JEE (Main)

PAPER-1 (B.E./B. TECH.)

2021

COMPUTER BASED TEST (CBT)

Memory Based Questions & Solutions

Date: 25 July, 2021 (SHIFT-1) | TIME : (9.00 a.m. to 12.00 p.m)

Duration: 3 Hours | Max. Marks: 300

SUBJECT: PHYSICS

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PART : PHYSICS

1. A body of mass 2 kg and linear velocity 4 m/s collides elastically head on with another body at rest. After collision body of mass 2 kg starts moving with velocity 1 m/s then what will the velocity of center of mass of system ?

(1) 1.5 m/s (2) 0.5 m/s (3) 3.5 m/s (4) 2.5 m/s

Ans. **(4)**

Sol. From linear momentum conservation

$2 \times 4 + 0 = 2 \times 1 + m_2 v_2$

From the definition of elastic collision

$v_2 - v_1 = e(u_1 - u_2)$

$v_2 - 1 = 1(4 - 0)$

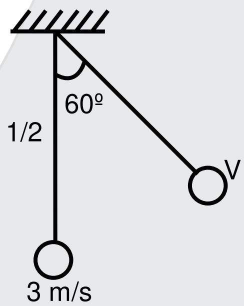
$v_2 = 5$

$8 = 2 + m_2 \times 5$

$m_2 = 6/5$

$$V_{cm} = \frac{m_1 v_1 + m_2 v_2}{m_1 + v_2} = \frac{2 \times 4 + 0}{2 + \frac{6}{5}} = 2.5 \text{ m/s}$$

2. A simple pendulum of length 1/2 m has initial speed 3 m/s when pendulum mass is at lowermost point. What will be the speed of pendulum mass, when string of pendulum makes an angle of 60º with vertical ?



(1) 2 m/s (2) 4 m/s (3) 6 m/s (4) 8 m/s

Ans. **(1)**

Sol. $\frac{1}{2} m u^2 = \frac{1}{2} m v^2 + mg\ell(1 - \cos 60°)$

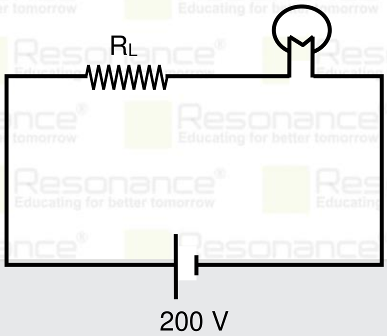
$u^2 = v^2 + 2g\ell(1 - \cos 60°)$

$9 = v^2 + 20 \times 1/2 \times 1/2$

$9 = v^2 + 5$

$v = 2$ m/s

3. A bulb has rated power 200 W and rated voltage 100 V. This bulb is connected in circuit as shown in figure. What should be value of load resistance R_L so that bulb works at rated voltage ?



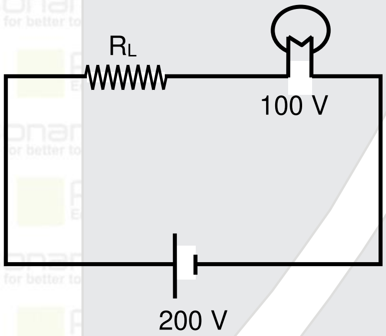
(1) 25Ω (2) 50Ω (3) 75Ω (4) 100Ω

Ans. **(2)**

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

$200 = \frac{(100)^2}{R}$

$R = 50\ \Omega$



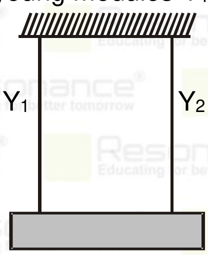
Current through bulb

$i = \frac{100}{50} \Rightarrow 2A$

$V_L = 100$

$R_L = \frac{100}{2} = 50\ \Omega$

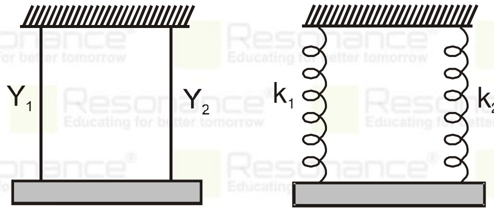
4. Two geometrical identical wires have young modules Y_1 and Y_2 then find equivalent young modules :



(1) $Y_1 + Y_2$ (2) $\frac{Y_1 + Y_2}{2}$ (3) $\frac{Y_1Y_2}{Y_1 + Y_2}$ (4) $\sqrt{Y_1Y_2}$

Ans. **(2)**

Sol.

