PHYSICS

SECTION-I

Straight Objective Type

This section contains 6 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D), out of which **ONLY ONE** is correct.

Q.1 Student I,II and III perform an experiment for measuring the acceleration due to gravity (g) using a simple pendulum, They used different lengths of the pendulum and l or record time for different number of oscillations.The observations are ahown in the table.

The least count for length = 0.1 cm

Least count for time = 0.1 s

Student	Length of the Pendulum (cm)	Number of Oscillations (n)	Total time for (n) oscillations (s)	Time period (s)
I	64.0	8	128.0	16.0
II	64.0	4	64.0	16.0
III	20.0	4	36.0	9.0

If E_I, E_{II} and E_{III} are percentage errors in g,i.e $\left(\frac{\Delta g}{g} x100\right)$ for students I, II and III respectively,

(A) $E_I = 0$ (B) E_I is minimum

(C) $E_I = E_{II}$ (D) E_{II} is minimum

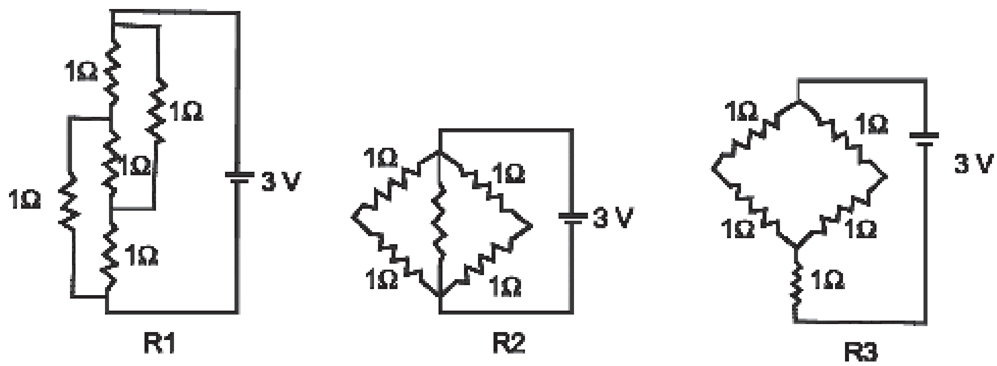
Sol. **(B)**

$$\frac{\Delta g}{g} = 2\frac{\Delta T}{g} + \frac{\Delta l}{l}$$

For student 1, T = 128.0, $\Delta T = 0.1$ s. This has the least error.

Q.2 Figure shows three resistor configuration R_1, R_2 and R_3 connected to 3 V battery. If the power dissipated by the configuration R_1, R_2 and R_3 is P_1, P_2 and P_3, respectively, then

Figure



(A) $P_1 > P_2 > P_3$ (B) $P_1 > P_3 > P_2$

(C) $P_2 > P_1 > P_3$ (D) $P_3 > P_2 > P_1$

Sol. **(C)**

$R_1 = 1\Omega$ (Balanced wheat stone bridge)

$R_2 = 0.5\ \Omega$

$R_3 = 2\Omega$

As $P = \frac{V^2}{R} \Rightarrow P \propto \frac{1}{R}$

Q.3 Which one of the following statements is WRONG in the context of X- rays generated from a X-ray tube ?

(A) Wavelength of characteristic x - rays decreases when the atomic number of the target increases

(B) Cut-off wavelength of the continuous X-rays depends on the atomic number of the target

(C) Intensity of the characteristic X-rays depends on the electrical power given to the x-ray tube

(D) Cut-off wavelength of the continuous x-rays depends on the energy of the elecrons in the x-ray tube

Sol. (B)

Cut off wavelength $\lambda_c = \frac{hc}{eV}$, where V is the accelerating voltage.

