SECTION 1 Multiple Choice Question (MCQ)

- This section contains **TEN (10)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, darken the bubble corresponding to the correct answer.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : $+3$ If **ONLY** the bubble corresponding to the correct option is darkened.
Zero Marks : 0 If none of the bubble is darkened (i.e., the question is unanswered).
Negative Marks : -0.75 In all other cases.

Q.1 *A radioactive process is given by* $^{232}_{90}Th + X \rightarrow {}^{233}_{90}Th$. *Here, X is* _____.

(A) neutron (B) proton (C) beta particle (D) alpha particle

Q.2 *A needle is placed between the focal point and the optical center of a thin convex lens. Which of the following statements is correct?*

(A) The image formed is real.
(B) The image formed is inverted.
(C) The image formed will be of the same size as that of the needle.
(D) The image formed will be behind the needle.

Q.3 *In a circuit, a fully charged capacitor is connected in series with a resistor. When the circuit is closed, which of the following statements is correct?*

(A) The magnitude of the current in the circuit is always zero.
(B) The magnitude of the current in the circuit is constant with time.
(C) The magnitude of the current in the circuit decreases with time.
(D) The magnitude of the current in the circuit increases with time.

Q.4 *A spherical shell of radius* $1\ m$, *centered at the origin, is placed in a region of electric field* $\vec{E} = 2\,\hat{x}$, *where* $\hat{x}$ *is the unit vector along the* x*-axis. The net electric flux through the spherical shell is* _____$Weber$.

(A) 0 (B) $2\,\pi$ (C) $4\,\pi$ (D) $8\,\pi$

Q.5 *A point particle is travelling vertically down from the sky with a speed* $0.8\,c$, *with respect to the ground, where* c *is the speed of light. The particle covers a distance* L *as measured by a stationary observer on the ground. In the rest frame of the particle, the distance covered by the particle is* _____.

(A) $0.3L$ (B) $0.6L$ (C) L (D) $1.7L$

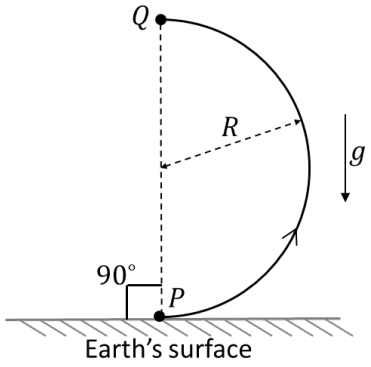
Q.6 *A planet of mass* m_p *moves in a circular orbit of radius* R, *around a star of mass* m_s. *The linear speed of the planet does not depend on* _____. *(*G *represents the universal gravitational constant)*

(A) m_s (B) m_p (C) R (D) G

Q.7 *Surface tension of a liquid has the dimension of energy per unit area. The SI unit of surface tension is _____.*

(A) Nm^2 (B) N/m^2 (C) N/m (D) Nm

Q.8 *A point particle of mass m is lifted slowly along a semi-circle of radius R from point P to point Q, as shown in the figure below. The work done in the process is _____. (Take acceleration due to gravity, g, as a constant)*



(A) $2\pi mgR$ (B) mgR (C) $2mgR$ (D) πmgR

Q.9 *Consider a system performing damped harmonic motion as a function of time. Which of the following statements is correct?*

(A) The amplitude decreases and the frequency increases.
(B) Both the amplitude and the frequency decrease.
(C) Both the amplitude and the frequency remain constant.
(D) The amplitude decreases and the frequency remains constant.

Q.10 *The Celsius (C) and Fahrenheit (F) temperature scales are related by the relation $F = (9/5)\,C + 32$. The temperature at which both these scales show the same reading is _____ C.*

(A) -40 (B) -32 (C) -60 (D) -20

SECTION 2 SDI

- This section contains **TEN (10)** questions.
- The answer to each question is a **SINGLE DIGIT NON-NEGATIVE INTEGER (SDI)**.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : $+4$ If **ONLY** the bubble corresponding to the correct answer is darkened.
Zero Marks : 0 In all other cases.