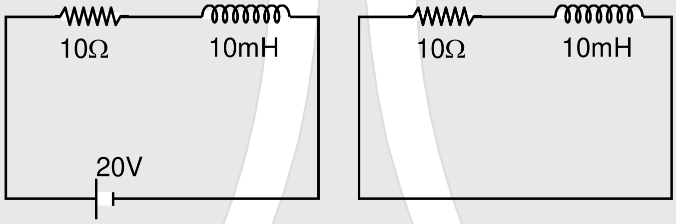


$K_{eq} = K_1 + K_2$

$\frac{Y2A}{\ell} = \frac{Y_1A}{\ell} + \frac{Y_2A}{\ell}$

$Y = \frac{Y_1 + Y_2}{2}$

5. Battery is connected to a resistor and a inductor for a long time as shown in figure, then battery is removed & short circuited. Find the current in the circuit after 1 ms after battery get removed :



(1) 1.32A (2) 0.44A (3) 0.65A (4) 0.74A

Ans. **(4)**

Sol. $i_0 = \frac{20}{10} = 2A$

$i = i_0 e^{-Rt/L}$

$= 2 \times e^{-\frac{10\times10^{-3}}{10\times10^{-3}}} = \frac{2}{e} = 0.74A$

6. A particle of mass 4m at rest splits into two particle of mass 3 m and m. If both the masses have different velocities then find ratio of their De-Broglie wavelength ?

(1) 1 : 1 (2) 1 : 2 (3) 2 : 1 (4) 1 : 3

Ans. **(1)**

Sol. $\lambda = \frac{h}{P}$

here momentum is same for both

$\frac{\lambda_{2m}}{\lambda_m} = \frac{1}{1}$

7. An electron, a proton and an alpha particle are get accelerated by giving same K.E., then which of the following is correct about De-Broglie wavelength.

(1) $\lambda_e < \lambda_p < \lambda_\alpha$ (2) $\lambda_e > \lambda_p > \lambda_\alpha$ (3) $\lambda_e = \lambda_p < \lambda_\alpha$ (4) $\lambda_e = \lambda_p > \lambda_\alpha$

Ans. **(2)**

Sol. $\lambda = \frac{h}{\sqrt{2mKE.}} \Rightarrow \lambda \propto \frac{1}{\sqrt{m}}$

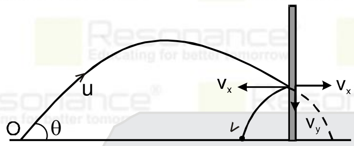
$m_\alpha > m_p > m_e$

so $\lambda_e > \lambda_p > \lambda_\alpha$

8. A ball of mass m is thrown towards wall in two different situations,
(i) Ball strikes perpendicular to wall (ii) Ball strikes at an angle of 45° to wall
What will be ratio of impulse in two cases ?
(1) 2 : 1 (2) 1 : 1 (3) 1 : 2 (4) 3 : 1

Ans. (2)

Sol.



During elastic collision with vertical wall, velocity in vertical direction remains constant and component velocity along horizontal direction become opposite after collision.
So, change in momentum,
$\Delta P = 2\text{ mu}\cos\theta$ in each case

So, $\dfrac{\Delta P_1}{\Delta P_2} = \dfrac{2mu\cos\theta}{2mu\cos\theta} = 1 : 1$

9. Photons of wavelength 400nm strikes on a material with energy 1000J in 10 sec. what will be no. of electron leaving the material in one second ?
(1) 5×10^9 (2) 5×10^{16} (3) 5×10^{13} (4) 5×10^{10}

Ans. (2)

Sol. Energy $= N \times \dfrac{hc}{\lambda}$

$1000 = \dfrac{12400}{4000} \times N \times 1.6 \times 10^{-19}$

$N = \dfrac{1000 \times 4}{12400 \times 1.6 \times 10^{-19}}$

So, number of electron leaving from material in 1 sec $= \dfrac{N}{10} = 5 \times 10^{16}$

10. A radioactive nuclei of initial number of active nuclei N_0. Decays $N_0/4$ active nuclei in time t_1 and decays to $N_0/2$ active nuclei in time t_2. Find the ratio between t_1 and t_2 ?
(1) 0.42 (2) 0.55 (3) 0.62 (4) 0.75

