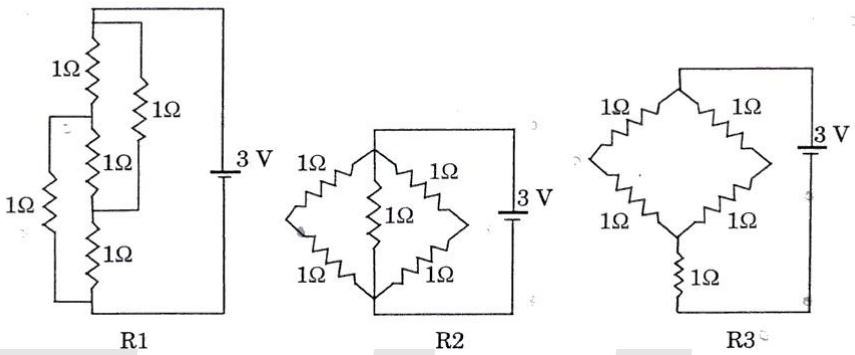
IITJEE-2008 Physics Paper - I

PART - II (PHYSICS)

SECTION - I

24. Figure shows three resistor configurations 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 :



24. (**C**) In R_1 : Balanced wheatstone network. So $R_{eq} = 1\Omega$. & $P_1 = 9$ **W**.
In R_2 : All branches in parallel. Req = 0.5 Ω. & $P_2 = 18$ **W**.
In R_3: Lowest 1Ω in series with parallel combination. So Req. = 2Ω & P3 = 4.5 **W**.

25. 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 $E_{\mathbf{I}}$, $E_{\mathbf{II}}$ and $E_{\mathbf{III}}$ are the percentage errors in g, i.e., $\left(\frac{\Delta g}{g}\times 100\right)$ for students I, II and III, respectively.

25. (**B**) $g = (4\pi^2 Ln^2) / t^2$, $\therefore \Delta g / g = (\Delta L / L) + 2(\Delta t / t)$
In $E_{\mathbf{I}}$, $\Delta g / g = (0.1 / 64) + 2(0.1 / 128)$
In $E_{\mathbf{II}}$, $\Delta g / g = (0.1 / 64) + 2(0.1 / 64)$
In $E_{\mathbf{III}}$, $\Delta g / g = (0.1 / 20) + 2(0.1 / 36)$
$\therefore \boldsymbol{E_{\mathbf{I}} < E_{\mathbf{II}} < E_{\mathbf{III}}}$.

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

26. (**B**) $\lambda_{\mathbf{cut-off}} = hc / E$

27. 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

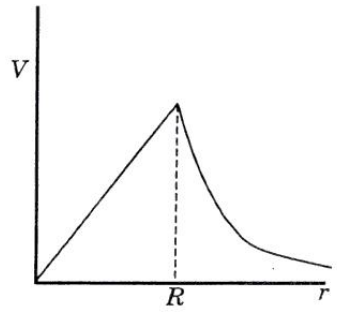
27. (**A**) For minimum deviation, $r_1 = r_2 = A / 2. = \mathbf{30°}$

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

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

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

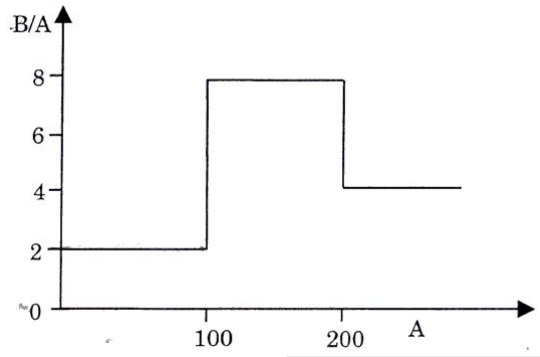
28. (**C**) $V = \sqrt{((4 / 3) \pi \rho G r^2)}$ for $r \le R$
$= \sqrt{((4 / 3) \pi \rho G R^3 \setminus r)}$ for $r > R$



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

29. (**C**) PT^2 = constant $\Rightarrow V \propto T^3$
$\therefore$ Coefficient of volume expansion = $\Delta V / V\Delta T = (1 / V) (dV / dT) = \mathbf{3 / T}$.

30. 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.



30. (**BD**) In (A), resulting nucleus has same B / A. So no energy release.
In (B), B / A increases. So release of energy.
In (C), B / A reduces. So no release of energy.
In (D), B / A increases. So release of energy.

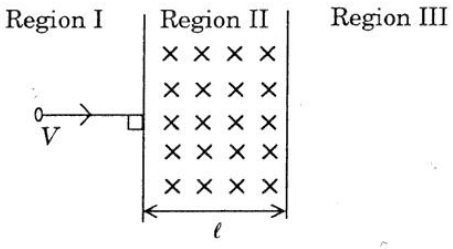
31. Two balls, having linear moment $\vec{p}_1 = p\hat{i}$ and $\vec{p}_2 = -p\hat{i}$, undergo a collision in free space. There is no external force acting on the balls. Let $\vec{p}_1'$ and $\vec{p}_2'$ be their final momenta. The following option(s) is (are) **NOT ALLOWED** for any non-zero value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

31. (**AD**) Since initial momentum is Zero, $\vec{p}_1' + \vec{p}_2' = 0$.
So (A), (D) not permissible

32. 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 lit 2. Choose the correct choice(s).

