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IIT-JEE

Previous Year

Paper - I

“2008”

(Physics)

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Physics

PART - II

Useful Data:

Plank's constant $h = 4.1 \times 10^{-15}$ eV.s

Velocity of light $c = 3 \times 10^{8}$ m/s

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.

24. Two beams of red and violet colours are made to pass separately through a prism (angle of the prism is 60°). In the position of minimum deviation, the angle of refraction will be

(A) 30° for both the colours
(B) greater for the violet colour
(C) greater for the red colour
(D) equal but not 30° for both the colours

Sol. **(A)**

At minimum deviation for any wavelength

$r_1 = r_2 = A/2$, Because $r_1 + r_2 = A$

25. 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 electrons in the X-ray tube

Sol. **(B)**

$\lambda_{cutoff} = \frac{hc}{eV}$ (independent of atomic number)

26. 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)**

$\gamma = \frac{1}{V}\left(\frac{dV}{dT}\right)$

PT^2 = constant

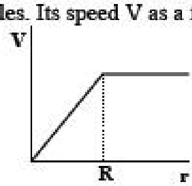
$\frac{nRT}{V}T^2$ = constant

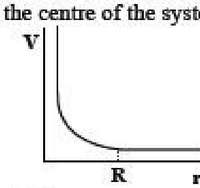
$\therefore \quad \gamma = \frac{3}{T}$

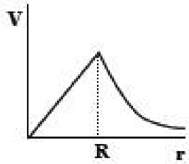
27. A spherically symmetric gravitational system of particles has a mass density

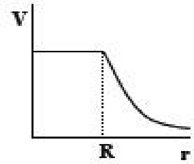
$$\rho = \begin{cases} \rho_0 & \text{for } r \le R \\ 0 & \text{for } r > R \end{cases}$$

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)**

$$G\frac{4}{3}\pi\rho_0 r = \frac{v^2}{r}, \qquad r \le R$$

Hence, $v \propto r$

$$\left(\frac{G\frac{4}{3}\pi\rho_0 R^3}{r^2}\right) = \left(\frac{v^2}{r}\right), \qquad r \ge R$$

Hence $\quad v \propto \frac{1}{\sqrt{r}}$

28. Students I, II and III perform an experiment for measuring the acceleration due to gravity (g) using a simple pendulum. They use different lengths of the pendulum and /or record time for different number of oscillations. The observations are shown in the table.

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 the percentage errors in g, i.e., $\left(\frac{\Delta g}{g}\times 100\right)$ 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 maximum

Sol. **(B)**

$$g = 4\pi^2\left(\frac{\ell}{T^2}\right)$$

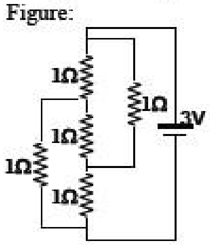
$$\frac{\Delta g}{g} = \frac{\Delta \ell}{\ell} + 2\frac{\Delta T}{T}$$

$\Rightarrow E = \frac{\Delta \ell}{\ell} + 2\frac{\Delta t}{t}$, greater the value of t, lesser the error

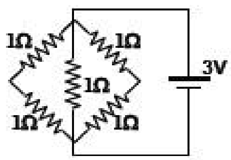
Hence, fractional error in the Ist observation is minimum

29. Figure shows three resistor configurations R1, R2 and R3 connected to 3V battery. If the power dissipated by the configuration R1, R2 and R3 is P1, P2 and P3, respectively, then

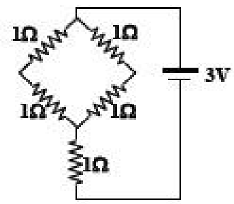
Figure:



R1



R2



R3

(A) P1 > P2 >P3
(B) P1 > P3 >P2
(C) P2 > P1 >P3
(D) P3 >P2 > P1

Sol. (C)

$P = \frac{V^2}{R}$

$R_1 = 1\ \Omega$, $R_2 = 1/2\ \Omega$, $R_3 = 2\ \Omega$

$\therefore \quad P_2 > P_1 > P_3$

SECTION – II

Multiple Correct Answers Type

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

30. 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)**

For at least one maxima, $\sin\theta = \lambda/d$

If $\lambda = d$, $\sin\theta = 1$ and $y \to \infty$

If $\lambda < d < 2d$, $\sin\theta$ exists and y is finite

31. The 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 $\vec{p}_1'$ 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)**

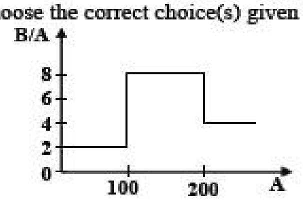
$\vec{P} = \vec{P}_1 + \vec{P}_2 = \vec{P}_1' + \vec{P}_2'$

$F_{ext} = 0$

$|\vec{P}| = 0$

32. 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) given below.

Figure:



(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

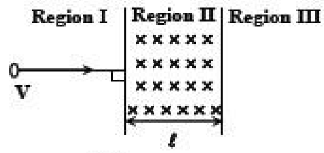
Sol. **(B) & (D)**

If $(BE)_{final} - (BE)_{initial} > 0$

Energy will be released.