Q.11 *A circular coil of radius* $1\,m$ *and having* 200 *turns, kept in vacuum, is carrying a current of* $1/\pi$ $Ampere$. *The magnitude of the magnetic field at the center of the coil is* _____$\times 10^{-5}\,Tesla$. *(Take permeability of the free space* $\mu_0 = 4\pi \times 10^{-7} Tesla\,m/Ampere$*)*

Q.12 *The magnitude of force acting on a point charge of* $3\,Coulomb$*, placed in a uniform electric field of magnitude* $3\,Volt/m$*, is* _____N.

Q.13 *A uniform vertical cylindrical tank, closed from all sides, having mass* $10\,kg$ *and height* $8\,m$*, is half-filled with water. The mass of the water in the tank is also* $10\,kg$*. The height of the center of mass of the cylinder-water system measured from the bottom of the cylinder is* _____ m.

Q.14 *A wheel of radius* $50\,cm$ *rolls without slipping on a horizontal surface. If the angular speed of the wheel about its center of mass is* $10\,rad/s$*, then the translational speed of its center of mass is* _____ m/s.

Q.15 *An object is placed at the center of curvature of a concave mirror and the corresponding image formed has a height of* $6\,cm$*. The height of the object is* _____ cm.

Q.16 *A mass of* $4\,kg$ *is lifted vertically upwards from the ground to a height of* $0.2\,m$*. Neglecting air resistance and assuming the acceleration due to gravity to be* $10\,m/s^2$*, the work done on the mass is* _____ $Joule$.

Q.17 *At room temperature* $(23^\circ\,C)$*, a thin metal rod has a length* $L = 1\,m$*. The temperature of the rod is increased to* $32^\circ\,C$*. The resulting change in the length of the rod is* _____ $\times 10^{-5}\,m$*. (The coefficient of linear thermal expansion for the metal rod is* $\alpha = 10^{-5}/^\circ C$*).*

Q.18 *A stationary detector detects sound waves of frequency* f' *from a source, moving with speed* v_s *and emitting sound waves of frequency* f*. If* v *is the speed of sound and* $f' = f/3$*, then* $v_s =$ _____ v.

Q.19 *Suppose a hypothetical gas law has the form* $PV^2 = aT$*, where* P *is the pressure,* V *is the volume,* a *is some constant of appropriate dimension, and* T *is the temperature. Keeping the temperature constant, the volume of the gas is increased from an initial value,* $V_i = 2\,units$*, to a final value,* $V_f = 4\,units$*. The work done on the gas is* _____ $\times\,(aT/32)$.

Q.20 *Light travels in a medium with a speed that is half of its speed in the vacuum. The permeability of the medium is same as the permeability of the free space. The ratio of permittivity of the medium with respect to the permittivity of the free space is*_____.

SECTION 3: Paragraph based MCQ

- This section contains **FIVE (05)** paragraphs.
- Based on each paragraph, there are **TWO (02)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places.
- Answer to each question will be evaluated according to the following marking scheme:

  Full Marks : $+3$ If **ONLY** the bubble corresponding to the correct answer is darkened.
  Zero Marks : $0.$ If none of the bubble is darkened (i.e., the question is unanswered).
  Negative Marks : -0.75 In all other cases.

Faraday's law states that whenever magnetic flux Φ *passing through a loop changes, an e.m.f.* (ϵ) *will be induced as per the relation* $\epsilon(t) = -\,d\Phi/dt$*, where* t *is the time.*

Q.21 *The flux through the loop at time* t *is given by* $\Phi(t) = sin^2(t)\ Weber$*. The magnitude of the e.m.f. at time* $t = \pi/2\ second$ *is*_____ $Volt$.

(A) 0 (B) 1 (C) 2 (D) 3

Faraday's law states that whenever magnetic flux Φ *passing through a loop changes, an e.m.f.* (ϵ) *will be induced as per the relation* $\epsilon(t) = -\,d\Phi/dt$*, where* t *is the time.*

Q.22 *The e.m.f. at time* t *is* $\epsilon(t) = sin\ 2t\ Volt$*. If the effective resistance of the circuit is* $3\ Ohm$*, then the current through the circuit at time* $t = \pi/6\ second$ *is* _____$Ampere$.