Ans. (1)

Sol. $N = N_0 e^{-\lambda t}$

$\dfrac{3N_0}{4} = N_0 e^{-\lambda t_1}$

$t_1 = \dfrac{\ell n\frac{4}{3}}{\lambda}$; $t_2 = \dfrac{\ell n 2}{\lambda}$

$\dfrac{t_1}{t_2} = \dfrac{\ell n\frac{4}{3}}{\ell n 2} = \dfrac{2\ell n2 - \ell n3}{\ell n2} = 2 - \dfrac{1.098}{0.693} = 2 - 1.58 = 0.42$

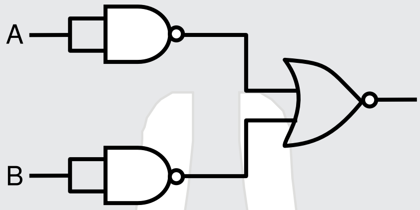
11. For an ideal gas, C_v is the specific heat at constant volume and C_p is the Specific heat at constant pressure. if at some temperature T_P, they are related as $C_P - C_v = R$ and for some other temperature T_Q They are related as $C_P - C_v = 1.1R$, then which is correct

(1) $T_P > T_Q$ (2) $T_Q > T_P$ (3) $T_P = T_Q$ (4) can't say

Ans. **(1)**

Sol. At high temperature gas behaves has ideal gas.

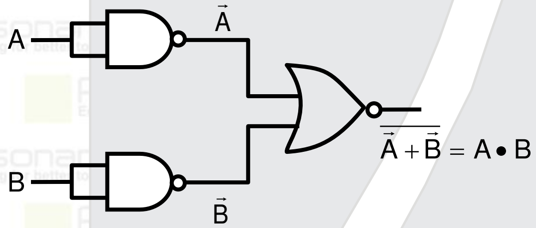
12. Find equivalent circuit



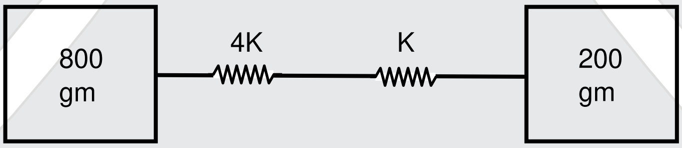
(1) NOR (2) OR (3) AND (4) NAND

Ans. **(3)**

Sol.



13. Two block of mass 800 gm and 200gm are attached by two springs of spring constant 4 K and K in series as shown in figure. Find angular frequency of oscillation of system ? (Value of K = 20 N/m)



(1) 10 rad/s (2) 16 rad/s (3) 12 rad/s (4) 14 rad/s

Ans. **(1)**

Sol. $T = 2\pi\sqrt{\dfrac{\mu}{k_{eq}}}$

$\mu = \dfrac{m_1 m_2}{m_1 + m_2} \Rightarrow \dfrac{200 \times 800}{200 + 800} = 160\,g = 0.16\,kg$

$K_{eq} = \dfrac{k_1 k_2}{k_1 + k_2} = \dfrac{4k \times k}{4k + k} = \dfrac{4}{5}k = \dfrac{4}{5} \times 20 = 16\,\dfrac{N}{m}$

$T = 2\pi\sqrt{\dfrac{0.16}{16}}$; $T = \pi/5$ sec.

$\omega = \dfrac{2\pi}{T} = 10$ rad/s

14. A conducting loop of radius 0.1 m has a time variable magnetic field $B(t) = \frac{4}{100}\left[1 - \frac{t}{100}\right]$. Find energy dissipated till magnetic field becomes zero if resistance of loop is 0.01Ω.

(1) 16×10^{-7} J (2) 8×10^{-7} J (3) 4×10^{-7} J (4) 2×10^{-7} J

Ans. **(1)**

Sol. $\varepsilon = \left|-A\frac{dB}{dt}\right|$

$\varepsilon = \pi(0.1)^2 \times \frac{4}{100} \times \frac{1}{100}$

$\varepsilon = 4\pi \times 10^{-6}$ v

When B = 0, t = 100

Energy $= \frac{\varepsilon^2}{R} \times t = \frac{(4\pi \times 10^{-6})^2}{10^{-2}} \times 100 = 16\pi^2 \times 10^{-8} = 16 \times 10^{-7}$ J