Q.4 Two beams of red and violet colours are made to pass separately through a prism (angle of the prism is 60^0) in the position of minimum deviation, the angle of refraction will be

(A) 30^0 for both the colours

(B) Greater for the violet colour

(C) Greater for the red coulour

(D) Equal but not 30^0 for both the colours

Sol. (A)

Angle of refraction at minimum deviation is $\frac{A}{2}$

Q.5 An ideal gas is expanding such that PT^2 = constant. The coefficient of volume expansion of the gas is

(A) $\frac{1}{T}$ (B) $\frac{2}{T}$ (C) $\frac{3}{T}$ (D) $\frac{4}{T}$

Sol. (C)

PT^2 = constant also PV = nRT

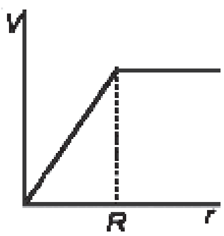
$\Rightarrow \left(\frac{T}{V}\right)T^2$ = Constant or $V \propto T^3$

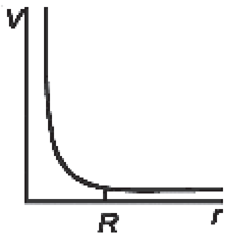
$\frac{\Delta v}{V} = \frac{3\Delta T}{T} \Rightarrow \frac{\Delta v}{v\Delta T} = \frac{3}{T}$

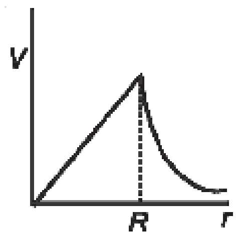
Q.6 A spherically symmetric gravitational system of particles has a mass density

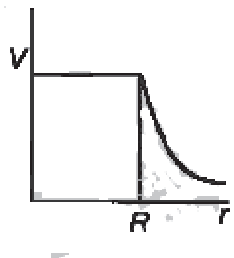
$$p = \begin{cases} \rho_0 \text{ for } r \le R \\ 0 \text{ for } r > R \end{cases}$$

Where ρ_0 is a constant. A test mass can undergo circular motion under the influence of the gravitational field of particles. Its speed V as a function of distance r ($0 < r < \infty$) from the centre of the system is represented by

(A) 

(B) 

(C) 

(D) 

Sol. (C)

For $r \le R$, $F = Kr$.

$\Rightarrow \dfrac{mv^2}{r} = kr \Rightarrow V \propto r$

For $r > R$, $F = \dfrac{k}{r^2} \Rightarrow \dfrac{mv^2}{r} = \dfrac{k}{r^2} = v \Rightarrow \dfrac{1}{\sqrt{r}}$

SECTION-II

Multiple Correct Answers Type

The section contains 4 multiple correct anwers type questions. Each question has 4 choices (A), (B), (C) and (D), out of which **ONE OR MORE** is/are correct.

Q.7 Two balls, having linear momenta $\vec{p}_1 = p\hat{i}$ and $\vec{p}_2 = P\hat{i}$, undergo a collision in free space. There is no external force acting on the balls. Let Let $\vec{p}_1$ and $\vec{p}_2$ be their final momenta. The following option (s) is (are) **NOT ALLOWED** for any non-zero value of $p, a_1, a_2, b_1, b_2, c_1$ and c_2

(A) $\vec{p}'_1 = a_1\hat{i} + b_1\hat{j} + c_1\hat{k}$
$\vec{p}'_2 = a_2\hat{i} + b_2\hat{j}$

(B) $\vec{p}'_1 = c_1\hat{k}$
$\vec{p}'_2 = c_2\hat{k}$

(C) $\vec{p}'_1 = a_1\hat{i} + b_1\hat{j} + c_1\hat{k}$
$\vec{p}'_2 = a_2\hat{i} + b_2\hat{j} - c_1\hat{k}$

