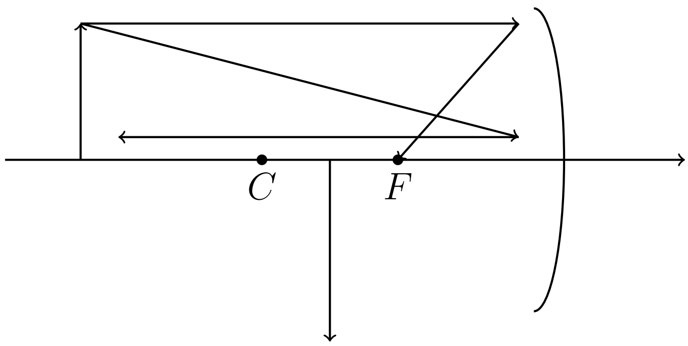
JEECUP Group A Physics Sample Paper – 11

Duration: 45 Minutes **Maximum Marks: 100**

Instructions

- This paper contains **25** Multiple Choice Questions (Single Correct).
- Each correct answer carries **+4 marks**. No marks will be deducted for incorrect answers. Unattempted questions carry **0** marks.
- Only **one** option is correct for each question.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Q1. An object is placed at a distance of 24 cm from a concave mirror of focal length 18 cm. The image formed is real and inverted. The distance of the image from the mirror is:



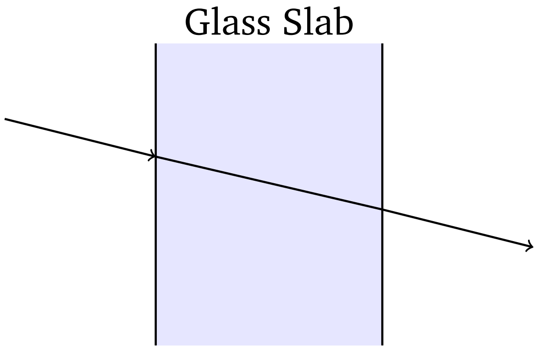
(A) 48 cm

(B) 72 cm

(C) 36 cm

(D) 12 cm

Q2. A ray of light enters a rectangular glass slab obliquely and emerges parallel to the incident ray after refraction through the slab. The phenomenon responsible for the sideways displacement of the ray is:



(A) Total internal reflection

(B) Refraction at parallel surfaces

(C) Diffraction

(D) Dispersion

Q3. The refractive index of a medium with respect to air is $\sqrt{2}$. The critical angle for the medium is:

(A) $30°$

(B) $45°$

(C) $60°$

(D) $90°$

Q4. A convex lens has a focal length of 25 cm. The power of the lens in dioptre is:

(A) $+2D$

(B) $+4D$

(C) $-2D$

(D) $-4D$

Q5. An object of height 3 cm forms an image of height -9 cm in a concave mirror. The magnification produced by the mirror is:

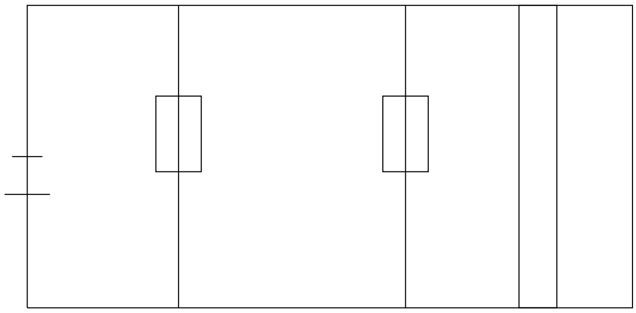
(A) -3

(B) $-1/3$

(C) $+3$

(D) $+1/3$

Q6. Four resistors each of resistance 4Ω are connected in such a way that two pairs are connected in parallel and the resulting combinations are connected in series. The equivalent resistance of the arrangement is:



(A) 2Ω

(B) 4Ω

(C) 6Ω

(D) 8Ω

Q7. A conductor carries a steady current of 5 A for 4 minutes. The amount of electric charge flowing through the conductor is:

(A) 300 C

(B) 600 C

(C) 900 C

(D) 1200 C

Q8. A heater coil of resistance 20Ω is connected to a 220 V supply. The heat produced in 1 minute is closest to:

(A) 1.45×10^5 J

(B) 1.0×10^5 J

(C) 2.9×10^5 J

(D) 4.8×10^4 J

Q9. An electric bulb rated 100 W, 220 V is used for 10 hours. The electrical energy consumed by the bulb is:

(A) 0.1 kWh

(B) 1 kWh

(C) 10 kWh

(D) 100 kWh

Q10. A fuse wire used in household electric circuits should have:

(A) High melting point and low resistance

(B) Low melting point and high resistance

(C) High melting point and high resistance

(D) Low melting point and low resistance

Q11. A body starting from rest acquires a velocity of 20 m/s in 5 seconds under uniform acceleration. The distance travelled by the body during this interval is:

(A) 25 m

(B) 50 m

(C) 75 m

(D) 100 m

Q12. A passenger standing in a moving bus falls backward when the bus suddenly starts moving forward. This is due to:

(A) Newton's first law of motion

(B) Newton's second law of motion

(C) Newton's third law of motion

(D) Universal gravitation

Q13. Two bodies of masses 2 kg and 3 kg move with velocities 4 m/s and 6 m/s respectively in the same direction. The total momentum of the system is:

(A) 10 kg m/s

(B) 18 kg m/s

(C) 26 kg m/s

(D) 30 kg m/s

Q14. A body moving on a rough horizontal surface gradually comes to rest because of the force of friction. The kinetic energy of the body is mainly converted into:

(A) Electrical energy

(B) Heat energy

(C) Sound energy only

(D) Potential energy

Q15. A stone of mass 2 kg falls freely through a vertical distance of 5 m. Taking $g = 10$ m/s^2, the work done by gravity on the stone is:

(A) 25 J

(B) 50 J

(C) 100 J

(D) 200 J

Q16. A body of mass 4 kg moving with velocity 10 m/s is brought to rest. The loss in kinetic energy of the body is:

(A) 100 J

(B) 200 J

(C) 400 J

(D) 800 J

Q17. A machine performs useful work of 800 J by consuming 1000 J of energy. The efficiency of the machine is:

(A) 20%

(B) 40%

(C) 60%

(D) 80%

Q18. Equal masses of water at $80°C$ and $20°C$ are mixed together in an insulated vessel. Neglecting heat losses, the final temperature of the mixture will be:

(A) $20°C$

(B) $40°C$

(C) $50°C$

(D) $80°C$

Q19. Cooking utensils are generally made of metals because metals usually possess:

(A) Low density

(B) High elasticity

(C) High thermal conductivity

(D) High electrical resistance

Q20. The amount of heat required to convert unit mass of a liquid completely into vapour at its boiling point without any change in temperature is known as:

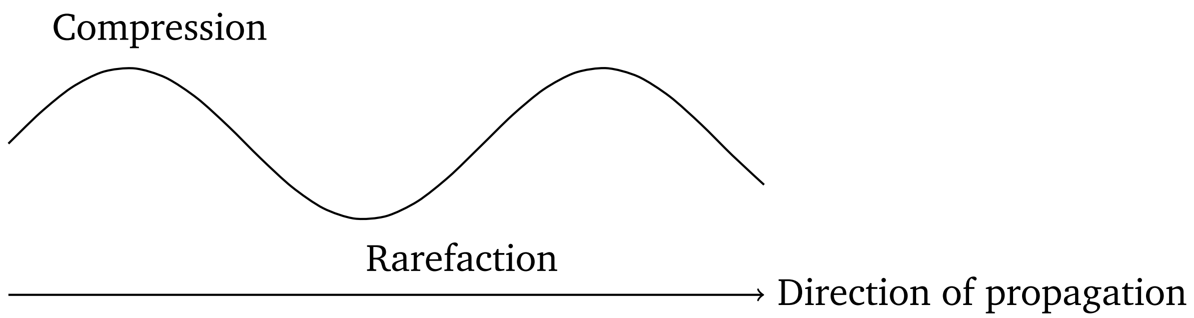
(A) Specific heat

(B) Latent heat of fusion

(C) Latent heat of vaporisation

(D) Thermal capacity

Q21. A sound wave travels with a speed of 330 m/s and has a frequency of 550 Hz. The wavelength of the sound wave is:



(A) 0.6 m

(B) 1.2 m

(C) 1.8 m

(D) 2.4 m

Q22. A person claps near a tall building and hears the reflected sound after a short interval. This phenomenon is known as:

(A) Reverberation

(B) Diffraction

(C) Echo

(D) Interference

Q23. When a radioactive nucleus emits a β-particle, the atomic number of the nucleus:

(A) Decreases by 1

(B) Increases by 1

(C) Remains unchanged

(D) Decreases by 2

Q24. Which of the following radiations is not affected by electric and magnetic fields due to the absence of electric charge?

