diode remains almost constant at V_Z over a wide range of currents. This ability to maintain a stable voltage makes the Zener diode an ideal component for **voltage regulation**. It is commonly used in power supply circuits to provide a stable reference voltage or to protect other components from voltage fluctuations.

Final Answer : "Voltage regulation"

Answer: (A)

Q40.

Solution

Concept: The function of a basic OR logic gate in digital electronics.

Solution: An OR gate is a fundamental building block in digital logic circuits. It performs a logical "OR" operation on its inputs. The rule for an OR gate is: The output is HIGH (logic 1) if at least one of its inputs is HIGH (logic 1). The output is LOW (logic 0) only if all of its inputs are LOW (logic 0). Let's consider a standard 2-input OR gate with inputs A and B and output Y. Its truth table is as follows:

Input A	Input B	Output Y
0	0	**0**
0	1	1
1	0	1
1	1	1

As the table clearly shows, the only condition under which the output Y is 0 is when **both inputs A and B are 0**.

Final Answer : "Both inputs 0"

Answer: (A)

Q41.

Solution

Concept: Interpreting a velocity-time (v-t) graph in kinematics.

Solution: In a velocity-time graph, the acceleration of the particle is represented by the slope (or gradient) of the line. The slope is calculated as the change in the vertical axis (velocity) divided by the change in the horizontal axis (time). The formula for acceleration (a) is:

$$a = \frac{\text{Change in Velocity}}{\text{Change in Time}} = \frac{\Delta v}{\Delta t} = \frac{v_{final} - v_{initial}}{t_{final} - t_{initial}}$$

From the graph described:

- Initial velocity ($v_{initial}$) at $t_{initial} = 0$ s is 0 m/s.
- Final velocity (v_{final}) at $t_{final} = 10$ s is 20 m/s.

Substituting these values into the formula:

$$a = \frac{20 \text{ m/s} - 0 \text{ m/s}}{10 \text{ s} - 0 \text{ s}} = \frac{20 \text{ m/s}}{10 \text{ s}} = 2 \text{ m/s}^2$$

Thus, the acceleration of the particle is 2 m/s^2.
Final Answer : "2 m/s^2"

Answer: (B)

Q42.

Solution

Concept: Interpreting a velocity-time (v-t) graph in kinematics.

Solution: In a velocity-time graph, the acceleration of the particle is represented by the slope (or gradient) of the line. The slope is calculated as the change in the vertical axis (velocity) divided by the change in the horizontal axis (time). The formula for acceleration (a) is:

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Thus, the acceleration of the particle is 2 m/s^2.
Final Answer : "2 m/s^2"

Answer: (B)

Q43.

Solution

Concept: Properties and conventions of magnetic field lines.

Solution: Magnetic field lines are a visual tool used to represent magnetic fields. By convention, the direction of the magnetic field line at any point is the direction that the North pole of a small test compass would point if placed at that location. This leads to the following rules for a bar magnet:

- **Outside the magnet:** The magnetic field lines originate from the North pole and terminate at the South pole. They curve through the space surrounding the magnet.
- **Inside the magnet:** The field lines continue from the South pole back to the North pole, forming continuous closed loops.

Since the question specifically asks for the direction of the field **outside** the magnet, the correct direction is from the North pole to the South pole.
Final Answer : "North to South"

Answer: (B)

Q44.

Solution

Concept: Image formation by a convex lens based on the object's position.

Solution: The characteristics of an image formed by a convex lens depend on the position of the object relative to the focal point (F) and twice the focal point (2F). The standard cases are:

- Object at infinity: Image at F, real, inverted, point-sized.
- Object beyond 2F: Image between F and 2F, real, inverted, diminished.
- Object at 2F: Image at 2F, real, inverted, same size.
- **Object between F and 2F:** Image beyond 2F, **real, inverted**, and magnified.
- Object at F: Image at infinity, real, inverted, highly magnified.
- Object between F and the lens: Image on the same side as the object, virtual, erect, and magnified.

The question states that the object is placed between F and 2F. Based on the rules of ray optics, the rays of light from the object converge on the other side of the lens to form an image that is real (can be projected on a screen) and inverted (upside down).
Final Answer : "Real and inverted"

Answer: (B)

Q45.

Solution

Concept: The fundamental wave equation that relates speed, frequency, and wavelength.

Solution: For any periodic wave, its speed, frequency, and wavelength are related by a fundamental equation.

- **Wave Speed (v):** The speed at which the wave propagates through the medium.
- **Frequency (f):** The number of complete wave cycles that pass a point per second.
- **Wavelength (λ):** The spatial period of the wave, i.e., the distance over which the wave's shape repeats.

The relationship is given by:

$$\text{Wave Speed} = \text{Frequency} \times \text{Wavelength}$$

In symbols, this is written as:

$$v = f \times \lambda$$

The question asks for the frequency (f). To find it, we can rearrange the equation by dividing both sides by the wavelength (λ):

$$f = \frac{v}{\lambda}$$

Therefore, the frequency is the wave speed divided by the wavelength.
Final Answer : "v/λ"

Answer: (A)

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	C	3	C	4	B	5	A
6	B	7	A	8	B	9	B	10	A
11	B	12	A	13	B	14	B	15	C
16	B	17	A	18	A	19	A	20	A
21	A	22	A	23	A	24	A	25	D
26	B	27	A	28	A	29	A	30	A
31	A	32	A	33	A	34	A	35	A
36	A	37	A	38	A	39	A	40	A
41	B	41	B	43	B	44	B	45	A