JEE Main 2023 (2nd Attempt)
(Shift - 01 Physics Paper)

12.04.2023

PHYSICS — TEST PAPER WITH SOLUTION

SECTION-A

31. An ice cube has a bubble inside. When viewed from one side the apparent distance of the bubble is 12 cm. when viewed from the opposite side, the apparent distance of the bubble is observed as 4 cm. If the side of the ice cube is 24 cm, the refractive index of the ice cube is

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

(3) $\frac{2}{3}$ (4) $\frac{6}{5}$

Official Ans. by NTA (2)

Allen Ans. (2)

Sol. $d_{apparent} = \frac{d_{actual}}{\mu_{rel}}$

$12 = \frac{x}{\mu}$ …(1)

$4 = \frac{24 - x}{\mu}$ …(2)

On solving we get $\mu = 1.5$

32. Two satellites A and B move round the earth in the same orbit. The mass of A is twice the mass of B. The quantity which is same for the two satellites will be :

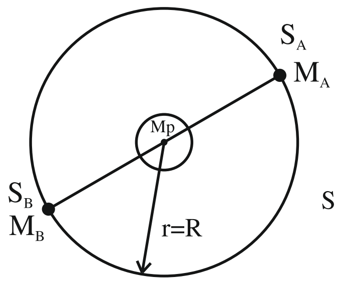
(1) Potential energy (2) Total energy

(3) Kinetic energy (4) Speed

Official Ans. by NTA (4)

Allen Ans. (4)

Sol.



$$P.E = -\frac{GM_PM_A}{R}$$

$$K.E = +\frac{GM_PM_A}{2R}$$

$$T.E = -\frac{GM_PM_A}{2R}$$

$$\text{Speed} = v = \sqrt{\frac{GM_p}{R}}$$

Speed of satellite in Independent of mass of satellite.

33. The amplitude of 15 sin (1000 πt) is modulated by 10 sin (4πt) signal. The amplitude modulated signal contains frequencies of

1. 500 Hz. 2. 2 Hz

3. 250 Hz 4. 498 Hz

5. 502 Hz

Choose the correct answer from the options given below:

(1) (1) and (3) only

(2) (1) and (4) only

(3) (1) and (2) only

(4) (1), (4) and (5) only

Official Ans. by NTA (4)

Allen Ans. (4)

Sol. Equation of Carrier wave

$c(t) = 15 \sin (1000 \pi t)$

$$f_i = \frac{\omega_c}{2\pi} = \frac{1000\pi}{2\pi} = 500\text{ Hz}$$

Equation of modulated wave

$m(t) = 10 \sin (4 \pi t)$

$$f_m = \frac{\omega_m}{2\pi} = \frac{4\pi}{2\pi} = 2\text{ Hz}$$

Frequencies contained in resultant Amplitude modulated wave are (500–2)Hz, 500 Hz and (500+2) Hz.

Correct ans is (4)

34. In an n-p-n common emitter (CE) transistor the collector current changes from 5 mA to 16 mA for the change in base current from 100 μA and 200 μA, respectively. The current gain of transistor is________.

(1) 110 (2) 0.9

(3) 210 (4) 9

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. Current gain in common emitter transistor

$$\beta = \frac{\Delta I_C}{\Delta I_B} = \frac{16mA - 5mA}{200\,\mu A - 100\mu A} = \frac{11\,mA}{100\mu A} = 110$$

35. If the r.m.s. speed of chlorine molecule is 490 m/s at 27° C, the r.m.s. speed of argon molecules at the same temperature will be (Atomic mass of argon = 39.9u, molecular mass of chlorine = 70.9u)

(1) 751.7 m/s (2) 451.7 m/s

(3) 651.7 m/s (4) 551.7 m/s

Official Ans. by NTA (3)

Allen Ans. (3)

Sol. $V_{rms} = \sqrt{\frac{3RT}{M}}$ $\frac{\upsilon_{Ar}}{\upsilon_{Cl}} = \sqrt{\frac{M_{Cl}}{M_{Ar}}}$