(D) $\vec{p}'_1 = a_1\hat{i} + b_1\hat{j}$
$\vec{p}_2 = a_2\hat{i} + b_1\hat{j}$

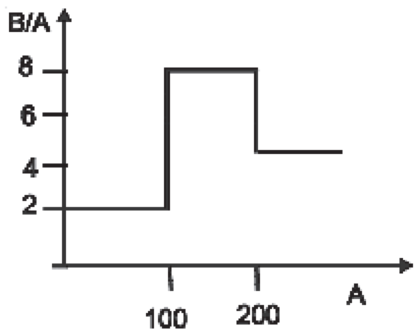
Sol. (A,D)

$\sum \vec{P}_{initial} = 0$

$\Rightarrow \sum \vec{P}_{final} = 0$

For (A), $\vec{p}'_1 + \vec{p}'_2$ can never be zero for non zero c_1. For (B) $\vec{p}'_1 + \vec{p}'_2$ can never be zero for non zero b_1.

Q.8 Assume that the nuclear binding energy per nucleon (B/A) versus mass number (A) is as shown in the figure. use this plot to choose the correct choice (S) gives below.



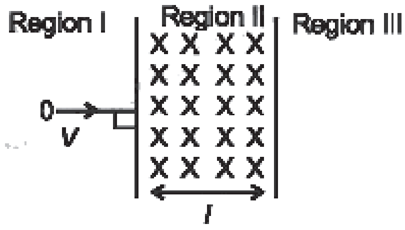
(A) Fusion of two nuclei with mass numbers lying in the range of 1 < A < 50 will release energy
(B) Fusion of two nuclei with mass numbers lying in the range of 51 < A < 100 will release energy
(C) Fission of a nucleus lying in the mass range of 100 < A < 200 will release energy when broken into two equal fragments
(D) Fission of a nucleus lying in the mass range of 200 < A < 260 will release energy when broken into two equal fragments

Sol. **(B,D)**

When BE/ necleon increases, energy is released.

If final product has atomic number between 100 and 200 energy will be released

Q.9 A particle of mass m and charge q, moving with velocity v enters Region II normal to the boundary as shown in the figure. Region II has a uniform magnetic field B perpendicular to the plane of the paper. The length of



(A) The particle enters Region III only if its velocity $V > \frac{qlB}{m}$

(B) The particle enters Region III only if its velocity $V < \frac{qlB}{m}$

(C) Path length of the particle in Region II is maximum when velocity $V = \frac{qlB}{m}$

(D) Time spend in Region II is same for any velocity V as long as the particle returns to region

Sol. **(ACD)**

When radius r > l, particle will move to region III

$$\frac{mV}{qB} > l \Rightarrow V > \frac{qBl}{m}$$

When $V = \frac{qBl}{m}$, The particle moves in the biggest semicircle possible in region II

Time spent $t = \frac{\pi m}{qB}$ in region II, provided particle particle returns to region I.

Q.10 In a young's double slit experiment, the separation between the two slits is d and the wavelength of the light is λ,The intensity of light falling on slit 1 is four times the intensity of light falling on slit 2. Choose the correct choice (s)

(A) If $d = \lambda$, the screen will contain only one maximum

(B) If $\lambda < d < 2\lambda$, at least one more maximum (besides the central maximum) will be observed on the screen

(C) If the intensity of light falling on slit 1 is reduced so that it becomes equal to that of slit 2, the intensities of the observed dark and bright fringes will increase

(D) If the intensity of light falling on slit 2 is increased so that it becomes equal to that of slit 1 the intensities of the observed dark and bright fringes will increase

Sol. **(A,B)**

At centre $\Delta x = 0$ for which maxima is obtained. The path difference at a large distance from the screen $\Delta x \rightarrow d$.

when $d = \lambda$, the path difference is between 0 to λ

Only central maxima exists in that case

When $\lambda < d < 2\lambda$, Δx lies between 0 to 2λ, So more than one maxima will be obtained

When both the slits gives same intensity, dark fringes are parfectly dark.

SECTION-III

Reasoning Type

This section contains 4 reasoning type questions. Each question has 4 choices (A), (B), (C) and (D), out of which **ONLY ONE** is correct.

