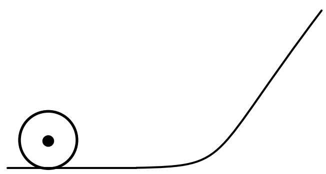
JEE Main Online Exam 2019

Questions & Solutions

8th April 2019 | Shift - II

Physics

Q.1 A Solid sphere and solid cylinder of identical radii approach an incline with the same linear velocity (See figure). Both roll without slipping all throughout. The two climb maximum heights h_{sph} and h_{cyl} on the incline. The ratio $\frac{h_{sph}}{h_{cyl}}$ is given by



(1) $\frac{2}{\sqrt{5}}$ (2) $\frac{14}{15}$ (3) $\frac{4}{5}$ (4) 1

Ans. **[2]**

Sol. $\frac{1}{2}mv^2(1+\eta) = mgh$

$h \propto 1 + \eta$

$$\frac{h_{sp}}{h_{cyl}} = \frac{1+\frac{2}{5}}{1+\frac{1}{2}} = \frac{7/5}{3/2} = \frac{14}{15}$$

Q.2 In a line of sight radio communication, a distance of about 50 km is kept between the transmitting and receiving antennas. If the height of the receiving antena is 70m, then the minimum height of the transmitting antenaa should be – (Radius of the Earth = 6.4×10^6 m).

(1) 32 m (2) 51 m (3) 40 m (4) 20 m

Ans. **[1]**

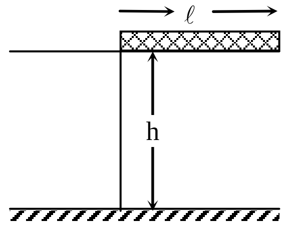
Sol. $D = \sqrt{2Rh_T} + \sqrt{2Rh_R}$

$50 \times 10^3 = \sqrt{2Rh_T} + \sqrt{2Rh_R}$

$h_T = \left[5\times10^4 - \sqrt{2\times6.4\times10^6\times70}\right]^2$

$h_T \simeq 32$ m

Q.3 A rectangular solid box of length 0.3 m is held horizontally, with one of its sides on the edge of a platform of height 5 m. When released, it slips off the table in a very short time τ = 0.01 s, remaining essentially horizontal. The angle by which it would rotate when it hits the ground will be (in radians) close to –



(1) 0.5 (2) 0.02 (3) 0.28 (4) 0.3

Ans. **[1]**

Sol. $\alpha = \frac{MgL/2}{ML^2/3} = \frac{3g}{2L}$

$\omega = \frac{3g}{2L}\tau = \frac{30(0.01)}{2(0.3)} = 0.5$

$t = \sqrt{\frac{2\times5}{10}} = 1\sec$

$\Delta\theta = \omega t = (0.5)(1) = 0.5$ Rad

Q.4 Young's moduli of two wires A and B are in the ratio 7 : 4. Wire A is 2 m long and has radius R. Wire B is 1.5 m long and has radius 2 mm. If the two wires stretch by the same length for a given load, then the value of R is close to -

(1) 1.9 mm (2) 1.7 mm (3) 1.3 mm (4) 1.5 mm

Ans. **[2]**

Sol. $\frac{F}{A} = Y\frac{\Delta\ell}{\ell}$

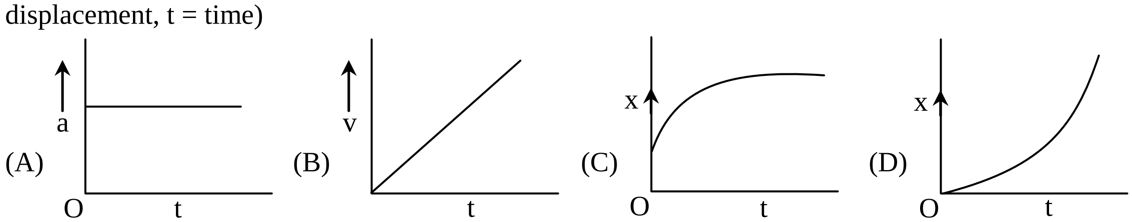
$F \propto \frac{AY}{\ell}$

$\frac{A_1Y_1}{\ell_1} = \frac{A_2Y_2}{\ell_2}$

$\frac{R^2(7)}{2} = \frac{2^2(4)}{1.5}$

R = 1.74

Q.5 A particle starts from origin O from rest and moves with a uniform acceleration along the positive x-axis. Identify all figures that correctly represent the motion qualitatively. (a = acceleration, v = velocity, x = displacement, t = time)

