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|JEE MAIN 2025 | DATE : 23 JANUARY 2025 (SHIFT-1) MORNING

PHYSICS

SECTION-1

[:Q.1] Given below are two statements:

Statement I : The hot water flows faster than cold water

Statement II : Soap water has higher surface tension as compared to fresh water.

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

[:A] Both statement I and Statement II are ture.

[:B] Both statement I and statement II are false.

[:C] Statement I is correct but statement II is false

[:D] Statement I is incorrect but statement II is true.

[:ANS] **C**

[:SOLN] Hot water is less viscous than cold water. Soap water reduces surface tension

[:Q.2] The position of a particle moving on x-axis is given by $x(t) = A \sin t + B \cos^2 t + Ct^2 + D$, where t is time. The dimension of $\frac{ABC}{D}$ is

[:A] L^2T^{-2}

[:B] L^2

[:C] L

[:D] L^3T^{-2}

[:ANS] **A**

[:SOLN] Dimension of A = [L]

,, ,, B = [L]

,, ,, C = $\left[LT^{-2}\right]$

,, ,, D = [L]

$\therefore \quad \frac{ABC}{D} = \left[L^2T^{-2}\right]$

[:Q.3] The electric field of an electromagnetic wave in free space is

$$\vec{E} = 57\cos\left[7.5\times10^6 t - 5\times10^{-3}(3x+4y)\right]\left(4\hat{i} - 3\hat{j}\right) N/C$$

The associated magnetic field in Tesla is

[:A] $\vec{B} = \frac{57}{3\times10^8}\cos\left[7.5\times10^6 t - 5\times10^{-3}(3x+4y)\right](5\hat{k})$

[:B] $\vec{B} = \frac{57}{3\times10^8}\cos\left[7.5\times10^6 t - 5\times10^{-3}(3x+4y)\right](\hat{k})$

[:C] $\vec{B} = -\frac{57}{3\times10^8}\cos\left[7.5\times10^6 t - 5\times10^{-3}(3x+4y)\right](5\hat{k})$

[:D] $\vec{B} = -\frac{57}{3\times10^8}\cos\left[7.5\times10^6 t - 5\times10^{-3}(3x+4y)\right](\hat{k})$

[:ANS] **C**

[:SOLN] $\vec{K} = 3\hat{i} + 4\hat{j}$

$\hat{k} = \frac{3\hat{i} + 4\hat{j}}{5}$

$\vec{E} = \frac{4\hat{i} - 3\hat{j}}{5}$

As $\hat{B} = \hat{k} \times \hat{E}$

$\hat{B} = -\hat{z}$

$B_0 = \frac{E_o}{c} = \frac{57}{3\times10^8}$

[:Q.4] Regarding self-inductance:

(a) The self inductance of the coil depends on its geometry

(b) Self inductance does not depend on the permeability of the medium

(c) Self-induced e.m.f. opposes any change in the current in a circuit

(d) Self-inductance is electromagnetic analogue of mass in mechanics

(e) Work needs to be done against self-induced e.m.f. in establishing the current.

Choose the correct answer from the options given below.

[:A] A, B, C, E only

[:B] A, B, C, D only

[:C] B, C, D, E only

[:D] A, C, D, E only

[:ANS] **4**

[:SOLN] Self inductance of coil

$L = \frac{\mu_0 N^2 A}{2\pi R}$

[:Q.5] A sub atomic particle of mass 10^{-30} kg is moving with a velocity 2.21×10^6 m/s. Under the matter wave consideration. The particle will behave closely like______.

[:A] X-rays

[:B] Infra red radiation

[:C] Gamma rays

[:D] Visible radiation

[:ANS] **A**

[:SOLN] $\lambda = \frac{h}{p} = \frac{6.63 \times 10^{-34}}{10^{-30} \times 2.21 \times 10^6}$

$= 3 \times 10^{-10}$ m

[:Q.6] A gun fires a lead bullet of temperature 300K into a wooden block. The bullet having melting temperature of 600K penetrates into the block and melts down. If the total heat required for the process 625 J, then the mass of the bullet is _______grams. (Letent heat of fusion of lead = 2.5×10^4 JKg^{-1} and specific heat capacity of lead = 125 $JKg^{-1}K^{-1}$)

[:A] 20

[:B] 5

[:C] 10

[:D] 15

[:ANS] **C**

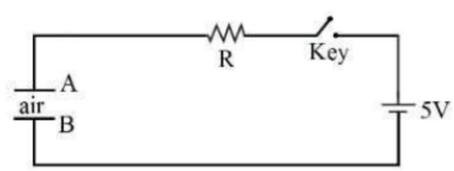
[:SOLN] Q = $ms\Delta T + mL$

625 = $m\left[125 \times 300 + 2.5 \times 10^4\right]$

625 = $m[62500]$

m = $\frac{1}{100}$ kg = 10gm

[:Q.7] Identify the valid statements relevant to the given circuit at the instant when the key is closed.