33. 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 the Region II is ℓ. Choose the correct choice(s).

Figure:



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

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

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

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

Sol. **(A), (C) & (D)**

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.

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34. 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 False, STATEMENT-2 is True

Sol. **(A)**

35. 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 an 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)**
$$a = \frac{mgR^2 \sin\theta}{I_{cm} + mR^2}$$

36. 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 resistance.

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 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)**
$$R_{unknown} = \frac{R(100-\ell)}{\ell}$$

37. STATEMENT-1
An astronaut in an orbiting space station above the Earth experiences weightlessness.

and

STATEMENT-2
An object moving around the Earth under the influence of Earth's gravitational force is in a state of 'free-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)**

SECTION – IV

Linked Comprehension 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. 38 to 40

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.

38. The quantum number n of the state finally populated in He^+ ions is

(A) 2 (B) 3 (C) 4 (D) 5

Sol. **(C)**

39. The wavelength of light emitted in the visible region by He^+ ions after collisions 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)**

$E_4 - E_3 = \frac{hc}{\lambda}$ [λ: visible region]

40. 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)**

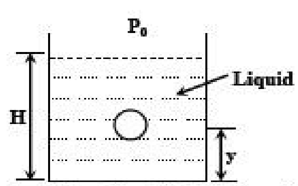
$KE \propto Z^2/n^2$

$$\frac{KE_H}{KE_{He}} = \left(\frac{Z_H}{2} \Big/ \frac{Z_{He}}{2}\right)^2 = \frac{1}{4}$$

Paragraph for Question Nos. 41 to 43

A small spherical monoatomic ideal gas bubble $\left(\gamma = \frac{5}{3}\right)$ is trapped inside a liquid of density ρ_ℓ (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 P_0 (Neglect surface tension).

Figure:



41. As the bubble moves upwards, besides the buoyancy force the following forces 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)**

Buoyant force is resultant of pressure-force of liquid.

42. When the gas bubble is at a height y from the bottom, its temperature is

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

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

Sol. **(B)**

$P_1^{1-\gamma}T_1^{\gamma} = P_2^{1-\gamma}T_2^{\gamma}$

$P_1 = P_0 + \rho_\ell gH, \quad T_1 = T_0$

$P_2 = P_0 + \rho_\ell g(H - y)$

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

(A) $\rho_\ell nRgT_0 \frac{(P_0 + \rho_\ell gH)^{2/5}}{(P_0 + \rho_\ell gy)^{7/5}}$

(B) $\frac{\rho_\ell nRgT_0}{(P_0 + \rho_\ell gH)^{2/5}[P_0 + \rho_\ell g(H - y)]^{3/5}}$

(C) $\rho_\ell nRgT_0 \frac{(P_0 + \rho_\ell gH)^{3/5}}{(P_0 + \rho_\ell gy)^{8/5}}$

(D) $\frac{\rho_\ell nRgT_0}{(P_0 + \rho_\ell gH)^{3/5}[P_0 + \rho_\ell g(H - y)]^{2/5}}$

Sol. **(B)**

$\rho_\ell Vg = \text{Buoyancy force} = \rho_\ell g \frac{nRT_2}{P_2}$

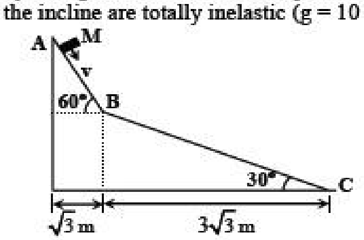
$T_2 = T_0\left[\frac{P_0 + \rho_\ell g(H - y)}{P + \rho_\ell gH}\right]^{2/5}$

$P_2 = P_0 + \rho_\ell g(H - y)$

Paragraph for Question Nos. 44 to 46

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° to 30° at point B. The block is initially at rest at A. Assume that collisions between the block and the incline are totally inelastic ($g = 10$ m/s^2).

Figure:



44. 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

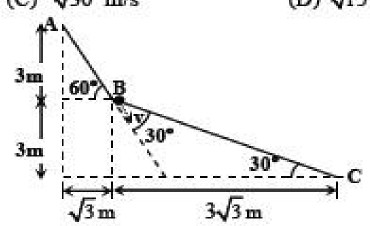
Sol. **(B)**

Along the plane velocity just before collision

$v = \sqrt{2g(3)} = \sqrt{60}$ m/s

Along the plane velocity just after collision

$v_B = v \cos 30° = \sqrt{45}$ m/s



45. 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)**

$mg(3) = \frac{1}{2}m(v_C^2 - v_B^2) \Rightarrow \quad v_C = \sqrt{105}$ m/s

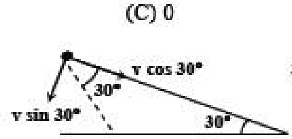
46. If collision between the block and the incline is completely elastic, then the vertical (upward) component of the velocity of the block at point B, immediately after it strikes the second incline is

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

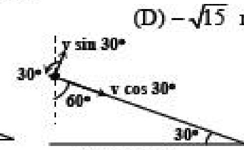
Sol. **(C)**

$v_y = v \sin 30° \cos 30° - v \cos 30° \cos 60°$

$v_y = 0$



Before collision



After collision