Reliable INSTITUTE
Unleashing Potential

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

JEE (Main) 2021

Questions & Solutions

Date : 26 February, 2021 (SHIFT-2) Time ; (3.00 pm to 06.00 pm)

Duration : 3 Hours | Max. Marks : 300

SUBJECT : PHYSICS

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PHYSICS

1. If 'C' and 'V' represent capacity and voltage respectively then what are the dimensions of λ, where $\frac{C}{V} = \lambda$?

(1) $[M^{-2}L^{-3}I^{2}T^{6}]$ (2) $[M^{-3}L^{-4}I^{3}T^{7}]$ (3) $[M^{-1}L^{-3}I^{-2}T^{-7}]$ (4) $[M^{-2}L^{-4}I^{3}T^{7}]$

Official Ans. by NTA (4)

Sol. $\lambda = \frac{C}{V} = \frac{Q}{V^2} = \frac{Q^3}{W^2} = \frac{A^3T^3}{M^2L^4T^{-4}}$

$= [M^{-2}L^{-4}T^{7}A^{3}]$

2. The length of metallic wire is ℓ_1 when tension in it is T_1. It is ℓ_2 when the tension is T_2. The original length of the wire will be -

(1) $\frac{\ell_1 + \ell_2}{2}$ (2) $\frac{T_2\ell_1 + T_1\ell_2}{T_1 + T_2}$ (3) $\frac{T_2\ell_1 - T_1\ell_2}{T_2 - T_1}$ (4) $\frac{T_1\ell_1 - T_2\ell_2}{T_2 - T_1}$

Official Ans. by NTA (3)

Sol. $\frac{T_1}{A} = \frac{y(\ell_1 - \ell)}{\ell}$

$\frac{T_2}{A} = \frac{y(\ell_2 - \ell)}{\ell}$

$\frac{T_1}{T_2} = \frac{\ell_1 - \ell}{\ell_2 - \ell}$

$T_1\ell_2 - T_1\ell = T_2\ell_1 - T_2\ell$

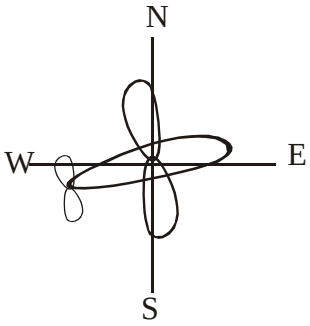
$\frac{T_1\ell_2 - T_2\ell_1}{T_1 - T_2} = \ell$

3. An aeroplane, with its wings spread 10 m, is flying at a speed of 180 km/h in a horizontal direction. The total intensity of earth's field at that part is 2.5×10^{-4} Wb/m^2 and the angle of dip is 60°. The emf induced between the tips of the plane wings will be :-

(1) 108.25 mV (2) 54.125 mV (3) 88.37 mV (4) 62.50 mV

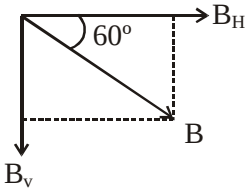
Official Ans. by NTA (1)

Sol.



$$\Sigma = B_V v \ell$$

$$\sin 60^o = \frac{Bv}{B}$$



$$\frac{\sqrt{3}}{2} = \frac{Bv}{B}$$

$$Bv = \frac{\sqrt{3}}{2} B$$

$$E = \frac{\sqrt{3}}{2} B \ell v$$

$$= \frac{\sqrt{3}}{2} \times 2.5 \times 10^{-4} \times 10 \times 180 \times \frac{5}{18}$$

$$= \frac{\sqrt{3}}{2} \times 2.5 \times 5 \times 10^{-2}$$

$$= 10.825 \times 10^{-2}$$

$$= 108.25 \text{ mv}$$

4. A tuning fork A of unknown frequency produces 5 beats/s with a fork of known frequency 340 Hz. When fork A is filed, the beat frequency decreases to 2 beats/s. What is the frequency of fork A?

(1) 342 Hz (2) 345 Hz (3) 335 Hz (4) 338 Hz

Official Ans. by NTA (3)

Sol. On filing freq. increases so freq. of A would be 335. initially and on filing it would be 338 Hz. So beat freq. become 2 Hz.

5. A particle executes S.H.M., the graph of velocity as a function of displacement is :-

(1) A circle (2) A parabola (3) An ellipse (4) A helix

Official Ans. by NTA (3)

Sol. $v = \omega\sqrt{A^2 - x^2}$

$\frac{v^2}{A^2\omega^2} + \frac{x^2}{A^2} = 1$

$\therefore$ Ellipse is the correct graph.