$\Rightarrow \upsilon_{Ar} = 1.33 \times 490 = 651.7\,m/s$

36. A proton and an α-particle are accelerated from rest by 2V and 4V potentials, respectively. The ratio of their de-Broglie wavelength is:

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

(3) 8:1 (4) 16:1

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. $\lambda = \frac{h}{m\upsilon} = \frac{h}{\sqrt{2mK}} = \frac{h}{\sqrt{2mq\Delta V}}$

$$\frac{\lambda_\alpha}{\lambda_p} = \sqrt{\frac{m_p V_p q_p}{m_\alpha V_\alpha q_\alpha}}$$

$$\Rightarrow \frac{\lambda_\alpha}{\lambda_p} = \sqrt{\frac{1 \times 2 \times 1}{4 \times 4 \times 2}} = \frac{1}{4}$$

$\Rightarrow \lambda_p : \lambda_\alpha = 4:1$

37. Given below are two statements:

Statement I : The diamagnetic property depends on temperature.

Statement II : The included magnetic dipole moment in a diamagnetic sample is always opposite to the magnetizing field.

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

(1) Statement I is incorrect but Statement II is true

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

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

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

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. Conceptual

38. A wire of resistance 160 Ω is melted and drawn in wire of one-fourth of its length. The new resistance of the wire will be

(1) 10 Ω (2) 640 Ω

(3) 40 Ω (4) 16 Ω

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. Volume = Constant

$A_1L_1 = A_2L_2$

$A_1L = A_2\frac{L}{4}$

$\boxed{4A_1 = A_2}$

$R_1 = \frac{\rho L_1}{A_1}$ $R_2 = \frac{\rho L_2}{A_2}$

$$\frac{R_2}{R_1} = \frac{L_2A_1}{A_2L_1} = \frac{L}{4}\frac{A_1}{4A_1L}$$

$$R_2 = \frac{1}{16}R_1 = 10\,\Omega$$

39. Match List I with List II

List I		List II	
A.	Spring constant	I.	(T^{-1})
B.	Angular speed	II.	(MT^{-2})
C.	Angular momentum	III.	(ML^2)
D.	Moment of Inertia	IV.	(ML^2T^{-1})

Choose the correct answer from the options given below:

(1) A-II, B-I, C-IV, D-III

(2) A-IV, B-I, C-III, D-II

(3) A-II, B-III, C-I, D-IV

(4) A-I, B-III, C-II, D-IV

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. Spring Constant

$$[K] = \frac{[F]}{[x]} = \frac{MLT^{-2}}{L} = MT^{-2}$$

$$[\omega] = \frac{[\theta]}{[t]} = \frac{1}{T} = T^{-1}$$

40. Three force $F_1 = 10N$, $F_2 = 8$ N, $F_3 = 6$ N are acting on a particle of mass 5 kg. The forces F_2 and F_3 are applied perpendicular so that particle remains at rest. If the force F_1 is removed, then the acceleration of the particle is:

(1) 2 ms^{-2} (2) 0.5 ms^{-2}

(3) 4.8 ms^{-2} (4) 7 ms^{-2}

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. Resultant of $\vec{F_2}$ and $\vec{F_3}$ should be opposite to $\vec{F_1}$

$$a = \frac{10}{5} = 2\,m/s^2$$

41. A body cools from 80°C to 60°C in 5 minutes. The temperature of the surrounding is 20°C. The time it takes to cool from 60°C to 40°C is:

(1) 500 s (2) $\frac{25}{3}$ s

(3) 450 s (4) 420 s

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. Rate of cooling α Temperature difference

$$\frac{80-60}{5} = k\{70-20\} \text{ --- (1)}$$

$$\frac{60-40}{t} = k[50-20] \text{ ---- (2)}$$

$$\frac{4t}{20} = \frac{50}{30}$$

$$t = \frac{25}{3}\text{min} = 500\,\text{sec}$$

$$\Rightarrow t = 500\,\text{seconds}$$

42. An engine operating between the boiling and freezing points of water will have

1. efficiency more than 27%

2. efficiency less than the efficiency a Carnot engine operating between the same two temperatures.