15. An Electric field of a wave propagating as $E = E_0 \cos(kz - 5.6 \times 10^3 t)$ reflecting from mirror at z = a, then

(1) $\lambda = 5.6$ m

(2) $f = 5.6 \times 10^3$ Hz

(3) Equation of reflecting wave $E = E_0 \cos(kz - 5.6 \times 10^3 t)$

(4) Equation of reflecting wave $E = -E_0 \cos(kz + 5.6 \times 10^3 t)$

Ans. **(4)**

Sol. $w = 5.6 \times 10^3$

$2\pi f = 5.6 \times 10^3$

$f = \frac{5.6 \times 10^3}{2\pi} = \frac{5.6 \times 10^3}{2 \times 3.14} = 891.7\text{Hz}$

$C = f\lambda$

$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{891.7} = 3.36 \times 10^5$ m

Reflecting wave

$E = E_0 \cos(-kz - 5.6 \times 10^3 + \pi)$

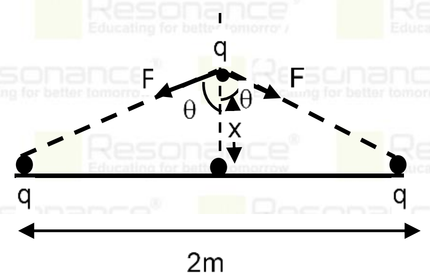
$E = -E_0 \cos(kz + 5.6 \times 10^3 + \pi)$

16. Two similar charge of magnitude q are fixed at distance of 2m. And another opposite charge of same magnitude is brought at center point between two charges and given a slight displacement along equatorial direction and released then angular frequency of oscillations of opposite charge will be? (Value of $q^2 = 10\ C^2$) (Mass of opposite charge 0.2 gram)

(1) 3×10^7 rad/s (2) 3×10^5 rad/s (3) 3×10^{-5} rad/s (4) 3×10^6 rad/s

Ans. **(1)**

Sol.



Net force on charge is

$F_{net} = 2F\cos\theta$ Here $F = \frac{kq^2}{(1+x^2)}$

$F_{net} = \frac{2kq^2}{(1+x^2)} \cdot \frac{X}{\sqrt{1+X^2}}$

$F_{net} = \frac{2kq^2x}{(1+x^2)^{3/2}}$ $\because x << 1$, so $x^2 <<< 1$

$F_{net} = 2kq^2 x$

$ma = 2kq^2 x$

$a = \frac{2kq^2x}{m}$

$\omega = \sqrt{\frac{2kq^2}{m}} = \sqrt{\frac{2\times 9\times 10^9\times 10}{2\times 10^{-4}}} = 3x10^7 \text{ rad/sec}.$

17. Water drops are falling from a tap in regular interval of time. A drop falls from the tap and after 4 second of falling, the drop is 34.3m away from next drop. Then drops are falling at rate of (Use $g = 9.8\ m/s^2$)

(1) 1 drop in 1 sec (2) 1 drop in 7 sec (3) 1 drop in 5 sec (4) 1 drop in 6 sec

Ans. **(1)**

Sol. Let next drop after t sec distance travelled by I[st] drop in 4 sec. is $S_1 = \frac{1}{2}at^2 = 78.4$ m (t should be less then 4 sec) distance travelled by succeeding drop in 4 – t sec

$S_2 = \frac{1}{2}a(4-t)^2$

$S_1 - S_2 = 34.3$

$78.4 - 4.9(4-t)^2 = 34.3$

$(4-t)^2 = 9$

$4 - t = 3$

$t = 1$ sec

18. In YDSE, distance between the slits are varied as $d = a + b \sin \omega t$. What will be difference between maximum and minimum fringe width?

(1) $\frac{2bD\lambda}{a^2-b^2}$ (2) $\frac{4bD\lambda}{a^2-b^2}$ (3) $\frac{3bD\lambda}{a^2+b^2}$ (4) $\frac{5bD\lambda}{a^2+b^2}$

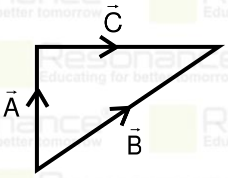
Ans. **(1)**

Sol. Fringe width = $\frac{D\lambda}{d}$

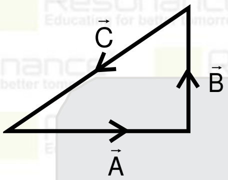
$\beta = \frac{D\lambda}{(a+b\sin wt)}$

$\beta_{max} - \beta_{sin} \Rightarrow \frac{D\lambda}{a-b} - \frac{D\lambda}{a+b} \Rightarrow D\lambda\left[\frac{a+b-a+b}{a^2+b^2}\right] = \frac{2bD\lambda}{a^2-b^2}$

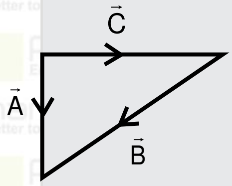
19. Match the following column.