6. The trajectory of a projectile in a vertical plane is $y = \alpha x - \beta x^2$, where α and β are constants and x & y are respectively the horizontal and vertical distances of the projectile from the point of projection. The angle of projection θ and the maximum height attained H are respectively given by

(1) $\tan^{-1}\alpha, \frac{\alpha^2}{4\beta}$ (2) $\tan^{-1}\beta, \frac{\alpha^2}{2\beta}$ (3) $\tan^{-1}\alpha, \frac{4\alpha^2}{\beta}$ (4) $\tan^{-1}\left(\frac{\beta}{\alpha}\right), \frac{\alpha^2}{\beta}$

Official Ans. by NTA (1)

Sol. For $y_{mex} \Rightarrow \frac{dy}{dx} = \alpha - 2\beta x = 0$

$x = \frac{\alpha}{2\beta}$

$y_{max} = H_{max} = \alpha \times \frac{\alpha}{2\beta} - \beta\left(\frac{\alpha}{2\beta}\right)^2$

$= \frac{\alpha^2}{2\beta} - \frac{\alpha^2}{4\beta} = \left(\frac{\alpha^2}{4\beta}\right)$

$2x = R = \frac{\alpha}{\beta} = \frac{2u^2 \sin\theta\cos\theta}{g}$

$H = \frac{\alpha^2}{4\beta} = \frac{u^2 \sin^2\theta}{2g}$

$\tan\theta = \alpha$

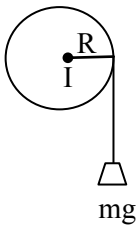
$\theta = \tan^{-1}(\alpha)$

7. A cord is wound round the circumference of wheel of radius r. The axis of the wheel is horizontal and the moment of inertia about it is I. A weight mg is attached to the cord at the end. The weight falls from rest. After falling through a distance 'h', the square of angular velocity of wheel will be :-

(1) $\frac{2mgh}{I + 2mr^2}$ (2) $\frac{2mgh}{I + mr^2}$ (3) 2gh (4) $\frac{2gh}{I + mr^2}$

Official Ans. by NTA (2)

Sol.



$mg - T = ma$

$TR = I\alpha$

$a = R\alpha$

$$mg - \frac{I\alpha}{R} = ma$$

$$a = \frac{mg}{m + \frac{I}{R^2}}$$

$$V = \sqrt{\frac{2mgh}{m + \frac{I}{R^2}}} = \omega R$$

$$\omega^2 = \frac{2mgh}{I + mR^2}$$

8. The internal energy (U), pressure (P) and volume (V) of an ideal gas are related as $U = 3PV + 4$. The gas is :-

(1) Diatomic only (2) Polyatomic only

(3) Either monoatomic or diatomic (4) Monoatomic only

Official Ans. by NTA (2)

Sol. $U = 3\,PV + 4$

$$\frac{f}{2}\,PV = 3\,PV + 4$$

$$f = 6 + \frac{8}{PV}$$

$f > 6$ $\therefore$ Polyatomic gas.

9. Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A : For a simple microscope, the angular size of the object equals the angular size of the image.

Reason R : Magnification is achieved as the small object can be kept much closer to the eye than 25 cm and hence it subtends a large angle.

In the light of the above statements, choose the most appropriate answer from the options given below :

(1) A is true but R is false

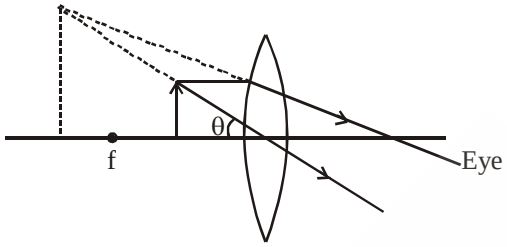
(2) Both A and R are true but R is NOT the correct explanation of A.

(3) Both A and R are true and R is the correct explanation of A

(4) A is false but R is true

Official Ans. by NTA (3)

Sol.



Both make same angle, since image can be at a distance greater than 25 cm, object can be closer to eye then 25 cm.

10. Given below are two statements :

Statement I : An electric dipole is placed at the centre of a hollow sphere. The flux of electric field through the sphere is zero but the electric field is not zero anywhere in the sphere.

Statement II : If R is the radius of a solid metallic sphere and Q be the total charge on it. The electric field at any point on the spherical surface of radius r (< R) is zero but the electric flux passing through this closed spherical surface of radius r is not zero.