3. efficiency equal to 27%

4. efficiency less than 27%

(1) 2, 3 and 4 only (2) 2 and 3 only

(3) 2 and 4 only (4) 1 and 2 only

Official Ans. by NTA (3)

Allen Ans. (3)

Sol. $\eta = \left(1 - \frac{273}{373}\right) \times 100 = 26.8\%$

43. Given below are two statements:

Statement I : A truck and a car moving with same kinetic energy are brought to rest by applying brakes which provide equal retarding forces. Both come to rest in equal distance.

Statement II : A car moving towards east takes a turn and moves towards north, the speed remains unchanged. The acceleration of the car is zero.

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

(1) Statement I is correct but Statement II is incorrect

(2) Statement I is incorrect but Statement II is correct

(3) Both Statement I is correct but Statement II are incorrect

(4) Both Statement I is correct but Statement II are correct

Official Ans. by NTA (1)

Allen Ans. (1)

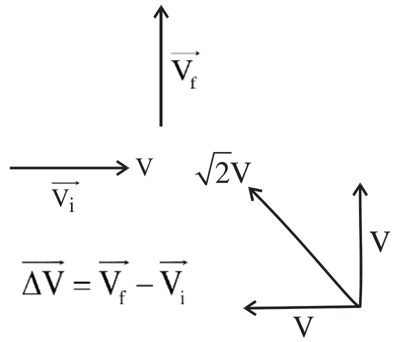
Sol. Work done = ΔKE

Work done = –FS = 0 – K

$$S = \frac{K}{F}$$

Statement 1 $\rightarrow$ correct

Statement 2 $\rightarrow$ incorrect



Velocity is changing $\Rightarrow \vec{a} \neq 0$

Ans. 1

44. A particle is executing Simple Harmonic Motion (SHM). The ratio of potential energy and kinetic energy of the particle when its displacement is half of its amplitude will be:

(1) 1 : 1 (2) 2 : 1

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

Official Ans. by NTA (4)

Allen Ans. (4)

Sol. $x = \frac{A}{2}$, P.E. $= \frac{1}{2}kx^2$

$$K.E. = \frac{1}{2}kA^2 - \frac{1}{2}kx^2$$

$$\frac{P.E}{K.E} = \frac{x^2}{A^2 - x^2} = \frac{A^2}{4\left(\frac{3A^2}{4}\right)} = \frac{1}{3}$$

45. A ball is thrown vertically upward with an initial velocity of 150 m/s. The ratio of velocity after 3 s and 5s is $\frac{x+1}{x}$. The value of x is _______.

Take ($g = 10$ m/s^2).

(1) 6 (2) 5

(3) –5 (4) 10

Official Ans. by NTA (2)

Allen Ans. (2)

Sol. $\vec{v} = \vec{u} + \vec{a}t$

$$V = 150 - 10t$$

$V(3) = 150 - 30 = 120$

$V(5) = 150 - 50 = 100$

$$\frac{120}{100} = \frac{x+1}{x} = \frac{6}{5} \Rightarrow x = 5$$

Ans. (2)

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

Assertion A : If an electric dipole of dipole moment 30×10^{-5} Cm is enclosed by a closed surface, the net flux coming out of the surface will be zero.

Reason R : Electric dipole consists of two equal and opposite charges.

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

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

(2) A is true but R is false

(3) Both A and R true but R is NOT the correct explanation of A

(4) A is false but R is true

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. $\vec{P} = 30 \times 10^{-5}$Cm

Using Gauss law

$$\phi = \frac{Q_{in}}{\varepsilon_0} \text{ and } Q_{in} = 0$$

$\Rightarrow \phi = 0$

Statement 1 and Statement 2 are correct.

Ans. (1)

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

Assertion A : EM waves used for optical communication have longer wavelengths than that of microwave, employed in Radar technology.