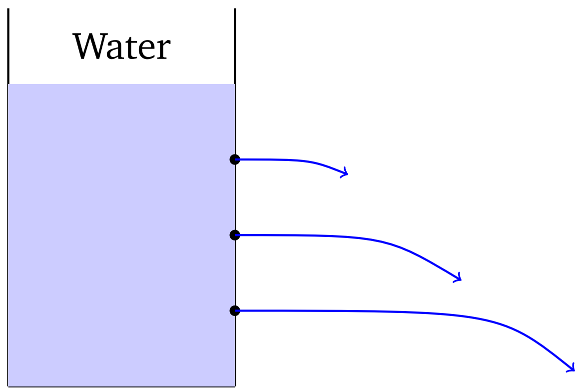
(A) α-rays

(B) β-rays

(C) γ-rays

(D) Cathode rays

Q25. The pressure exerted by a liquid column at a point inside the liquid depends directly upon:



(A) Shape of the vessel

(B) Area of liquid surface

(C) Depth and density of liquid

(D) Volume of the container

Detailed Solutions

Q1.

Solution

Concept: For a spherical mirror:

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$

For a concave mirror using Cartesian sign convention:

- $u < 0$
- $f < 0$
- $v < 0$ for a real image

Solution: Step 1: Identify the given values with their proper signs based on the convention:

$$\text{Object distance, } u = -24 \text{ cm}$$
$$\text{Focal length, } f = -18 \text{ cm}$$

Step 2: Substitute these values into the Mirror Formula:

$$\frac{1}{-18} = \frac{1}{v} + \frac{1}{-24}$$

Step 3: Isolate the term with the image distance (v):

$$\frac{1}{v} = -\frac{1}{18} + \frac{1}{24}$$

Step 4: Find the least common multiple (LCM) of 18 and 24, which is 72, to perform the fraction subtraction:

$$\frac{1}{v} = \frac{-4 \cdot 1 + 3 \cdot 1}{72} = \frac{-4+3}{72} = -\frac{1}{72}$$

Step 5: Solve for v by taking the reciprocal:

$$v = -72 \text{ cm}$$

The negative sign confirms that the image is real and formed in front of the mirror. Thus, the physical distance of the image from the mirror is 72 cm.

Final Answer: $\boxed{72 \text{ cm}}$

Answer: (B)

Go Back to Question 1

Q2.

Solution

Concept: When a ray of light passes obliquely through a rectangular glass slab with parallel refracting boundaries:

- It undergoes refraction twice: first at the air-to-glass interface (bending towards the normal) and then at the glass-to-air interface (bending away from the normal).
- Because the opposite boundaries of the slab are parallel, the angle of emergence equals the angle of incidence ($i = e$). This causes the emergent ray to travel in the same direction as, and parallel to, the original incident path.
- The perpendicular distance between the original incident path produced forward and the shifted emergent ray is called the lateral shift or lateral displacement.

Solution: Step 1: Analyze the physical process. Light changes its path at the first boundary and bends in the opposite direction by an equal angle at the second boundary.

Step 2: This dual bending ensures that the emergent ray is parallel to the incident ray but shifted to the side.

Step 3: This sideways displacement (lateral shift) is fundamentally due to refraction taking place at two parallel boundaries of the medium.

Step 4: Therefore, the phenomenon responsible for the sideways displacement is refraction at parallel surfaces.

Final Answer: Refraction at parallel surfaces

Answer: (B) Go Back to Question 2

Q3.

Solution

Concept: The critical angle (C) is the angle of incidence in a denser optical medium for which the corresponding angle of refraction in the rarer medium is exactly 90°. According to Snell's Law at the critical boundary:

$$\mu_{\text{denser}} \cdot \sin C = \mu_{\text{rarer}} \cdot \sin 90^\circ$$

Since the rarer medium is air ($\mu_{\text{rarer}} = 1$) and the denser medium has a refractive index μ, this relationship simplifies to:

$$\sin C = \frac{1}{\mu}$$

Solution: Step 1: Identify the given refractive index of the medium with respect to air:

$$\mu = \sqrt{2}$$

Step 2: Substitute this value into the critical angle equation:

$$\sin C = \frac{1}{\sqrt{2}}$$

Step 3: Find the angle C within the domain $[0^\circ, 90^\circ]$ whose sine is $\frac{1}{\sqrt{2}}$:

$$C = \sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = 45^\circ$$

Therefore, the critical angle for this medium is 45°.

Final Answer: $\boxed{45^\circ}$

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept: The power (P) of a lens measures its ability to converge or diverge light rays. It is mathematically defined as the reciprocal of its focal length (f) when the focal length is expressed in meters:

$$P = \frac{1}{f \text{ (in meters)}}$$

- The SI unit of power is the Dioptre (D), where $1\ D = 1\ \text{m}^{-1}$.
- Convex (converging) lenses have positive focal lengths and thus positive power.