In the light of the above statements, choose the correct answer from the options given below :

(1) Both Statement I and Statement II are true

(2) Statement I is true but Statement II is false

(3) Both Statement I and Statement II are false

(4) Statement I is false but Statement II is true.

Official Ans. by NTA (2)

11. The recoil speed of a hydrogen atom after it emits a photon in going from n = 5 state to n = 1 state will be :

(1) 4.17 m/s (2) 2.19 m/s (3) 3.25 m/s (4) 4.34 m/s

Official Ans. by NTA (1)

Sol. $E_1 = -\frac{13.6\ eV}{1^2} = -13.6\ eV$

$E_5 = -\frac{13.6\ eV}{25} = -0.54\ eV$

$E_5 - E_1 = 13.6 - 0.54 = 13.06\ eV$

$13.06\ eV = E_1 + E_2$

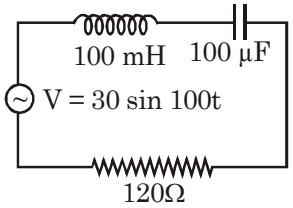
$= CP_1 + \frac{P_2^2}{2m}$

$= CP_2 + \frac{P_2^2}{2m}$

On solving

recoil speed = 4.17 m/sec

12. Find the peak current and resonant frequency of the following circuit (as shown in figure).



(1) 0.2 A and 50 Hz (2) 0.2 A and 100 Hz

(3) 2 A and 100 Hz (4) 2A and 50 Hz

Official Ans. by NTA (1)

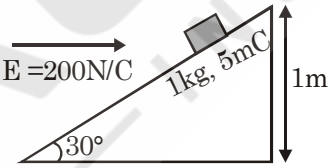
Sol. $Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{120^2 + (10-100)^2} = 150\Omega$

$I_0 = \frac{V_0}{z} = \frac{30}{150} = 0.2A$

$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{10^{-1}\times 10^{-4}}} = \frac{1}{\sqrt{10^{-5}}} = 2\pi f$

$f = \frac{100}{2\pi\sqrt{10}} = \frac{100}{2\times 10}$ 5Hz

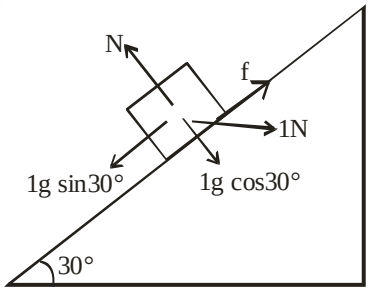
13. An inclined plane making an angle of 30° with the horizontal is placed in a uniform horizontal electric field 200 $\frac{N}{C}$ as shown in the figure. A body of mass 1kg and charge 5 mC is allowed to slide down from rest at a height of 1m. If the coefficient of friction is 0.2, find the time taken by the body to reach the bottom.[g = 9.8 m/s^2, sin 30° = $\frac{1}{2}$; cos 30° = $\frac{\sqrt{3}}{2}$]



(1) 0.92 s (2) 0.46 s (3) 2.3 s (4) 1.3 s

Official Ans. by NTA (4)

Sol.



$N = qE\sin 30° + mg\cos 30°$

$$a = \frac{mg\sin30° - qE\cos30° - \mu N}{m}$$

$a = 2.302$

$$t = \sqrt{\frac{2\ell}{a}}$$

$t = 1.31$ sec

14. Two masses A and B, each of mass M are fixed together by a massless spring. A force acts on the mass B as shown in figure. If the mass A starts moving away from mass B with acceleration 'a', then the acceleration of mass B will be :

(1) $\frac{Ma - F}{M}$

(2) $\frac{MF}{F + Ma}$

(3) $\frac{F + Ma}{M}$

(4) $\frac{F - Ma}{M}$

Official Ans. by NTA (4)