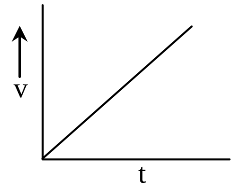


(1) (A) (2) (A), (B), (D) (3) (B), (C) (4) (A), (B), (C)

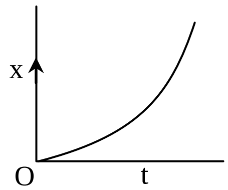
Ans. **[2]**

Sol. a = constant

$U \propto t$



$x \propto t^2$



Q.6 The electric field in a region is given by $\vec{E} = (Ax + B)\hat{i}$, where E is in NC^{-1} and x is in metres. The value of constants are A = 20 SI unit and B = 10 SI unit. If the potential at x =1 is V_1 and that at x = –5 is V_2, then $V_1 - V_2$ is

(1) –520 V (2) 180 V (3) –48 V (4) 320 V

Ans. **[2]**

Sol. $\Delta V = \frac{A}{2}[x^2]_1^{-5} + B[x]_1^{-5}$

= 10(24) – 60

= 180

Q.7 A rocket has to be launched from earth in such a way that it never returns. If E is the minimum energy delivered by the rocket launcher, what should be the minimum energy that the launcher should have if the same rocket is to be launched from the surface of the moon? Assume that the density of the earth and the moon are equal and that of earth's volume is 64 times the volume of the moon.

(1) $\frac{E}{4}$ (2) $\frac{E}{32}$ (3) $\frac{E}{16}$ (4) $\frac{E}{64}$

Ans. **[3]**

Sol. $E \propto R^2$

$\frac{E'}{E} = \frac{R^2}{16R^2}$

$E' = \frac{E}{16}$

Q.8 A damped harmonic oscillator has a frequency of 5 oscillations per second. The amplitude drops to half its value for every 10 oscillations. The time it will take to $\frac{1}{1000}$ of the original amplitude is close to -

(1) 50 s (2) 100 s (3) 10 s (4) 20 s

Ans. **[4]**

Sol. T = 2 sec

$(2)^{10} \simeq 1024$

So time t = 10 T

= 20 sec

Q.9 In a simple pendulum experiment for determination of acceleration due to gravity (g), time taken for 20 oscillations is measured by using a watch of 1 second least count. The mean value of time taken comes out to be 30 s. The length of pendulum is measured by using a meter scale of least count 1 mm and the value obtained is 55.0 cm. The percentage error in the determination of g is close to -

(1) 0.7 % (2) 6.8 % (3) 0.2 % (4) 3.5 %

Ans. [2]

Sol. $T = 2\pi\sqrt{\frac{\ell}{g}}$

$$g = \frac{4\pi^2\ell}{T^2}$$

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

$$\% \left|\frac{\Delta g}{g}\right| = \frac{0.1}{55}\times 100 + 2\frac{1}{30}\times 100$$

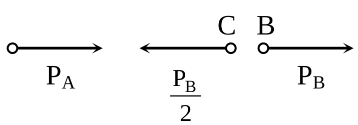
$= 6.8$ %

Q.10 A nucleus A, with a finite de-broglie wavelength λ_A, undergoes spontaneous fission into two nuclei B and C of equal mass. B flies in the same direction as that of A, while C flies in the opposite direction with a velocity equal to half of that of B. The de-broglie wavelengths λ_B and λ_C of B and C are respectively -

(1) $\lambda_A, \frac{\lambda_A}{2}$ (2) $\lambda_A, 2\lambda_A$ (3) $2\lambda_A, \lambda_A$ (4) $\frac{\lambda_A}{2}, \lambda_A$

Ans. [4]

Sol.



$$\lambda_B = \frac{\lambda_A}{2}; \qquad \lambda_C = 2\lambda_B = \lambda_A$$

$$P_A = P_B - \frac{P_B}{2} \Rightarrow \qquad P_B = 2P_A$$

Q.11 The magnetic field of an electromagnetic wave is given by –

$$\vec{B} = 1.6\times10^{-6}\cos(2\times10^7 z + 6\times10^{15} t)(2\hat{i}+\hat{j})\frac{Wb}{m^2}$$