Solution: Step 1: Convert the given focal length of the convex lens from centimeters to the SI unit of meters:

$$f = +25 \text{ cm} = \frac{25}{100} \text{ m} = +0.25 \text{ m}$$

Step 2: Calculate the power using the reciprocal of the focal length:

$$P = \frac{1}{+0.25 \text{ m}} = +4 \text{ m}^{-1}$$

Step 3: Express the power in Dioptres (D):

$$P = +4D$$

The positive sign indicates the converging nature of the convex lens.

Final Answer: $\boxed{+4D}$

Answer: (B)

Go Back to Question 4

Q5.

Solution

Concept: Linear magnification (m) produced by a spherical mirror is defined as the ratio of the height of the image (h_i) to the height of the object (h_o):

$$m = \frac{h_i}{h_o}$$

According to the Cartesian sign convention:

- Heights measured perpendicular to and above the principal axis (erect objects) are positive.
- Heights measured perpendicular to and below the principal axis (inverted images) are negative.

Solution: Step 1: Identify the given heights with their respective signs:

$$\text{Height of object, } h_o = +3 \text{ cm}$$
$$\text{Height of image, } h_i = -9 \text{ cm}$$

Step 2: Substitute these values into the magnification formula:

$$m = \frac{-9 \text{ cm}}{+3 \text{ cm}}$$

Step 3: Calculate the value:

$$m = -3$$

The negative sign indicates that the image is real and inverted, and its magnitude (3) shows that the image is magnified to three times the size of the object.

Final Answer: $\boxed{-3}$

Answer: (A)

Go Back to Question 5

Q6.

Solution

Concept: The electrical circuit arrangement consists of two parallel pairs of resistors, and these two pairs are connected in series with each other.

- For a parallel combination of two resistors R_1 and R_2, the equivalent resistance R_p is:

$$R_p = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

- For a series combination of two equivalent resistances, the total equivalent resistance R_{eq} is:

$$R_{eq} = R_{p1} + R_{p2}$$

Solution: Step 1: Calculate the equivalent resistance of the first parallel pair (R_{p1}), consisting of two $4\ \Omega$ resistors:

$$R_{p1} = \frac{4\ \Omega \cdot 4\ \Omega}{4\ \Omega + 4\ \Omega} = \frac{16}{8}\ \Omega = 2\ \Omega$$

Step 2: Since the second parallel pair is identical, its equivalent resistance (R_{p2}) is also:

$$R_{p2} = 2\ \Omega$$

Step 3: These two equivalent resistances are connected in series. Calculate the total equivalent resistance (R_{eq}):

$$R_{eq} = R_{p1} + R_{p2} = 2\ \Omega + 2\ \Omega = 4\ \Omega$$

The equivalent resistance of this series-parallel arrangement is $4\ \Omega$.

Final Answer: $\boxed{4\ \Omega}$

Answer: (B)

Go Back to Question 6

Q7.

Solution

Concept: Electric current (I) is defined as the rate of flow of electric charge (Q) through a cross-section of a conductor:

$$I = \frac{Q}{t}$$

By rearranging this formula, the total charge (Q) transported by a steady current over a time interval (t) is:

$$Q = I \cdot t$$

To obtain the charge in the SI unit of Coulombs (C), the time interval must be expressed in seconds (s).

Solution: Step 1: Identify the given current:

$$I = 5 \text{ A}$$

Step 2: Convert the given time from minutes to the SI unit of seconds:

$$t = 4 \text{ minutes} = 4 \cdot 60 \text{ seconds} = 240 \text{ s}$$

Step 3: Calculate the total charge (Q) using the rearranged formula:

$$Q = 5 \text{ A} \cdot 240 \text{ s}$$

$$Q = 1200 \text{ C}$$

Therefore, the amount of electric charge flowing through the conductor is 1200 C.

Final Answer: $\boxed{1200 \text{ C}}$

Answer: (D)

Go Back to Question 7

Q8.

Solution

Concept: According to Joule's Law of Heating, the electrical energy converted into heat (H) in a resistor of resistance R connected across a constant potential difference V for a duration t is:

$$H = P \cdot t = \frac{V^2}{R} \cdot t$$

All parameters must be converted into SI units (time in seconds) to find the heat in Joules (J).

Solution: Step 1: Identify and convert the given parameters into SI units:

$$\begin{aligned} \text{Voltage, } V &= 220 \text{ V} \\ \text{Resistance, } R &= 20 \ \Omega \\ \text{Time, } t &= 1 \text{ minute} = 60 \text{ seconds} \end{aligned}$$

Step 2: Substitute these parameters into the heat formula:

$$H = \frac{(220 \text{ V})^2}{20 \ \Omega} \cdot 60 \text{ s}$$

Step 3: Compute the steps systematically:

$$\begin{aligned} V^2 &= 220 \cdot 220 = 48400 \text{ V}^2 \\ H &= \frac{48400}{20} \cdot 60 \\ H &= 2420 \cdot 60 \\ H &= 145200 \text{ J} \end{aligned}$$

Step 4: Express the final heat energy in scientific notation:

$$H = 1.452 \times 10^5 \text{ J}$$

This is closest to the option 1.45×10^5 J.