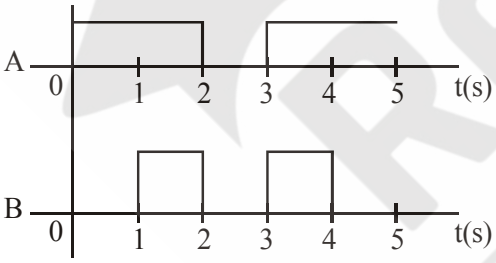
Sol. $Kx = Ma$

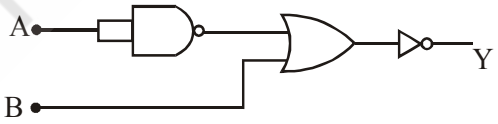
$F + Kx = Ma_B$

$F + Ma = Ma_B$

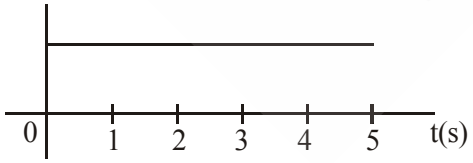
$$a_B = \frac{F}{M} + a$$

15. Draw the output signal Y in the given combination of gates :-

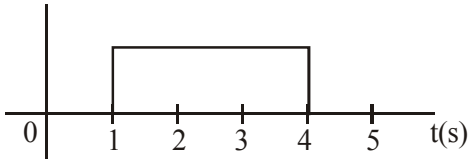




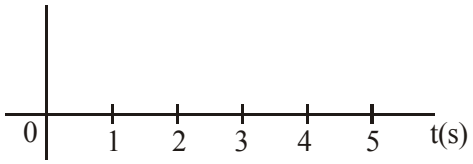
(1)



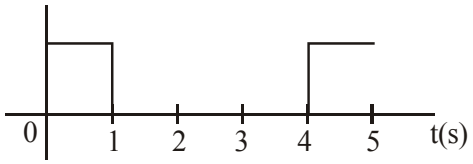
(2)



(3)



(4)



Official Ans. by NTA (4)

Sol. $y = \overline{\overline{A} + B} = A.\overline{B}$

16. A radioactive sample is undergoing α decay. At any time t_1, its activity is A and another time t_2, the activity is $\frac{A}{5}$. What is the average life time for the sample?

(1) $\frac{\ell n5}{t_2 - t_1}$ (2) $\frac{t_1 - t_2}{\ell n5}$ (3) $\frac{t_2 - t_1}{\ell n5}$ (4) $\frac{\ell n(t_2 + t_1)}{2}$

Official Ans. by NTA (3)

Sol. $A = A_0 e^{-\lambda t}$ (Radio active decay law)

$\frac{A}{5} = Ae^{-\lambda(t_2 - t_1)}$

$\ell n\ 5 = \lambda\ (t_2 - t_1)$

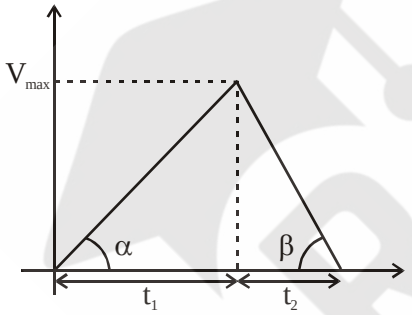
$\frac{1}{\lambda} = \frac{t_2 - t_1}{\ell n5}$

17. A scooter accelerates from rest for time t_1 at constant rate a_1 and then retards at constant rate a_2 for time t_2 and comes to rest. The correct value of $\frac{t_1}{t_2}$ will be :-

(1) $\frac{a_1 + a_2}{a_2}$ (2) $\frac{a_2}{a_1}$ (3) $\frac{a_1}{a_2}$ (4) $\frac{a_1 + a_2}{a_1}$

Official Ans. by NTA (2)

Sol.



$\tan\alpha = \frac{V_{max}}{t_1}$

$a_1 = \frac{V_{max}}{t_1}$

$\tan\beta = \frac{V_{max}}{t_2}$

$a_2 = \frac{V_{max}}{t_2}$

$\frac{a_1}{a_2} = \frac{t_2}{t_1}$

$\frac{t_1}{t_2} = \frac{a_2}{a_1}$

18. Given below are two statements:

Statement I : A second's pendulum has a time period of 1 second.

Statement II : It takes precisely one second to move between the two extreme positions.

In the light of the above statements, choose the correct answer from the options given below:

(1) Both Statement I and Statement II are false.

(2) Statement I is false but Statement II is true

(3) Statement I is true but Statement II is false

(4) Both Statement I and Statement II are true.