Reason R : Infrared EM waves are more energetic than microwaves, (used in Radar)

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

(1) A is false but R is true

(2) A is true but R is false

(3) Both A and R true but R is NOT the correct explanation of A

(4) Both A and R true and r is the correct explanation of A

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. Optical communication is performed in the frequency range of 1THz to 1000 THz.
(Microwave to UV)
So, EM waves used for optical communication have shorter wavelength than that of microwaves used in RADAR.
Also, $\upsilon_{INFRARED} > \upsilon_{MICROWAVE}$
$\therefore$ Infrared EM waves are more energetic than microwave

48. A 12.5 eV electron beam is used to bombard gaseous hydrogen at room temperature. The number of spectral lines emitted will be:
(1) 2 (2) 1
(3) 3 (4) 4
Official Ans. by NTA (3)
Allen Ans. (3)

Sol. According to Bohr's postulates, an electron makes jump to higher energy orbital if it absorbs a photon of energy equal to difference between the energies of an excited state and the ground state. Assuming that collided electron takes energy equal to 10.2 eV or 12.09 eV from incoming electron beam (some part lost due to collision). The maximum excited state is n = 3. So, number of spectral lines is $\frac{3(3-1)}{2} = 3$

49. The ratio of escape velocity of a planet to the escape velocity of earth will be:
Given : Mass of the planet is 16 times mass of earth and radius of the planet is 4 times the radius of earth.
(1) 4 : 1 (2) 2 : 1
(3) $1 : \sqrt{2}$ (4) 1 : 4
Official Ans. by NTA (1)
Allen Ans. (2)

Sol. $V_{escape} = \sqrt{\frac{2GM}{R}}$

$\therefore$ V_{escape} for planet $= \sqrt{\frac{2G(16M_E)}{(4R_E)}} = 2\sqrt{\frac{2GM_E}{R_E}}$

$= 2(V_{escape}$ for Earth)

50. Given below are two statements :
Statement I : When the frequency of an a.c. source in a series LCR circuit increases, the current in the circuit first increases, attains a maximum value and then decreases.
Statement II : In a series LCR circuit, the value of power factor at resonance is one.
In the light of given statements, choose the most appropriate answer from the options given below:
(1) Statement I is incorrect but Statement II is true.
(2) Both Statement I and Statement II are false.
(3) Statement I is correct but Statement II is false.
(4) Both Statement I and Statement II are true.
Official Ans. by NTA (4)
Allen Ans. (4)

Sol. Both statements are correct. Theory based.

SECTION-B

51. For a certain organ pipe, the first three resonance frequencies are in the ratio of 1:3:5 respectively. If the frequency of fifth harmonic is 405 Hz and the speed of sound in air is 324 ms^{-1} the length of the organ pipe is ________m.

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. For 5^{th} harmonic in closed organ pipe,

$$f_5 = \frac{5V}{4\ell} \Rightarrow 405 = \frac{5 \times 324}{4\ell}$$

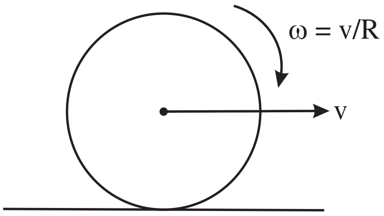
$$\Rightarrow \ell = 1m$$

52. For a rolling spherical shell, the ratio of rotational kinetic energy and total kinetic energy is $\frac{x}{5}$. The value of x is_________.

Official Ans. by NTA (2)

Allen Ans. (2)

Sol.



$$\frac{K_{rot}}{K_{Total}} = \frac{\frac{1}{2}\left(\frac{2}{3}mR^2\right)\left(\frac{V}{R}\right)^2}{\frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{3}mR^2\right)\left(\frac{V}{R}\right)^2}$$

$$\Rightarrow \frac{x}{5} = \frac{2}{5} \quad \Rightarrow x = 2$$

53. A compass needle oscillates 20 times per minute at a place where the dip is 30° and 30 times per minute where the dip is 60°. The ratio of total magnetic field due to the earth at two place respectively is $\frac{4}{\sqrt{x}}$. The value of x is

Official Ans. by NTA (243)

Allen Ans. (243)

Sol. Period of oscillation $\alpha \frac{1}{\sqrt{B_H}}$

$$T \alpha \frac{1}{\sqrt{B\cos\theta}} \Rightarrow \frac{T_1}{T_2} = \sqrt{\frac{B_2\cos\theta_2}{B_1\cos\theta_1}}$$

$$\Rightarrow \frac{60/20}{60/30} = \sqrt{\frac{B_2}{B_1}\frac{\cos 60^\circ}{\cos 30^\circ}} \Rightarrow \frac{3}{2} = \sqrt{\frac{B_2}{\sqrt{3}B_1}}$$