Q.11 STATEMENT-1 In a meter bridge experiment, null point for an unknown resistance is measured. Now the unknown resistance is put inside an enclosure maintained at a higher temperature. The null point can be obtained at the same point as before by decreasing the value of the standard resistanc.

and

STATEMENT-2 : Resistance of a metal increases with increase in temperature.

(A) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is a correct explanatio for STATEMENT-1

(B) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is NOT a correct explanation for STATEMENT-1

(C) STATEMENT-1 is True,STATEMENT-2 is False

(D) STATEMENT-1 is False, STATEMENT-2 is True

Sol. (B)

$\frac{R_1}{R_2} = \frac{l_1}{l_2}$ To keep l_1 and l_2 same, $\frac{R_1}{R_2}$ = Constant

If one resistance increases/ decreases, the other must also be increased/ decreased. Now the unknown resistance can have positive or negative temperature coefficient for resistance.

Q.12 STATEMENT-1: An object moving around the Earth under the influence of Earth's gravitational force is in a state of fre-fall'

(A) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is a correct explanation for STATEMENT-1

(B) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is NOT a correct explanation for STATEMENT-1

(C) STATEMENT-1 is True, STATEMENT-2 is False

(D) STATEMENT-1 is False, STATEMENT-2 is True

Sol. (A)

An object in a state of free fall i.e. moving under of gravity alone experience weightlessness.

Q.13 STATEMENT-1: Two cylinders, one hollow (metal) and the other solid (wood) with the same mass and identical dimensions are simultaneously allowed to roll without slipping down and inclined plane from the same height . The hollow cylinder will reach the bottom of the inclined plane first.

and

STATEMENT-2 By the principle of conservation of energy, the total kinetic energies of both the cylinders are identical when they reach the bottom of the incline.

(A) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is a correct explanation for STATEMENT-1

(B) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is NOT a correct explanation for STATEMENT-1

(C) STATEMENT-1 is True, STATEMENT-2 is False

(D) STATEMENT-1 is False, STATEMENT-2 is True

Sol. (D)

The body with a greater moment of inertia experiences lesser acceleration.

In pure rolling, energy is conserved. So, both objects have same total kinetic energy.

Q.14 STATEMENT-1: The stream of water flowing at high speed from a garden hose pipe tends to spread like a fountain when held vertically up, but tends to narrow down when held vertically down.

and

STATEMENT-2 In any steady flow of an incompressible fluid, the volume flow rate of the fluid remains constant.

(A) STATEMENT-1 is True, STATEMENT-2 is True STATEMENT-2 is a correct explanation for STATEMENT-1

(B) STATEMENT-1 is True, STATEMENT-2 is True: STATEMENT-2 is NOT a correct explanation for STATEMENT-1

(C) STATEMENT-1 is True, STATEMENT-2 is False

(D) STATEMENT-1 is Fals, STATEMENT-2 is True

Sol. (A)

As Volume flow rate is constant, A x v = constant

When jet moves up, V decreases and A increases

When jet goes down, v increase and A decreases

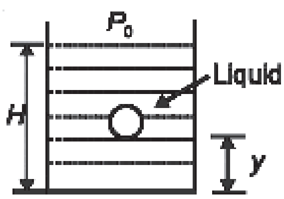
SECTION-IV

Linked Comprehesion type

This section contains 3 paragraphs. Based upon each paragraph, 3 multiple choice questions have to be answered. Each question has 4 choices (A), (B), (C) and (D), out of which ONLY ONE is correct

Paragraph for Question Nos. 15 to 17

A small spherical monoatomic ideal gas bubble $\left(\gamma = \frac{5}{3}\right)$ is trapped inside a liquid of density p_1 (see figure). Assume that the bubble does not exchange any heat with the liquid. The bubble contains n moles of gas. The temperature of the gas when the bubble is at the bottom is T_0, the height of the liquid is H and the atmospheric pressure is ρ_0 (Neglect surface tension).