(I) 

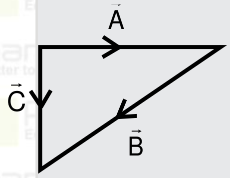
(a) $\vec{C}-\vec{A}-\vec{B}=0$

(II) 

(b) $\vec{A}-\vec{C}-\vec{B}=0$

(III) 

(c) $\vec{B}-\vec{A}-\vec{C}=0$

(IV) 

(d) $\vec{A}+\vec{B}+\vec{C}=0$

(1) (I) c ; (II) d ; (III) b ; (IV) a
(2) (I) d ; (II) c ; (III) b ; (IV) a
(3) (I) c ; (II) d ; (III) a ; (IV) b
(4) (I) b ; (II) d ; (III) a ; (IV) c

Ans. **(1)**

Sol. (I) $\vec{A}+\vec{C}=\vec{B}$

(II) $\vec{A}+\vec{B}+\vec{C}=0$

(III) $\vec{A}-\vec{B}-\vec{C}=0$

(IV) $\vec{A}+\vec{B}-\vec{C}=0$

20. In a parallel plate capacitor distance between the plates is 'd'. If dielectric of variable permeability is filled as :

$\varepsilon(x) = \varepsilon_0 + kx$; $0 < x \leq d/2$

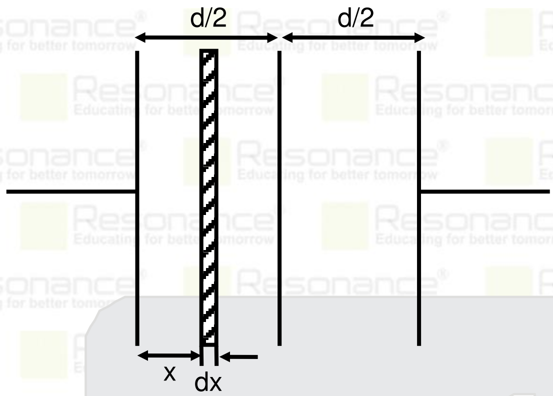
$\varepsilon(x) = \varepsilon_0 + k(d-x)$; $d/2 < x \leq d$

Find capacitance ?

(1) $\frac{1}{Ak}\times \ell n\frac{\varepsilon_0+\frac{kd}{2}}{\varepsilon_0}$ (2) $\frac{1}{Ak}\times 2\ell n\frac{\varepsilon_0+\frac{kd}{2}}{\varepsilon_0}$ (3) $\frac{1}{Ak}\times \ell n\frac{\varepsilon_0\frac{kd}{2}}{\varepsilon_0}$ (4) $\frac{1}{Ak}\times 2\ell n\frac{\varepsilon_0\frac{kd}{2}}{\varepsilon_0}$

Ans. **(2)**

Sol.



$\frac{1}{C_{eq}} \Rightarrow \int \frac{dx}{A\varepsilon}$

$\Rightarrow \int_0^{d/2} \frac{dx}{A(\varepsilon_0 + kx)} + \int_{d/2}^{d} \frac{dx}{A[\varepsilon_0 + k(d-x)]}$

$\Rightarrow \frac{1}{A}\left\{\frac{1}{k}[\ell n(\varepsilon_0 + kx)]_0^{d/2} + \frac{1}{k}[\ell n(\varepsilon_0 + k(d-x))]_{d/2}^{d}\right\}$

$\Rightarrow \frac{1}{Ak} \times 2\ell n \frac{\varepsilon_0 + \frac{kd}{2}}{\varepsilon_0}$

21. The position of an object varies as $\vec{R} = 10\lambda\beta t^2\hat{i} + 5\beta(t-5)\hat{j}$. Find time at which angular momentum becomes same as that of at t = 0, about origin ?