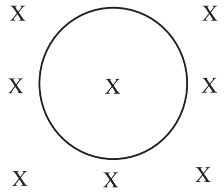
$$\Rightarrow \frac{9}{4} = \frac{B_2}{\sqrt{3}B_1} \Rightarrow \frac{B_1}{B_2} = \frac{4}{9\sqrt{3}} = \frac{4}{\sqrt{243}}$$

54. A conducting circular loop is placed in a uniform magnetic field of 0.4 T with its plane perpendicular to the field. Somehow, the radius of the loop starts expanding at a constant rate of 1 mm/s. The magnitude of induced emf in the loop at an instant when the radius of the loop is 2 cm will be __________ μV.

Official Ans. by NTA (50)

Allen Ans. (50)

Sol.



$$\frac{dr}{dt} = 10^{-3}\,m/s$$

$$\frac{dA}{dt} = 2\pi r\frac{dr}{dt}$$

$$\varepsilon = \left|\frac{-d\phi}{dt}\right| = \left|\frac{BdA}{dt}\right|$$

$$= 0.4 \times 2 \times \pi \times 2 \times 10^{-2} \times 10^{-3}V$$

$$= 16\pi\mu V = 50.24\ \mu V$$

55. To maintain a speed of 80 km/h by a bus of mass 500 kg on a plane rough road for 4 km distance, the work done by the engine of the bus will be _________KJ. [The coefficient of friction between tyre of bus and road is 0.04].

Official Ans. by NTA (784)

Allen Ans. (784)

Sol. For constant speed, WD by engine + WD by friction = 0 [by WET]

$WD_{engine} = -WD_{friction} = -[-\mu mgx]$

$= 0.04 \times 500 \times 9.8 \times 4 \times 10^3$

= 784 KJ

56. A common example of alpha decay is

$${}^{238}_{92}U \longrightarrow {}^{234}_{90}Th + {}_2He^4 + Q$$

Given :

$${}^{238}_{92}U = 238.05060u,$$

$${}^{234}_{90}Th = 234.04360u,$$

$${}^{4}_{2}He = 4.00260u, \text{and}$$

$$1u = 931.5\frac{MeV}{c^2}$$

The energy released (Q) during the alpha decay of ${}^{238}_{92}U$ is ______ MeV

Official Ans. by NTA (4)

Allen Ans. (4)

Sol. Energy released = $(\Delta m)_{amu} \times 931.5$ MeV

$= (m_u - m_{Th} - m_{He})_{amu} \times 931.5$ MeV

$= 0.0044 \times 931.5$ MeV = 4.0986 MeV

57. The current flowing through a conductor connected across a source is 2A and 1.2 A at 0°C and 100°C respectively. The current flowing through the conductor at 50°C will be ________ $\times 10^2$ mA.

Official Ans. by NTA (15)

Allen Ans. (15)

Sol. $i_o R_o = i_{100} R_{100}$ [For same source]

$\Rightarrow 2 R_o = 1.2 R_o [1 + 100\alpha]$ --- (1)

$\Rightarrow 1 + 100\alpha = \frac{5}{3} \Rightarrow 100\alpha = \frac{2}{3}$

$\Rightarrow 50\alpha = \frac{1}{3}$

$\therefore\ i_{50} R_{50} = i_o R_o$

$\Rightarrow i_{50} = \frac{i_o R_o}{R_{50}} = \frac{2 \times R_o}{R_o(1+50\alpha)} = \frac{2}{1+\frac{1}{3}} = 1.5A$

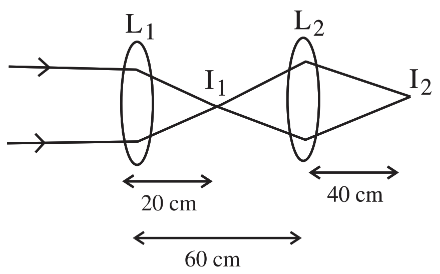
$= 15 \times 10^2$ mA

58. Two convex lenses of focal length 20 cm each are placed coaxially with a separation of 60 cm between them. The image of the distant object formed by the combination is at ________ cm from the first lens.