(A) $1/\sqrt{12}$ (B) $\sqrt{3}/2$ (C) $2/\sqrt{3}$ (D) $2\sqrt{3}$

A vertical column of liquid has a density that varies with height h *as* $\rho = \rho_0 - \rho_1 h$*, where* $\rho_0 = 1.0\ kg/m^3$ *and* $\rho_1 = 0.01\ kg/m^4$ *.*

Q.23 *The density of the liquid at a height of* $10\ m$ *is* _____ kg/m^3.

(A) 1.1 (B) 0.8 (C) 1.0 (D) 0.9

A vertical column of liquid has a density that varies with height h *as* $\rho = \rho_0 - \rho_1 h$*, where* $\rho_0 = 1.0\ kg/m^3$ *and* $\rho_1 = 0.01\ kg/m^4$ *.*

Q.24 *The height at which a small solid object of density* $0.95\ kg/m^3$ *will remain at rest inside the liquid column is* _____ m.

(A) 10 (B) 5 (C) 2 (D) 15

Simple harmonic motion (SHM) occurs when a particle is slightly displaced from its equilibrium position and is left to oscillate freely. The particle's displacement $x(t)$ can be described by the equation $x(t) = A\cos(\omega t + \phi)$, where A is the amplitude, ω is the angular frequency, t is the time, and ϕ is the phase constant.

Q.25 *If $\phi = \pi/2$, then the phase difference between the position and velocity of the particle is___.*

(A) 0 (B) $\pi/2$ (C) $\pi/4$ (D) π

Simple harmonic motion (SHM) occurs when a particle is slightly displaced from its equilibrium position and is left to oscillate freely. The particle's displacement $x(t)$ can be described by the equation $x(t) = A\cos(\omega t + \phi)$, where A is the amplitude, ω is the angular frequency, t is the time, and ϕ is the phase constant.

Q.26 *The magnitude of the amplitude of the acceleration is ____.*

(A) A (B) $A\omega$ (C) $A\omega^2$ (D) A/ω^2

The ideal gas law relates the pressure P and temperature T of a gas occupying a volume V as $PV = nRT$, where n is the number of moles of the gas, $R = 8.31\,J/mole\,K$ is the gas constant. The Avogadro's number $N_A = 6.02 \times 10^{23}/mole$.

Q.27 *If the number of molecules of a gas per cubic meter is 3.01×10^{25}, then the number of moles in one cubic meter of gas is _____.*

(A) 3.01×10^{25}
(B) 6.02×10^{23}
(C) 50
(D) 200

The ideal gas law relates the pressure P and temperature T of a gas occupying a volume V as $PV = nRT$, where n is the number of moles of the gas, $R = 8.31\,J/mole\,K$ is the gas constant. The Avogadro's number $N_A = 6.02 \times 10^{23}/mole$.

Q.28 *If 2×10^{-3} moles of the Hydrogen gas has volume $4 \times 10^{-3}\ m^3$ at temperature $T = 300\ K$, then the pressure of the gas is _____ Pascal.*

(A) 623.5 (B) 1146.5
(C) 1246.5 (D) 420.5

The hydrogen atom can be explained by Bohr's atom model. The energy of the electron in the n^{th} state is given by $-13.6/n^2$ eV.

Q.29 *The ionization energy of the Hydrogen atom from its ground state is _____ eV.*

(A) 27.2 (B) 13.6 (C) 6.8 (D) 3.4

The hydrogen atom can be explained by Bohr's atom model. The energy of the electron in the n^{th} state is given by $-13.6/n^2$ eV.

Q.30 *Let Bohr radius be a_0. If the electron occupies the n^{th} energy state, then the distance of the electron from the center of the nucleus is given by $n^k a_0$. The value of k is ____ .*

(A) 1 (B) 2 (C) 3 (D) 4