The associated electric field will be -

(1) $\vec{E} = 4.8\times10^2\cos(2\times10^7 z + 6\times10^{15} t)(-\hat{i}+2\hat{j})\frac{V}{m}$

(2) $\vec{E} = 4.8\times10^2\cos(2\times10^7 z - 6\times10^{15} t)(2\hat{i}+\hat{j})\frac{V}{m}$

(3) $\vec{E} = 4.8\times10^2\cos(2\times10^7 z + 6\times10^{15} t)(\hat{i}-2\hat{j})\frac{V}{m}$

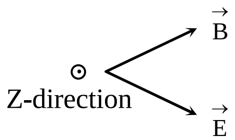
(4) $\vec{E} = 4.8\times10^2\cos(2\times10^7 z - 6\times10^{15} t)(-2\hat{j}+\hat{i})\frac{V}{m}$

Ans. [3]

Sol. $E_0 = CB_0$

$= 3 \times 10^8 \times 1.6 \times 10^{-6}$

$= 4.8 \times 10^2$



Q.12 A parallel plate capacitor has 1μF capacitance. One of its two plates is given +2μC charge and the other plate, +4 μC charge. The potential difference developed across the capacitor is -

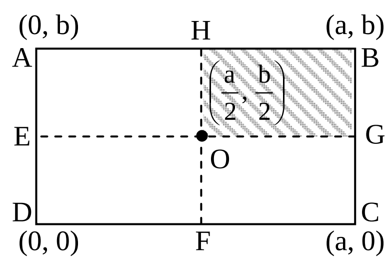
(1) 1V (2) 2V (3) 3V (4) 5V

Ans. [1]

Sol. $q_{cap} = \frac{4-2}{2} = 1\mu C$

$V = \frac{q}{C} = \frac{10^{-6}}{10^{-6}} = 1 \text{ volt}$

Q.13 A uniform rectangular thin sheet ABCD of mas M has length a and breadth b, as shown in the figure. If the shaded portion HBGO is cut-off, the coordinates of the centre of mass of the remaining portion will be -



(1) $\left(\frac{5a}{3}, \frac{5b}{3}\right)$ (2) $\left(\frac{2a}{3}, \frac{2b}{3}\right)$ (3) $\left(\frac{5a}{12}, \frac{5b}{12}\right)$ (4) $\left(\frac{3a}{4}, \frac{3b}{4}\right)$

Ans. [3]

Sol. $X_C = \frac{2m\left(\frac{a}{4}\right) + m\left(\frac{3a}{4}\right)}{3m} = \frac{5a}{12}$

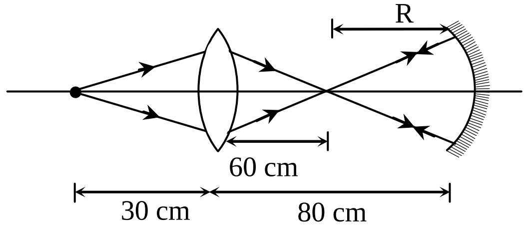
$Y_C = \frac{2m\left(\frac{b}{2}\right) + m\left(\frac{b}{4}\right)}{3m} = \frac{5b}{12}$

Q.14 A convex lens (of focal length 20 cm) and a concave mirror, having their principal axes along the same lines, are kept 80 cm apart from each other. The concave mirror is to the right of the convex lens. When an object is kept at a distance of 30 cm to the left of the convex lens, its image remains at the same position even if the concave mirror is removed. The maximum distance of the object for which this concave mirror, by itself would produce a virtual image would be -

(1) 20 cm (2) 10 cm (3) 25 cm (4) 30 cm

Ans. **[2]**

Sol.



$$\frac{1}{v} - \frac{1}{-30} = \frac{1}{20} \Rightarrow v = 60\text{cm}$$

R = 2f = 20 cm

f = 10 cm

Max distance for virtual image = f = 10 cm

Q.15 A electric dipole is formed by two equal and opposite charge q with separation d. The charges have same mass m. It is kept in a uniform electric field E. If it is slightly rotated from its equilibrium orientation, then its angular frequency ω is -

(1) $\sqrt{\frac{qE}{2md}}$ (2) $\sqrt{\frac{2qE}{md}}$ (3) $2\sqrt{\frac{qE}{md}}$ (4) $\sqrt{\frac{qE}{md}}$