Final Answer: $\boxed{1.45 \times 10^5 \text{ J}}$

Answer: (A)

Go Back to Question 8

Q9.

Solution

Concept: The commercial unit of electrical energy is the kilowatt-hour (kWh), which is defined as the energy consumed by an electrical appliance of power 1 kW operating for 1 hour:

$$\text{Energy } (E) = \text{Power } (P \text{ in kW}) \cdot \text{Time } (t \text{ in hours})$$

Solution: Step 1: Identify the given parameters:

$$\text{Power rating, } P = 100 \text{ W}$$
$$\text{Time of usage, } t = 10 \text{ hours}$$

Step 2: Convert the power rating from Watts (W) to kilowatts (kW):

$$P = \frac{100}{1000} \text{ kW} = 0.1 \text{ kW}$$

Step 3: Calculate the electrical energy consumed (E):

$$E = 0.1 \text{ kW} \cdot 10 \text{ hours}$$

$$E = 1 \text{ kWh}$$

The total electrical energy consumed by the bulb is 1 kWh (which is equivalent to 3.6×10^6 Joules).

Final Answer: $\boxed{1 \text{ kWh}}$

Answer: (B)

Go Back to Question 9

Q10.

Solution

Concept: An electrical fuse is a vital safety device connected in series with the live wire of an electrical circuit to protect appliances from overloading and short circuits. It operates on the principle of Joule's heating effect ($H = I^2Rt$).

- High Resistance: A relatively high resistance (compared to the copper main lines) is necessary so that significant heat is generated quickly in the fuse wire when current exceeds safe limits.
- Low Melting Point: A low melting point is essential so that the wire melts and breaks the circuit immediately when it heats up, preventing current flow before damage can occur to the appliances or building wiring.

Solution: Step 1: Analyze the function of a fuse. It must melt and break the circuit when current is too high.

Step 2: According to $H = I^2Rt$, high resistance (R) ensures that heat is generated rapidly at the fuse link.

Step 3: A low melting point ensures that the fuse melts at a relatively low temperature, safely cutting off the power.

Step 4: Therefore, the fuse wire must possess a low melting point and high resistance.

Final Answer: Low melting point and high resistance

Answer: (B)

Go Back to Question 10

Q11.

Solution

Concept: For an object starting from rest and accelerating uniformly, we can calculate the distance travelled (s) in two ways:

- Method 1 (Using average velocity): For uniform acceleration, the average velocity (v_{avg}) is the arithmetic mean of the initial and final velocities.

$$s = v_{\text{avg}} \cdot t = \left(\frac{u+v}{2}\right) \cdot t$$

- Method 2 (Using equations of motion): Calculate the uniform acceleration (a) first using $v = u + at$, then substitute into $s = ut + \frac{1}{2}at^2$.

Solution: Step 1: Identify the given kinematic variables:

$$\begin{aligned} \text{Initial velocity, } u &= 0 \text{ m/s} \quad \text{(starts from rest)} \\ \text{Final velocity, } v &= 20 \text{ m/s} \\ \text{Time interval, } t &= 5 \text{ s} \end{aligned}$$

Step 2: Apply the average velocity method:

$$s = \left(\frac{0+20}{2}\right) \cdot 5$$

$$s = 10 \text{ m/s} \cdot 5 \text{ s} = 50 \text{ m}$$

Step 3: Alternatively, verify using acceleration:

$$a = \frac{v-u}{t} = \frac{20-0}{5} = 4 \text{ m/s}^2$$

$$s = ut + \frac{1}{2}at^2 = 0 \cdot 5 + \frac{1}{2} \cdot 4 \cdot (5)^2 = 2 \cdot 25 = 50 \text{ m}$$

Both methods yield the same distance of 50 m.

Final Answer: $\boxed{50 \text{ m}}$

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept: Newton's First Law of Motion states that an object will remain at rest or in uniform motion in a straight line unless acted upon by a net external force. This property is known as inertia.

- Inertia of rest is the inherent tendency of an object to resist any change in its state of rest.

Solution: Step 1: Initially, both the bus and the passenger standing inside are at rest.

Step 2: When the bus suddenly accelerates forward, a forward force is exerted on the lower part of the passenger's body (their feet) through contact with the floor. As a result, the lower body begins to move forward with the bus.