32. (**AB**) $\Delta x = d \sin \theta$.
In (A), only central maximum.
In (B), 2 first order maximas formed
In (C), initially $I_M = 9I_2$, $I_m = I_2$
while finally, $I_M = 4I_2$, $I_m = 0$
In (D), finally, $I_m = 16I_2$, $I_m = 0$.

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).



33. (**ACD**) $R = mV / qB$. Enters region III only if $l < R$ i.e. $V > qBl / m$
Path length maximum if just touches boundary of region III i.e. $V = qlB / m$
If returning to region *I*, semicircle covered in region *II* and $t = 1/2\ T = \pi m / qB$ i.e.independent of V.

34. STATEMENT – 1
Two cylinders, one hollow (metal) and the other solid (wood) with the sasme mass and identical dimensions are simulataneously 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.

34. (**D**) $a = g \sin\theta / (1 + (I / MR_2))$
$\therefore a_H = g \sin\theta / 2$ while as $= g \sin\theta / 1.5$.
So solid cylinder reaches first.

35. STATEMENT – 1
The stream of water flowing at high speed from a garden hose pipe tends to spreads 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.

35. (**A**) By equation of continuity, as speed increases, area reduces and vice – versa.

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 nullpoint 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 increaes in temperature.

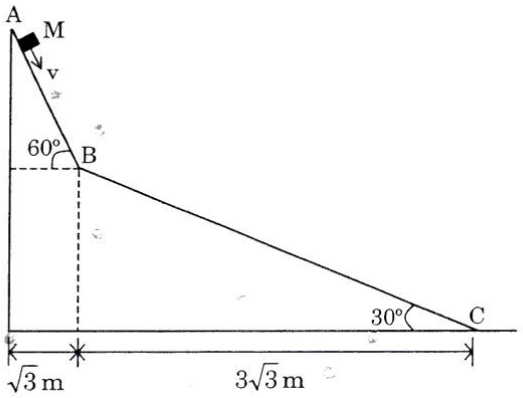
36. (**D**) $R_{\text{unknown}} / R_{\text{standard}} = l_{\text{null}} / (L - l_{\text{null}})$.
If R_{unknow} increase R_{standard} must increase for same null point.

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'.

37. (A)

Paragraph for Question Nos. 38 to 40

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 ($g = 10\ m/s^2$)



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

38. (**B**) At ***B***, speed just before striking = $\sqrt{(2gd_1 \tan 60°)} = \sqrt{60}\ ms^{-1}$.
Velocity compoment along $BC = v_B \cos 30° = \mathbf{\sqrt{45}\ ms^{-1}}$

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

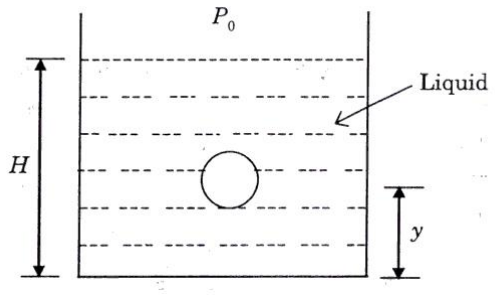
39. (**B**) $v_c^2 = v_{Ba}^2 + 2gd_2\tan 30° = 105 \Rightarrow v_c = \mathbf{\sqrt{105}\ ms^{-1}}$

40. If collission 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

40. (**C**) Along BC, $v_{\text{along}} = \sqrt{45}\ ms^{-1}$
Normal to BC, $v_{\text{normal}} = \sqrt{15}\ ms^{-1}$
$\therefore \quad v_{\text{up}} = v_{\text{normal}} \cos 30° - v_{\text{along}} \sin 30° = \mathbf{0}$

Paragraph for Question Nos. 41 to 43.

A small spherical monoatomic ideal gas bubble ($\gamma = 5 / 3$) is trapped inside a liquid of density p_l (see figure). Assume that 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).



41. As the bubble moves upwards, besides the buoyancy force the following forces are acting on it

41. (**D**)

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

42. (**B**) $P_i = P_o + \rho_l g H$, $P_f = P_o + \rho_l g (H - y)$
For adiabatic process, $T \propto P^{1-(1/\gamma)} \propto P^{2/5}$
$\therefore \; T_f = T_o (P_f / P_i)^{2/5}$

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

43. (**B**) $V_f = nRT_f / P_f$ and $F_b = V_f \rho_l g$

Paragraph for Question Nos. 44 to 46.

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.

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

44. (**C**) Energy output to H transition $2 \rightarrow 1$ is $E_0(1^{-2} - 2^{-2}) = 0.75\, E_0$
Energy input to He^+ transition $2 \rightarrow n$ is $4E_0\,(2^{-2} - n^{-2})$.
$\therefore \; 0.75E_0 = 4E_0\,(2^{-2} - n^{-2}) \Rightarrow n = \mathbf{4}$

45. The wavelength of light emitted in the visible region by He^+ ions after collisions with H atoms is

45. (**C**) Subsequent transition are $4 \rightarrow 3$, $4 \rightarrow 2$, $4 \rightarrow 1$, $3 \rightarrow 2$, $3 \rightarrow 1$, $2 \rightarrow 1$ of which only $4 \rightarrow 3$ is in visible region with $\Delta E \approx 2.62$eV. and $\lambda \approx \mathbf{4.8 \times 10^{-7}\ m}$.

46. The ratio of the kinetic energy of the $n = 2$ electron for the H atom to that of He^+ ion is

46. (**A**) $KE \propto TE \propto Z^2$.