Ans. **[2]**

Sol. $T = 2\pi\sqrt{\frac{I}{pE}} = 2\pi\sqrt{\frac{md^2/2}{qdE}} = 2\pi\sqrt{\frac{md}{2qE}} \Rightarrow \omega = \sqrt{\frac{2qE}{md}}$

Q.16 A cell of internal resistance r drives current through an external resistance R. The power delivered by the cell to the external resistance will be maximum when -

(1) R = 1000r (2) R = 0.001r (3) R = 2r (4) R = r

Ans. **[4]**

Sol. For maximum power transfer

R = r

Q.17 Calculate the limit of resolution of a telescope objective having a diameter of 200 cm, if it has to detect light of wavelength 500 nm coming from a star.

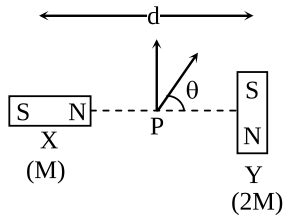
(1) 152.5×10^{-9} radian (2) 457.5×10^{-9} radian

(3) 610×10^{-9} radian (4) 305×10^{-9} radian

Ans. **[4]**

Sol. $\Delta\theta = \frac{1.22\lambda}{d} = \frac{1.22 \times 500 \times 10^{-9}}{200 \times 10^{-2}} = 305 \times 10^{-9}$ rad

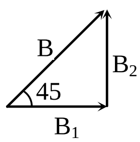
Q.18 Two magnetic dipoles X and Y are placed at a separation d, with their axes perpendicular to each other. The dipole moment of Y is twice that of X. A particle of charge q is passing through their midpoint P, at angle θ = 45 ° with the horizontal line, as shown in figure. What would be the magnitude of force on the particle at that instant? (d is much larger than the dimensions of the dipole)



(1) 0 (2) $\left(\frac{\mu_0}{4\pi}\right)\frac{M}{\left(\frac{d}{2}\right)^3}\times qv$ (3) $\sqrt{2}\left(\frac{\mu_0}{4\pi}\right)\frac{M}{\left(\frac{d}{2}\right)^3}\times qv$ (4) $\left(\frac{\mu_0}{4\pi}\right)\frac{2M}{\left(\frac{d}{2}\right)^3}\times qv$

Ans. **[1]**

Sol.



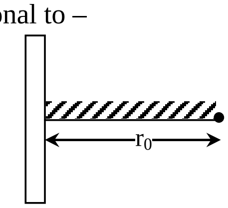
$B_1 = \frac{\mu_0}{4\pi}\frac{2(M)}{(d/2)^3}$

$B_2 = \frac{\mu_0}{4\pi}\frac{(2M)}{(d/2)^3}$

$B_1 = B_2$

$\vec{V}$ is along $\vec{B}$ thus $\vec{F}_{net} = \vec{0}$

Q.19 A positive point charge is released from rest at a distance r_0 from a position line chare with uniform density. The speed (v) of the point charge, as a function of instantaneous distance r from line charge, is proportional distance r from line charge, is proportional to –



(1) $v \propto e^{+r/r_0}$ (2) $v \propto \ell n\left(\frac{r}{r_0}\right)$ (3) $v \propto \left(\frac{r}{r_0}\right)$ (4) $v \propto \sqrt{\ell n\left(\frac{r}{r_0}\right)}$

Ans. **[4]**

Sol. $E \propto \frac{1}{r}$

$\Delta V \propto \ell n\left(\frac{r}{r_0}\right)$

$\frac{1}{2}mv^2 \propto \ell n\left(\frac{r}{r_0}\right)$

$v \propto \sqrt{\ell n\left(\frac{r}{r_0}\right)}$

Q.20 A circuit connected to an ac source of emf $e = e_0 \sin(100t)$ with t in seconds, gives a phase difference of $\frac{\pi}{4}$ between the emf e and current i. Which of the following circuits will exhibit this ?