Step 3: However, the upper part of the passenger's body is not in direct contact with the floor, so it tends to remain in its original state of rest due to the inertia of rest.

Step 4: This lag of the upper body relative to the feet causes the passenger to fall backward.

Step 5: Therefore, this phenomenon is directly explained by Newton's first law of motion.

Final Answer: Newton's first law of motion

Answer: (A)

Go Back to Question 12

Q13.

Solution

Concept: Linear momentum (p) is a vector quantity that represents the product of an object's mass (m) and its velocity ($\vec{v}$):

$$p = m \cdot v$$

For a system consisting of multiple moving bodies, the total linear momentum (P) is the vector sum of their individual momenta. Since both bodies are moving in the same direction, their velocities have the same sign, and we can add their magnitudes directly:

$$P = p_1 + p_2 = m_1 v_1 + m_2 v_2$$

Solution: Step 1: Identify the masses and velocities of the two bodies:

$$\text{First body: } m_1 = 2 \text{ kg}, \quad v_1 = 4 \text{ m/s}$$
$$\text{Second body: } m_2 = 3 \text{ kg}, \quad v_2 = 6 \text{ m/s}$$

Step 2: Calculate the momentum of the first body (p_1):

$$p_1 = 2 \text{ kg} \cdot 4 \text{ m/s} = 8 \text{ kg m/s}$$

Step 3: Calculate the momentum of the second body (p_2):

$$p_2 = 3 \text{ kg} \cdot 6 \text{ m/s} = 18 \text{ kg m/s}$$

Step 4: Sum the two momenta to find the total momentum of the system (P):

$$P = p_1 + p_2 = 8 \text{ kg m/s} + 18 \text{ kg m/s} = 26 \text{ kg m/s}$$

The total momentum of the system is 26 kg m/s.

Final Answer: $\boxed{26 \text{ kg m/s}}$

Answer: (C)

Go Back to Question 13

Q14.

Solution

Concept: Friction is a non-conservative, resistive force that does negative work on a moving body, dissipating its mechanical energy. According to the law of conservation of energy, energy cannot be created or destroyed; it can only be converted from one form to another.

Solution: Step 1: As the body slides over a rough horizontal surface, work is done against the force of friction.

Step 2: The mechanical energy, specifically the kinetic energy of the moving body, is systematically dissipated at the contacting surfaces.

Step 3: This dissipated kinetic energy is primarily converted into thermal energy (heat energy) at the contact boundary, which increases the temperature of both the body and the surface.

Step 4: Although a minute fraction of energy may be released as sound, the vast majority is converted into heat.

Final Answer: Heat energy

Answer: (B)

Go Back to Question 14

Q15.

Solution

Concept: The work done (W) by a constant force (F) acting on an object that undergoes a displacement (d) is given by:

$$W = F \cdot d \cdot \cos\theta$$

where θ is the angle between the force vector and the displacement vector. For a freely falling object, the accelerating force is gravity $(F_g = m \cdot g)$ acting vertically downwards, and the displacement (h) is also in the vertically downward direction $(\theta = 0°)$.

Solution: Step 1: Identify the given physical parameters:

Mass of the stone, $m = 2$ kg

Vertical height fallen, $h = 5$ m

Acceleration due to gravity, $g = 10$ m/s^2

Step 2: Substitute these values into the work formula with $\theta = 0°$ $(\cos 0° = 1)$:

$$W = (m \cdot g) \cdot h \cdot \cos 0°$$

$$W = 2 \text{ kg} \cdot 10 \text{ m/s}^2 \cdot 5 \text{ m} \cdot 1$$

Step 3: Calculate the numerical result:

$$W = 100 \text{ J}$$

Because both the gravitational force and displacement point in the same direction, gravity does positive work on the stone.

Final Answer: $\boxed{100 \text{ J}}$

Answer: (C)

Go Back to Question 15

Q16.

Solution

Concept: The kinetic energy ($K.E.$) of a moving body is given by:

$$K.E. = \frac{1}{2}mv^2$$

When a body is brought to rest, its final velocity is zero, which means its final kinetic energy is also zero. The loss in kinetic energy ($\Delta K.E.$) is the difference between its initial and final kinetic energy:

$$\Delta K.E. = K.E._{\text{initial}} - K.E._{\text{final}}$$

Solution: Step 1: Identify the given values:

$$\text{Mass of the body, } m = 4 \text{ kg}$$
$$\text{Initial velocity, } v_i = 10 \text{ m/s}$$
$$\text{Final velocity, } v_f = 0 \text{ m/s} \quad \text{(brought to rest)}$$

Step 2: Calculate the initial kinetic energy:

$$K.E._{\text{initial}} = \frac{1}{2} \cdot 4 \text{ kg} \cdot (10 \text{ m/s})^2$$
$$K.E._{\text{initial}} = 2 \cdot 100 = 200 \text{ J}$$

Step 3: Since the final velocity is zero, the final kinetic energy is:

$$K.E._{\text{final}} = 0 \text{ J}$$

Step 4: Compute the loss in kinetic energy:

$$\Delta K.E. = 200 \text{ J} - 0 \text{ J} = 200 \text{ J}$$

Final Answer: $\boxed{200 \text{ J}}$

Answer: (B)

Go Back to Question 16

Q17.