Official Ans. by NTA (2)

19. A wire of 1Ω has a length of 1m. It is stretched till its length increases by 25%. The percentage change in resistance to the nearest integer is:-

(1) 56% (2) 25% (3) 12.5% (4) 76%

Official Ans. by NTA (1)

Sol. $R_i = \frac{\rho \ell}{A}$

$R_f = \frac{\rho(1.25\ell)}{(A/1.25)} = \frac{\rho\ell}{A}(1.25)^2$

$\therefore R_f = R_i\,(1.5625)$

$\therefore R_f = R_i\,(1+0.5625)$

$\therefore \frac{R_f - R_i}{R_i} = 0.5625$

$\therefore \%\frac{\Delta R}{R} = 56.25\%$

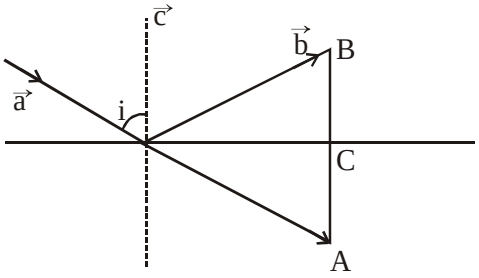
20. The incident ray, reflected ray and the outward drawn normal are denoted by the unit vectors $\vec{a}$, $\vec{b}$ and $\vec{c}$ respectively. Then choose the correct relation for these vectors.

(1) $\vec{b} = \vec{a} + 2\vec{c}$ (2) $\vec{b} = 2\vec{a} + \vec{c}$ (3) $\vec{b} = \vec{a} - 2(\vec{a}.\vec{c})\vec{c}$ (4) $\vec{b} = \vec{a} - \vec{c}$

Official Ans. by NTA (3)

Sol. $\vec{a}\cdot\vec{c} = |\vec{a}||\vec{c}|\cos(\pi - i)$

$= -\cos i$



$\overrightarrow{OA} + \overrightarrow{AB} = \overrightarrow{OB}$

$\vec{a} + 2\overrightarrow{AC} = \vec{b}$

$\cos i = \frac{AC}{OA}$

$AC = \cos i$

$\vec{a} + 2\cos i\ \vec{c} = \vec{b}$

hence $\vec{b} = \vec{a} - 2(\vec{a}.\vec{c})\vec{c}$

21. The volume V of a given mass of monoatomic gas changes with temperature T according to the relation $V = KT^{2/3}$. The work done when temperature changes by 90 K will be xR. The value of x is [R = universal gas constant]

Official Ans. by NTA 60

Sol. $V = KT^{2/3}$

$V^{3/2} = (K)^{3/2}\ T$

$\therefore\ TV^{-3/2} = \text{const.} \Rightarrow x-1 = -3/2$

$\therefore\ x = -1/2$

$\therefore\ \omega = \frac{nR\Delta T}{-x+1}$

$= \frac{1(R)(90)}{+\frac{1}{2}+1} = 60R$

22. If the highest frequency modulating a carrier is 5 kHz, then the number of AM broadcast stations accommodated in a 90 kHz bandwidth are .....

Official Ans. by NTA 9

Sol. Bandwidth of am
= 10 kHz

No. of channels = $\frac{90}{10} = 9$

23. Two stream of photons, possessing energies equal to twice and ten times the work function of metal are incident on the metal surface successively. The value of ratio of maximum velocities of the photoelectrons emitted in the two respective cases is x : y. The value of x is .....

Official Ans. by NTA (1)

Sol. Case–1.

$2\phi - \phi = \frac{1}{2}mv_1^2$ …(i)

Case –2

$10\phi - \phi = \frac{1}{2}mv_2^2$ ….(ii)

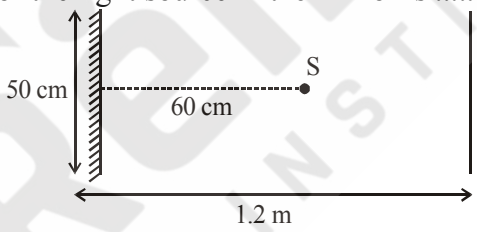
Dividing (i) and (ii)

$\frac{\phi}{9\phi} = \frac{v_1^2}{v_2^2}$

$\frac{1}{3} = \frac{v_1}{v_2}$

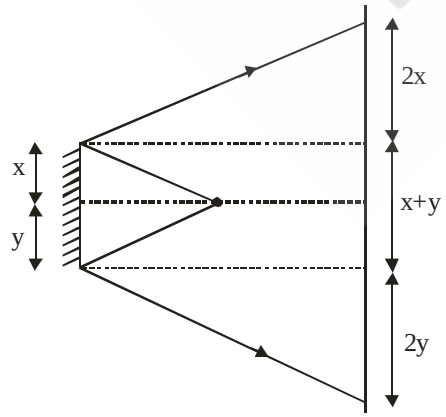
$\therefore$ x = 1

24. A point source of light S, placed at a distance 60 cm infront of the centre of a plane mirror of width 50 cm, hangs vertically on a wall. A man walks infront of the mirror along a line parallel to the mirror at a distance 1.2 m from it (see in the figure). The distance between the extreme points where he can see the image of the light source in the mirror is ..... cm.