Q.15 As the bubble moves upwards, besides the buoyancy force the following force are acting on it

(A) Only the force of gravity

(B) The force due to gravity and the force due to the pressure of the liquid

(C) The force due to gravity the force due to the pressure of the liquid and the force due to viscosity of the liquid

(D) The force due to gravity and the force due to viscosity of the liquid

Sol. (D)

The force due to pressure of liquid is Buoyont force. Besides this, gravity and viscous force act on the bubble

Q.16 When the gas bubble is at a height y from the bottom its temperature is

(A) $T_0\left(\frac{P_0+\rho_1 gH}{P_0+\rho_1 gy}\right)^{\frac{2}{5}}$ (B) $T_0\left(\frac{P_0+\rho_1 g(H-y)}{P_0+\rho_1 gH}\right)^{\frac{2}{5}}$

(C) $\left(\frac{P_0+\rho_1 gH}{P_0+\rho_1 gy}\right)^{\frac{3}{5}}$ (D) $T_0\left(\frac{P_0+\rho_1 g(H-y)}{P_0+\rho_1 gH}\right)^{\frac{3}{5}}$

Sol. (B)

As no heat exchange takes place, gas expands adiabativally

$P^{1-\lambda}\,T^{\lambda}$ = constants

$$T_2 = T_1\left(\frac{P_1}{P_2}\right)^{\frac{1-\gamma}{\gamma}}$$

$$T_1 = T_0 \quad P_1 = P_0 + \rho_1 gH\ ;\ P_2 = P_0 + \rho_1 g(H-y);\ \gamma = \frac{5}{3}$$

$$\Rightarrow T_2 = T_0\left[\frac{P_0+\rho gH}{P_0+\rho_1 g(H-y)}\right]^{\frac{1-5/3}{5/3}}$$

Q.17 The buoyancy force acting on the gas bubble is (Assume R is the universal gas constant)

(A) $\rho_1 nRgT_0\,\frac{(P_0+\rho_1 gH)^{\frac{2}{5}}}{(P_0+\rho_1 gy)^{\frac{7}{5}}}$ (B) $\frac{\rho nRgT_0}{(P_0+\rho_1 gH)^{2/5}[P_0+\rho_1 g(H-Y)]^{3/5}}$

(C) $\rho_1 nRgT_0\,\frac{(P_0+\rho_1 gH)^{\frac{3}{5}}}{(P_0+\rho_1 gy)^{\frac{8}{5}}}$ (D) $\frac{\rho nRgT_0}{(P_0+\rho_1 gH)^{3/5}[P_0+\rho_1 g(H-Y)]^{2/5}}$

Sol. (B)

Buoyont Force = $V\rho_1 g$

$$\text{Now } V = \frac{nRT}{P} = \frac{nRT_2}{[P_0+\rho_1 g(H-y)]}$$

Paragraph for Question Nos. 18 to 20

In a mixture of H-He$^+$ gas (He$^+$ is singly ionized He atom), H atoms and He$^+$ ions are excited to their respective first excited states. Subsequently, H atoms transfer their total excitation energy to He$^+$ ions (By collisions). Assume that the Bohr Model of atom is exactly valid.

Q.18 The quantum number of n of the state finally population in He^+ ions is
(A) 2 (B) 3 (C) 4 (D) 5

Sol. (C)

The total excitation energy of H atom is first axcited state is $\frac{-13.6}{(2)^2} - \left(\frac{-13.6}{1^2}\right)$ = 10.2 eV

He^+ ion absorb this energy and move to n^{th} quantum number state

So $10.2 = \frac{+13.6}{2^2}(4) - \frac{13.6(4)}{n^2}$ $\left(\because E_n = \frac{-13.6}{n^2}Z^2\right)$

$\Rightarrow$ n = 4

Q.19 The wavelength of light emitted in the visible region by He^+ ions after collision with H atoms is
(A) 6.5×10^{-7} m (B) 5.6×10^{-7} m (C) 4.8×10^{-7} m (D) 4.0×10^{-7} m