Official Ans. by NTA (100)

Allen Ans. (100)

Sol. $f_1 = 20$ cm $f_2 = 20$ cm



1st refraction in $L_1(I_1)$

$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{v} - \frac{1}{\infty} = \frac{1}{f}$

$\therefore\ v = f$

2nd refraction in L_2

$I_1 \rightarrow$ object

$I_2 \rightarrow$ image

$u = -40$ cm $f = 20$ cm

$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{v} - \frac{1}{(-40)} = \frac{1}{20}$

$\frac{1}{v} = \frac{1}{20} - \frac{1}{40} = \frac{6-3}{120}$

$\frac{1}{v} = \frac{3}{120} = \frac{1}{40}$

$\therefore\ v = 40$ cm

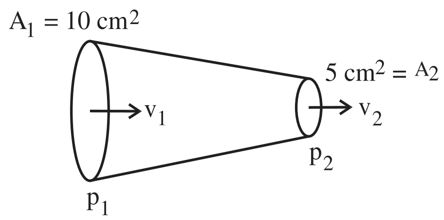
Correct Answer is 100.

59. Glycerine of density 1.25×10^3 kg m^{-3} is flowing through the conical section of pipe. The area of cross-section of the pipe at its ends is 10 cm^2 and 5 cm^2 and pressure drop across its length is 3 Nm^{-2}. The rate of flow of glycerine through the pipe is $x \times 10^{-5}$ m^3 s^{-1}. The value of x is ____.

Official Ans. by NTA (4)

Allen Ans. (4)

Sol.



$\Delta P = P_1 - P_2 = 3$ N/m^2 (given)

By continuity eq^n

$A_1 v_1 = A_2 v_2$

$\therefore\ v_1 = \frac{A_2}{A_1} v_2$ ----- (1)

By Bernoulli's eq^n

$$P_1 + \frac{1}{2}\rho v_1{}^2 = P_2 + \frac{1}{2}\rho v_2{}^2$$

$$P_1 - P_2 = \frac{1}{2}\rho(v_2^2 - v_1^2)$$

$$\Delta P = \frac{1}{2}\rho(v_2^2 - \frac{A_2^2}{A_1^2}v_2^2)$$

$$\Delta P = \frac{1}{2}\rho\left[1-\left(\frac{A_2}{A_1}\right)^2\right]v_2^2$$

$$3 = \frac{1}{2}\times 1.25\times 10^3\left[1-\left(\frac{5}{10}\right)^2\right]v_2^2$$

$$3 = \frac{1}{2}\times 1.25\times 10^3\left[1-\frac{1}{4}\right]v_2^2$$

$$3 = \frac{1}{2}\times 1.25\times 10^3\times\frac{3}{4}v_2^2$$

$\therefore$ $v_2 = 8 \times 10^{-2}$ m/s

So discharge rate = $A_2 v_2$

$= 5 \times 10^{-4} \times 8 \times 10^{-2}$

$= 4 \times 10^{-5}$ m^3/s

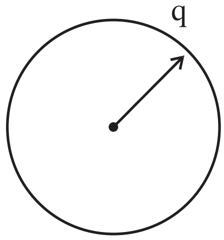
Correct ans is x = 4

60. 64 identical drops each charged upto potential of 10 mV are combined to form a bigger dorp. The potential of the bigger drop will be _______ mV.

Official Ans. by NTA (160)

Allen Ans. (160)

Sol.



Let q = charge on each drop

$$V = \frac{Kq}{r} \text{ ---- (1)}$$

Now for combination of 64 drop

$$64\times\frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$$

R = 4r

And Q = 64 q

Potential of bigger drop

$$= \frac{KQ}{R} = \frac{K64q}{4r} = 16\frac{Kq}{r}$$

= 16 × 10 mV = 160 mV.

Correct answer is 160.