Official Ans. by NTA (150)

Sol.



= 3 (x + y)
= 3(50)
= 150 cm

25. A particle executes S.H.M. with amplitude 'a' and time period 'T'. The displacement of the particle when its speed is half of maximum speed is $\frac{\sqrt{x}a}{2}$. The value of x is .....

Official Ans. by NTA (3)

Sol. $v = \omega\sqrt{A^2 - x^2}$

$$\frac{A\omega}{2} = \omega\sqrt{A^2 - x^2}$$

solving we get

$$x = \frac{\sqrt{3}A}{2}$$

26. 27 similar drops of mercury are maintained at 10V each. All these spherical drops combine into a single big drop. The potential energy of the bigger drop is ..... times that of a smaller drop.

Official Ans. by NTA 243

Sol.

$$U_1 = \frac{Kq^2}{2r}$$

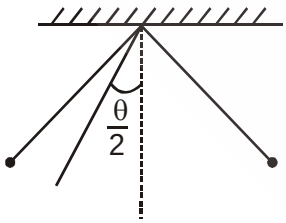
$$U_2 = \frac{27^2}{3}\left(\frac{Kq^2}{2r}\right) = 243U_1$$

27. Time period of a simple pendulum is T. The time taken to complete 5/8 oscillations starting from mean position is $\frac{\alpha}{\beta}T$. The value of α is .....

Official Ans. by NTA 7

Sol. Oscillation is $\left(\frac{1}{2} + \frac{1}{8}\right)$

For half oscilation, time required will be $\frac{T}{2}$



$\theta = \theta_0 \sin\omega t$

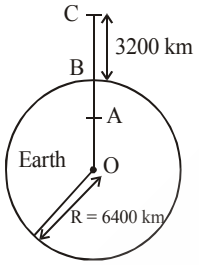
$\frac{1}{2} \sin\omega t$

$\omega t = \frac{\pi}{6}$

$\therefore t = \frac{T}{12}$

$\therefore \frac{T}{2} + \frac{T}{12} = \frac{7T}{12}$

28. In the reported figure of earth, the value of acceleration due to gravity is same at point A and C but it is smaller than that of its value at point B (surface of the earth). The value of OA : AB will be x : y. The value of x is .....



Official Ans. by NTA (4)

Sol. $\frac{GM}{\left(\frac{3R}{2}\right)^2} = \frac{GMr}{R^3}$

$\mathbf{OA} = \frac{4R}{9} = r$

$AB = R - \frac{4R}{9} = \frac{5R}{9}$

OA : AB

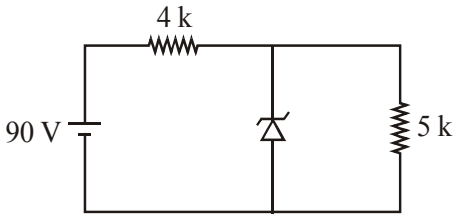
$\frac{4R}{9} : \frac{5R}{9} \Rightarrow 4 : 5 = x : y$

(x = 4)

29. 1 mole of rigid diatomic gas performs a work of Q/5 when heat Q is supplied to it. The molar heat capacity of the gas during this transformation is $\frac{xR}{8}$, The value of x is ..... [R = universal gas constant]

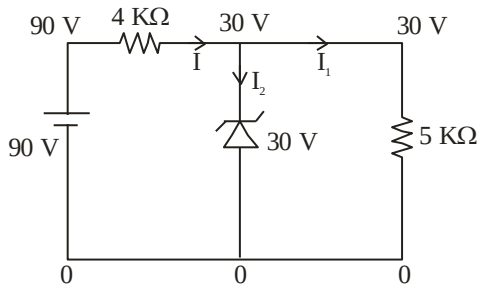
Official Ans. by NTA 25

30. The zener diode has a V_z = 30 V. The current passing through the diode for the following circuit is ..... mA.



Official Ans. by NTA 9

Sol.



$$I = \frac{90-30}{4} = 15mA$$

$$I_1 = \frac{30}{5K\Omega} = 6mA$$

$I_2 = 15mA - 6mA = 9mA$

Ans. 9