(1) 10 sec (2) 12 sec (3) 15 sec (4) 17 sec

Ans. (1)

Sol. $\vec{R} = 10\lambda\beta t^2\hat{i} + 5\beta(t-5)\hat{j}$

$\vec{v} = 20\lambda\beta t\,\hat{i} + 5\beta\hat{j}$

$\vec{L} = m(\vec{r} \times \vec{v})$

$\vec{L} = m\left(10\lambda\beta t^2\hat{i} + 5\beta(t-5)\hat{j}\right) \times \left(20\lambda\beta t\hat{i} + 5\beta\hat{j}\right)$

at t = 0, $\vec{L} = 0$

At any time t

$\vec{L} = m\left(50\lambda\beta^2 t\hat{k} - 100\lambda\beta^2(t-5)\right)\hat{k}$

$0 = 50\, m\, \lambda\beta^2\, [t - 2\,(t-5))\ \hat{k}$

$\Rightarrow t - 2t + 10 = 0$

$\Rightarrow t = 10$ sec

22. A message signal $x_m = 10 \sin(2\pi \times 10^5 t)$ is amplitude modulated with carrier signal $x_c = 20 \sin(2\pi \times 10^7 t)$ then find the half of band width.

(1) 100 KHz (2) 50 KHz (3) 200 KHz (4) 0 KHz

Ans. **(1)**

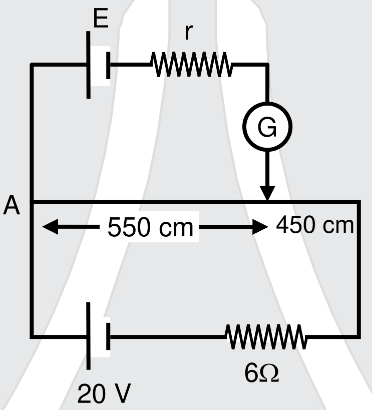
Sol. Band width = $2f_m$

$\therefore$ Half of bandwidth = f_m

$= 10^5$ Hz

= 100 KHz

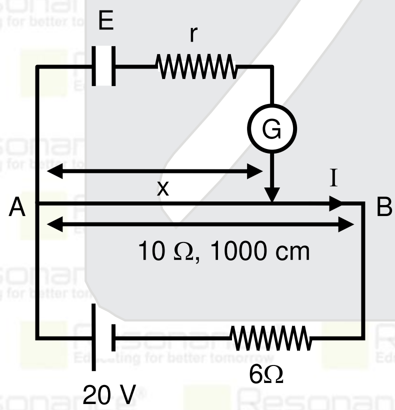
23. Circuit shown is in the balanced state in which galvanometer shows non-deflection. Given that wire AB has 0.01 Ω/cm of resistance. Find maximum possible value of voltage that can be measured by this set up.



(1) 10.5 V (2) 12.5V (3) 13.5V (4) 15.5V

Ans. **(2)**

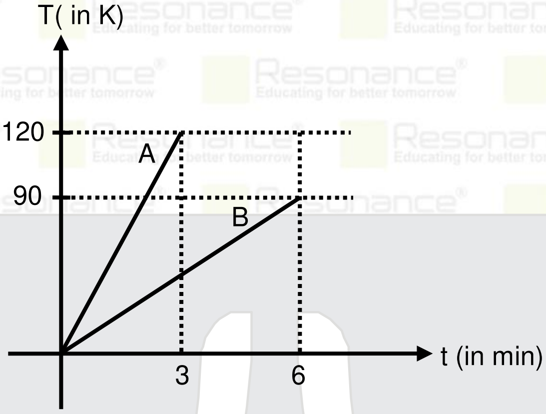
Sol. At zero deflection



The maximum value of E that can be measured = V_{AB}

$$V_{AB} = \frac{20}{10+6} \times 10 = 12.5\text{V}$$

24. The temperature vs time graph for two different gases A and B having same number of moles is as shown in figure. If heat is supplied by same rate to both the gases, the find the ratio of specific heat capacity of both the gases ?



(1) 3/8 (2) 5/8 (3) 7/8 (4) 9/8

Ans. **(1)**

Sol. $Q = nC\Delta T$

$\frac{dQ}{dt} = nC\frac{dT}{dt}$

Rate of heat is same for both gases

So, $n_1C_1\left(\frac{dT}{dt}\right)_1 = n_2C_2\left(\frac{dT}{dt}\right)_2$

$\frac{C_1}{C_2} = \frac{\left(\frac{dT}{dt}\right)_2}{\left(\frac{dT}{dt}\right)_1} = \frac{\frac{90}{6}}{\frac{120}{3}} = \frac{90\times 3}{120\times 6} = \frac{3}{8}$

25. For a magnetic material, the relative change in magnetic susceptibility is equal to 2.2×10^{-4}. Find the percentage change in magnetic field ?