Solution

Concept: The efficiency (η) of a machine is the ratio of the useful work output (W_{useful}) to the total energy input or energy consumed (E_{consumed}), expressed as a percentage:

$$\eta = \frac{W_{\text{useful}}}{E_{\text{consumed}}} \times 100\%$$

Solution: Step 1: Identify the given quantities:

$$\text{Useful work output, } W_{\text{useful}} = 800 \text{ J}$$
$$\text{Energy consumed, } E_{\text{consumed}} = 1000 \text{ J}$$

Step 2: Substitute these values into the efficiency formula:

$$\eta = \frac{800 \text{ J}}{1000 \text{ J}} \times 100\%$$

Step 3: Perform the calculation:

$$\eta = 0.8 \cdot 100\% = 80\%$$

The efficiency of the machine is 80%, meaning 20% of the consumed energy was dissipated as waste (typically heat or sound).

Final Answer: $\boxed{80\%}$

Answer: (D)

Go Back to Question 17

Q18.

Solution

Concept: According to the principle of calorimetry, in an insulated system with no heat exchange with the surroundings:

$$\text{Heat lost by hot substance} = \text{Heat gained by cold substance}$$

The quantity of heat (Q) exchanged during a temperature change is given by:

$$Q = m \cdot c \cdot \Delta T$$

where m is the mass, c is the specific heat capacity, and ΔT is the change in temperature.

Solution: Step 1: Set up the parameters for the mixture: Let the mass of both portions of water be m, and the specific heat capacity of water be c. Let the final equilibrium temperature of the mixture be T.

$$\text{Initial temperature of hot water, } T_1 = 80^\circ C$$
$$\text{Initial temperature of cold water, } T_2 = 20^\circ C$$

Step 2: Apply the calorimetry equation:

$$m \cdot c \cdot (T_1 - T) = m \cdot c \cdot (T - T_2)$$

Step 3: Since the masses and specific heat capacities are identical on both sides, divide both sides by $m \cdot c$:

$$T_1 - T = T - T_2$$

Step 4: Substitute the given temperatures and solve for T:

$$80 - T = T - 20$$

$$2T = 100$$

$$T = 50^\circ C$$

The final temperature of the mixture is $50^\circ C$.

Final Answer: $\boxed{50^\circ C}$

Answer: (C)

Go Back to Question 18

Q19.

Solution

Concept: The choice of materials for cooking utensils depends on their ability to efficiently conduct heat from an external thermal source (like a stove flame) to the food inside.

- Thermal conductivity is the property of a material that determines the rate at which heat flows through it.
- Metals have a high density of free electrons, which makes them exceptional conductors of both electricity and heat.

Solution: Step 1: Cooking utensils must transfer heat quickly and uniformly to cook food efficiently.

Step 2: Materials with high thermal conductivity allow rapid heat transfer with minimal energy loss.

Step 3: Because metals usually possess high thermal conductivity, they are the preferred material for manufacturing cooking pots, pans, and kettles.

Step 4: Other properties such as low density, high elasticity, or high electrical resistance do not govern thermal energy transfer.

Final Answer: High thermal conductivity

Answer: (C)

Go Back to Question 19

Q20.

Solution

Concept: During a change of state, heat is absorbed or released without any change in temperature. This heat is known as latent heat.

- Latent heat of fusion: The heat required to change a unit mass of a substance from solid to liquid at its melting point.
- Latent heat of vaporisation: The heat required to change a unit mass of a substance from liquid to gas (vapour) at its boiling point.

Solution: Step 1: Identify the phase change taking place in the question: converting a liquid completely into vapour.

Step 2: Identify the condition: the process occurs at its boiling point without any temperature change.

Step 3: By definition, the heat required per unit mass for a liquid-to-vapour phase change is the latent heat of vaporisation.

Final Answer: $\boxed{\text{Latent heat of vaporisation}}$

Answer: (C)

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Q21.