(1) RL circuit with R = 1 kΩ and L = 10 mH (2) RL:circuit with R = 1 kΩ and L = 1 mH

(3) RC circuit with R = 1 kΩ and C = 1μF (4) RC circuit with R = 1 kΩ and C = 10μF

Ans. **[4]**

Sol. $X_C = R$

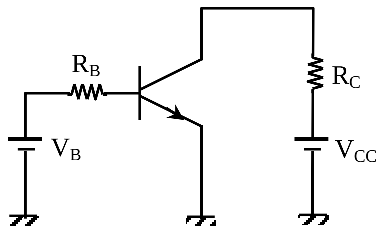
$\frac{1}{\omega C} = R$

$\frac{1}{100} = RC$

$R = 10^3\ \Omega$

$C = 10^{-5}$ F

Q.21 A common emitter amplifier circuit, built using an npn transistor, is shown in the figure. Its dc current gain is 250, R_C = 1 kΩ and V_{CC} = 10V. What is the minimum base current for V_{CE} to reach saturation ?



(1) 10 μA (2) 100 μA (3) 40 μA (4) 7 μA

Ans. **[3]**

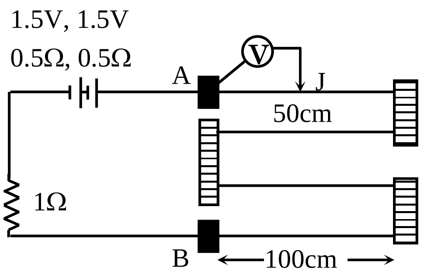
Sol. $V_{CC} - I_C R_C = 0$

$10 - I_C \times 10^3 = 0$

$I_C = 10^{-2}$

$I_B = \frac{I_C}{\beta} = \frac{10^{-2}}{250} = 40\mu A$

Q.22 In the circuit shown, a four-wire potentiometer is made of a 400 cm long wire, which extends between A and B. The resistance per unit length of the potentiometer wire is r = 0.01Ω/cm. If an ideal voltmeter is connected as shown with jockey J at 50 cm from end A, the expected reading of the voltmeter will be –



(1) 0.75 V (2) 0.25 V (3) 0.50 V (4) 0.20 V

Ans. **[2]**

Sol. $i = \frac{3}{1+1+4} = 0.5A$

$V = 0.5 \times 0.5 = 0.25$ volt

Q.23 The temperature, at which the root mean square velocity of hydrogen molecules equals their escape velocity from the earth, is closest to –

[Boltzmann Constant $k_B = 1.38 \times 10^{-23}$ J/K ; Avogadro Number $N_A = 6.02 \times 10^{26}$/ kg;
Radius of Earth : 6.4×10^6 m; Gravitational acceleration on earth = 10 ms^{-2}]

(1) 650 K (2) 3×10^5 K (3) 800 K (4) 10^4 K

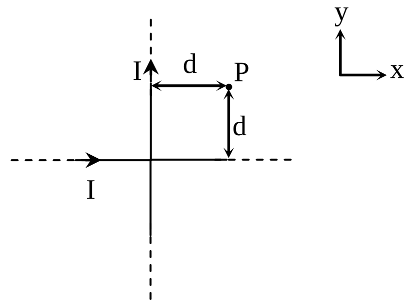
Ans. **[4]**

Sol. $V_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{2GM_E}{R_E}}$

$\frac{3\times 8.314\times T}{2\times 10^{-3}} = (11.2\times 10^3)^2$

$T = 10^4$ K

Q.24 Two very long, straight, and insulated wires are kept at 90° angle from each other in xy- plane as shown in the figure



These wires carry currents of equal magnitude I, whose directions are shown in the figure. The net magnetic field at point P will be -

(1) Zero (2) $-\frac{\mu_0 I}{2\pi d}(\hat{x}+\hat{y})$ (3) $\frac{\mu_0 I}{2\pi d}(\hat{x}+\hat{y})$ (4) $\frac{+\mu_0 I}{\pi d}(\hat{z})$

Ans. **[1]**

Sol. $\vec{B} = \frac{\mu_0 i}{2\pi d}\hat{k} - \frac{\mu_0 i}{2\pi d}\hat{k}$

$\vec{B} = \vec{0}$

Q.25 A body of mass m_1 moving with an unknown velocity of $v_1\hat{i}$, undergoes a collinear collision with a body of mass m_2 moving with a velocity $v_2\hat{i}$. After collision, m_1 and m_2 move with velocities of $v_3\hat{i}$ and $v_4\hat{i}$, respectively . If $m_2 = 0.5\, m_1$ and $v_3 = 0.5\, v_1$, then v_1 is -

(1) $v_4 - \frac{v_2}{4}$ (2) $v_4 + v_2$ (3) $v_4 - \frac{v_2}{2}$ (4) $v_4 - v_2$