(1) 0.012 (2) 0.025 (3) 0.022 (4) 0.028

Ans. **(3)**

Sol. $\mu_r = 1 + \chi$

$\Delta\mu_r = \Delta\chi$

also $B \propto \mu_r$

$B = k\mu_r$ (k = constant)

% change $= \frac{\Delta B}{B}\times 100 = \frac{k(\Delta\mu_r)}{k\mu_r}\times 100$

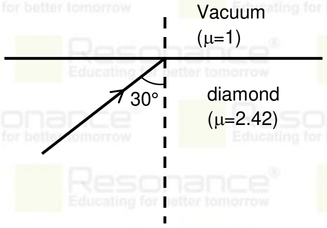
$= \frac{2.2\times 10^{-4}}{1}\times 100 = 0.022$ %

26. A ray incident at an angle 30° on the interface of diamond and vacuum from the diamond side then which of following is incorrect (given $\mu_{diamond} = 2.42$)

(1) The incident of ray will get refracted
(2) The ray will not get refracted if incident at 53°
(3) The ray will get refracted if incident at 22°
(4) There is always TIR for angle greater then 30°

Ans. (1)

Sol.



Critical angle $C = \sin^{-1}\left(\frac{1}{2.42}\right) = 24.4°$

Given Incident angle 30° > C

So there is TIR at interface

27. A monoatomic gas filled in a piston cylinder arrangement, its temperature changes from T_1 to T_2 and length of gas column changes from L_1 to L_2, against atmosphere. Then the ratio of T_1/T_2 :

(1) $\left(\frac{L_2}{L_1}\right)^{2/3}$ (2) $\left(\frac{L_1}{L_2}\right)^{2/3}$ (3) $\left(\frac{L_2}{L_1}\right)$ (4) $\left(\frac{L_1}{L_2}\right)$

Ans. (4)

Sol. PV = nRT

at constant atmospheric pressure

$\frac{T_1}{T_2} = \frac{V_1}{V_2}$

$\frac{T_1}{T_2} = \frac{AL_1}{AL_2}$

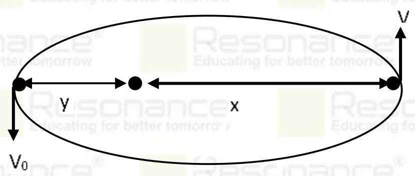
$\frac{T_1}{T_2} = \frac{L_1}{L_2}$

28. A particle is revolving around a planet with maximum distance x and minimum distance y. If maximum velocity of particle is v_0 then find minimum velocity of particle :

(1) $\frac{v_0 x}{y}$ (2) $\frac{v_0 y}{x}$ (3) $\frac{v_0 x^2}{y^2}$ (4) $\frac{v_0 y^2}{x^2}$

Ans. (2)

Sol.



By angular momentum conservation

$mv_0 y = mvx$

$v = \frac{v_0 y}{x}$

29. A radioactive material of mass number 198 decays with half-life of 3 days. If initial amount of radioactive material is 2 mg, then its initial activity will be ?

(1) 1626×10^{5} dps (2) 1626×10^{10} dps (3) 1626×10^{8} dps (4) 1626×10^{6} dps

Ans. **(2)**

Sol. No. of Nuclei = $\frac{m}{M}.N_A = \frac{2\times10^{-3}}{198}\times 6.02\times10^{23}$

$A_0 = \lambda N_0 = \frac{0.693}{3\times24\times60\times60}\times\frac{2\times10^{-3}}{198}\times 6.02\times10^{23}$

$1625 \times 10^{-8} \times 10^{18}$

1626×10^{10} dps

30. Based on given statement choose the correct option

Statement I : For a disc situated in x–y plane. The radius of gyration is same for x-axis, y-axis and z-axis.

Statement II : In case of rigid body motion there is no change in shape and mass.

(1) Statement 1 & 2 both are true

(2) Statement-1 & 2 both are true statement-2 is correct explant of statement-1

(3) Statement-1 is false Statement-2 is true

(4) Statement-2 is true Statement-1 is false.

Ans. **(3)**