Sol. (C)
The wavelength of visible region is between 400 nm to 700 nm. He^+ ion can show transition from n = 4 to n = 1 in different manners. Out of these, transition from n= 4 to n = 3 will lie in visible region

Now $\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$\frac{1}{\lambda} = R \times 4\left(\frac{1}{16} - \frac{1}{9}\right)$

$\lambda = \frac{36}{7R} = \frac{36}{7} \times 912 = 4.8 \times 10^{-7}$ m

Q.20 The ratio of the kinetic energy of the n= 2 electron for the H atom to that of He^+ ion is
(A) $\frac{1}{4}$ (B) $\frac{1}{2}$ (C) 1 (D) 2

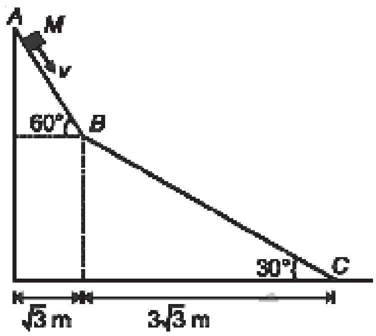
Sol. (A)
Kinetic energy $\propto V^2$

$V = v_0\frac{Z}{n^2} \Rightarrow K \propto Z^2$

$\Rightarrow \frac{K_H}{K_{He^+}} = \frac{1}{4}$

Paragraph for Question Nos 21 to 23

A small block of mass M moves on a frictionless surface of an inclined plane, as shown in figure. The angle of the incline suddenly changes from 60^0 to 30^0 at point B. The block is initially at rest at A. Assume that collisions



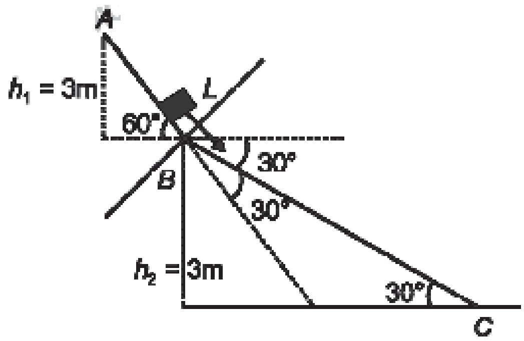
Q.21 The speed of the block at point B immediately after it strikes the second incline is

(A) $\sqrt{60}$ m/s (B) $\sqrt{45}$ m/s (C) $\sqrt{30}$ m/s (D) $\sqrt{15}$ m/s

Sol. (B)

The speed of block at point immediately before it strikes the second incline is

$V_1 = \sqrt{2gh_1} = \sqrt{2 \times 10 \times 3} = \sqrt{60}$



As collision is inelastic so component of velocity perpendicular to BC will vansih and velocity of the block after collision will be along BC

$V_2 = V_1 \cos 30^0$

$= \sqrt{60} \times \frac{\sqrt{3}}{2}$

$= \sqrt{45}$

Q.22 The speed of the block at point C, immediately before it leaves the second incline is

(A) $\sqrt{120}$ M/s (B) $\sqrt{105}$ m/s (C) $\sqrt{90}$ m/s (D) $\sqrt{75}$ m/s

Sol. (B)

If velocity at C is V_3, then

$V_3^2 = V_2^2 + 2gh_2$

$V_3^2 = 45 + 2 \times 10 \times 3$

$\Rightarrow = \sqrt{45 + 60} = \sqrt{105}$

Q.23 If collision between the blcok and the incline is completely elastic, then the vertical (upward) component of the velocity of the block at point B, immediately after it strikes the second incline is

(A) $\sqrt{30}$ m/s (B) $\sqrt{15}$ m/s (C) 0 (D) – $\sqrt{15}$ m/s

Sol. (C)

In elastic collision, laws of reflection is obeyed, so block rebounds horizontally