Ans. **[4]**

Sol. $m_1 v_1\hat{i} + m_2 v_2\hat{i} = m_1(0.5v_1)\hat{i} + m_2 v_4\hat{i}$

$m_1 v_1\hat{i} + \frac{m_1 v_2}{2} i = \frac{m_1 v_1}{2}\hat{i} + \frac{m_1 v_4}{2}\hat{i}$

$v_1 = v_4 - v_2$

Q.26 The ratio of mass densities of nuclei of ^{40}Ca and ^{16}O is close to -

(1) 0.1 (2) 2 (3) 5 (4)1

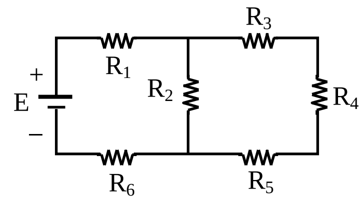
Ans. **[4]**

Sol. $\rho_{nucleus} \propto A^\circ$

$\frac{\rho_{Ca}}{\rho_O} = \frac{1}{1}$

1 : 1

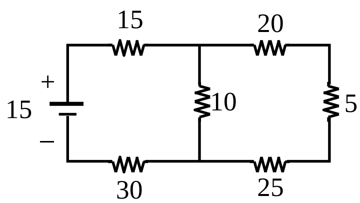
Q.27 In the figure shown, what is the current (in Ampere) drawn from the battery? You are given –
$R_1 = 15\Omega$, $R_2 = 10\Omega$, $R_3 = 20\Omega$, $R_4 = 5\Omega$, $R_5 = 25\Omega$, $R_6 = 30\Omega$, $E = 15V$



(1) 7/18 (2) 20/3 (3) 9/32 (4) 13/24

Ans. **[3]**

Sol.



$$i = \frac{15}{45+\frac{25}{3}} = \frac{3}{9+\frac{5}{3}} = \frac{9}{32}$$

Q.28 If surface tension (S), Moment of Inertia (I) and Plank's constant (h), were to be taken as the fundamental units, the dimensional formula for linear momentum would be-

(1) $S^{3/2}I^{1/2}h^{0}$ (2) $S^{1/2}I^{1/2}h^{-1}$ (3) $S^{1/2}I^{3/2}h^{-1}$ (4) $S^{1/2}I^{1/2}h^{0}$

Ans. **[4]**

Sol. $p \propto \sqrt{\text{mass} \times \text{Energy}}$

$\propto \sqrt{mR^2S}$

$\propto \sqrt{IS}$

$[p] = \left[I^{\frac{1}{2}} S^{\frac{1}{2}} \right]$

Q.29 Let $|\vec{A_1}| = 3, |\vec{A_2}| = 5$ and $|\vec{A_1} + \vec{A_2}| = 5$. The value of $(2\vec{A_1} + 3\vec{A_2}) \bullet (3\vec{A_1} - 2\vec{A_2})$ is -

(1) –112.5 (2) –106.5 (3) –118.5 (4) –99.5

Ans. **[3]**

Sol. $(2\vec{A}_1 + 3\vec{A}_2) \cdot (3\vec{A}_1 - 2\vec{A}_2)$

$= 6A_1^2 - 4\vec{A}_1 \cdot \vec{A}_2 + 9\vec{A}_1 \cdot \vec{A}_2 - 6A_2^2$

$= 6(A_1^2 - A_2^2) + 5A_1A_2 \cos\theta$

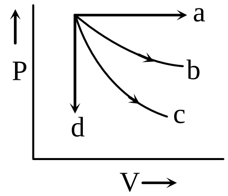
$= -96 + 5A_1A_2 \cos\theta$

$25 = 9 + 25 + 2\,(15 \cos\theta)$

$A_1A_2 \cos\theta = -9/2$

$$= -96 - \frac{5 \times 9}{2} = -118.5$$

Q.30 The given diagram shows four processes i.e., isochoric, isobaric, isothermal and adiabatic. The correct assignment of the processes, in the same order is given by -



(1) d a b c (2) a d c b (3) a d b c (4) d a c b

Ans. **[1]**

Sol. a $\rightarrow$ isobaric

d $\rightarrow$ isochoric

b $\rightarrow$ isothermal

c $\rightarrow$ adiabatic

(d a b c)