Solution

Concept: For any wave, the relationship between wave speed (v), frequency (f), and wavelength (λ) is given by the fundamental wave equation:

$$v = f \cdot \lambda$$

By rearranging this formula, we can solve for the wavelength (λ):

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

Solution: Step 1: Identify the given values of the sound wave:

$$\text{Speed of sound, } v = 330 \text{ m/s}$$
$$\text{Frequency, } f = 550 \text{ Hz}$$

Step 2: Substitute these values into the rearranged wave equation:

$$\lambda = \frac{330 \text{ m/s}}{550 \text{ Hz}}$$

Step 3: Perform the division to calculate λ:

$$\lambda = \frac{33}{55} = \frac{3}{5} = 0.6 \text{ m}$$

The wavelength of the sound wave is 0.6 m.

Final Answer: $\boxed{0.6 \text{ m}}$

Answer: (A)

Go Back to Question 21

Q22.

Solution

Concept: When sound waves strike a large, distant obstacle (such as a tall building or a cliff), they reflect back. If the reflected sound is heard distinctly after the original sound, this phenomenon is called an echo.

- To hear a distinct echo, the time interval between the original sound and the reflected sound must be at least 0.1 s due to the persistence of hearing in human ears.

Solution: Step 1: Analyze the physical scenario. A person claps and hears the reflected sound after a short delay.

Step 2: Compare this with the other options:

- Reverberation is the persistent prolongation of sound caused by multiple overlapping reflections in closed spaces.
- Diffraction is the bending of waves around obstacles or openings.
- Interference is the superposition of waves.

Step 3: A single, distinct reflection of a short sound like a clap is characterized as an echo.

Final Answer: Echo

Answer: (C)

Go Back to Question 22

Q23.

Solution

Concept: During beta-minus (β^-) decay, a neutron inside the parent nucleus decays into a proton, an electron (the β-particle), and an electron antineutrino:

$$\text{neutron} \longrightarrow \text{proton} + e^- + \bar{\nu}_e$$

The general nuclear equation for β^- decay is:

$$^A_Z X \longrightarrow ^A_{Z+1} Y + ^0_{-1} e + \bar{\nu}_e$$

where Z is the atomic number and A is the mass number.

Solution: Step 1: Analyze the transformation inside the nucleus. A neutron turns into a proton.

Step 2: Since a new proton is added to the nucleus, the atomic number (Z, which represents the number of protons) increases by 1.

Step 3: The mass number (A, total protons + neutrons) remains unchanged because the loss of one neutron is balanced by the gain of one proton.

Step 4: Therefore, the atomic number of the resulting nucleus increases by 1.

Final Answer: Increases by 1

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept: An electric or magnetic field exerts a force (Lorentz force) only on moving or stationary particles that carry a non-zero net electric charge:

$$\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$$

If a radiation or beam carries no net electric charge ($q = 0$), it passes through these fields without any deflection or effect.

Solution: Step 1: Evaluate the charge of each given radiation type:

- α-rays: Composed of Helium nuclei ($^4_2\text{He}^{2+}$) which carry a positive charge of $+2e$. They are deflected.
- β-rays: Fast-moving electrons (or positrons) carrying a negative charge of $-1e$ (or $+1e$). They are deflected.
- Cathode rays: Streams of high-speed electrons carrying a negative charge. They are deflected.
- γ-rays: High-energy electromagnetic radiation (photons) with zero rest mass and zero charge ($q = 0$).

Step 2: Because gamma (γ) rays have no electric charge, they are not affected by electric and magnetic fields.

Final Answer: $\boxed{\gamma\text{-rays}}$

Answer: (C)

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Q25.

Solution

Concept: The hydrostatic pressure (P) at any point inside a static liquid of uniform density (ρ) is given by:

$$P = P_0 + \rho \cdot g \cdot h$$

where P_0 is the atmospheric pressure at the liquid surface, g is the acceleration due to gravity, and h is the depth of the point below the free surface of the liquid. Consequently, the pressure contribution from the liquid column alone is:

$$P_{\text{liquid}} = \rho \cdot g \cdot h$$

Solution: Step 1: Analyze the formula $P_{\text{liquid}} = \rho \cdot g \cdot h$.

Step 2: The pressure depends directly on:

- The density of the liquid (ρ).
- The depth below the surface (h).

Step 3: This is illustrated in the diagram by the water jets. The water from the deepest hole (greatest h) experiences the highest pressure and is pushed out with the greatest horizontal speed.

Step 4: Hydrostatic pressure does not depend on the shape of the vessel, the surface area, or the volume of the container.

Step 5: Thus, the pressure depends directly upon the depth and density of the liquid.

Final Answer: Depth and density of liquid

Answer: (C)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	B	3	B	4	B	5	A
6	B	7	D	8	A	9	B	10	B
11	B	12	A	13	C	14	B	15	C
16	B	17	D	18	C	19	C	20	C
21	A	22	C	23	B	24	C	25	C