(a) There will be no current through resistor R

(b) There will be maximum current in the connecting wires.

(c) Potential difference between the capacitor plates A and B is minimum

(d) Charge on the capacitor plates is minimum

Choose the correct answer from the options given below:

[:A] a, b, d only

[:B] a, c only

[:C] b, c, d only

[:D] c, d only

[:ANS] **C**

[:SOLN] Initially capacitor behave as a short circuit so current will be maximum

Charge on capacitor will be zero

Potential difference across capacitor will be zero

[:Q.8] A spherical surface of radius of curvature R, separates air from glass (refractive index = 1.5). The centre of curvature is in the glass medium. A point object 'O' placed in air on the optic axis of the surface, so that its real image is formed at 'I' inside glass. The line OI intersects the spherical surface at P and PO = PI. The distance PO equal to

[:A] 2 R

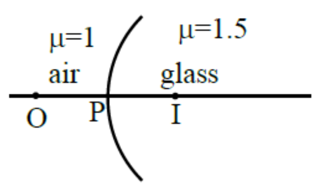
[:B] 3 R

[:C] 5 R

[:D] 1.5 R

[:ANS] **C**

[:SOLN]



$PO = u = -x$

$PI = v = x$

$PO = PI$

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

$$\frac{1.5}{x} + \frac{1}{x} = \frac{1}{2R}$$

$X = 5R$

[:Q.9] A radioactive nucleus n_2 has 3 times the decay constant as compared to the decay constant of another radioactive nucleus n_1. If initial number of both nuclei are the same. what is the ratio of number of nuclei of n_2 to the number of nuclei of n_1. after one half-life of n_1?

[:A] 1/8

[:B] 4

[:C] 1/4

[:D] 8

[:ANS] **C**

[:SOLN] $N_2 = N_0 e^{-3\lambda t}$

$N_1 = N_0 e^{-\lambda t}$

$\frac{N_2}{N_1} = e^{-2\lambda t}$

$t_{\text{half life of} N_1} t = \frac{\ln 2}{\lambda} {}_n 1$

$\frac{N_0}{2} = N_0 e^{-\lambda t}$

$\lambda t = \ln 2$

$t = \frac{\ln 2}{\lambda}$

$= e^{-2\lambda \frac{\ln 2}{\lambda}}$

$\frac{N_2}{N_1} = \frac{1}{4}$

[:Q.10] The electric flux is $\phi = \alpha\sigma + \beta\lambda$ where λ and σ are linear and surface charge density, respectively. $\left(\frac{\alpha}{\beta}\right)$ represents

[:A] charge

[:B] electric field

[:C] area

[:D] displacement

[:ANS] **D**

[:SOLN] $\phi = \alpha\sigma + \beta\lambda$

$[\phi] = [\alpha\sigma] = [\beta\lambda]$

$[\alpha] = \frac{[\phi]}{[\sigma]}$ $\left[\frac{\alpha}{\beta}\right] = \frac{[\lambda]}{[\sigma]}$

$[\beta] = \frac{[\phi]}{[\lambda]} = \frac{[Q/L]}{[Q/\text{Area}]} = \left[\frac{\text{Area}}{\text{Length}}\right]$

$\left[\frac{\alpha}{\beta}\right] = L$

[:Q.11] A light hollow cube of side length 10 cm and mass 10g. is floating in water. It is pushed down and released to execute simple harmonic oscillations. The time period of oscillations is $y\pi \times 10^{-2}$ s, where the value of y is

(Acceleration due to gravity, g = 10m/s^2, density of water = 10^3 kg/m^3)

[:A] 6

[:B] 4

[:C] 1

[:D] 2

[:ANS] **D**

[:SOLN] $a^2x\,\rho g = ma_{net}$

$\frac{L^2\rho g}{m}x = a_{net}$

$T = 2\pi\sqrt{\frac{m}{L^2\rho g}}$

where m = 10g L = 10 cm, $\rho =$ 1000 kg/m^3

[:Q.12] A solid sphere of mass 'm' and radius 'r' is allowed to roll without slipping from the highest point of an inclined plane of length 'L' and makes an angle 30° with the horizontal. The speed of the particle at the bottom of the plane is v_1. If the angle of inclination is increased to 45° while keeping L constant. Then the new speed of the sphere at the bottom of the plane is v_2. The ratio $v_1^2 : v_2^2$ is

[:A] 1 : 3

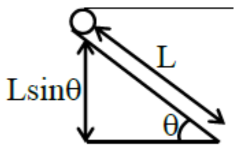
[:B] 1 : 2

[:C] $1 : \sqrt{2}$

[:D] $1 : \sqrt{3}$

[:ANS] **C**

[:SOLN]



using WET

$$W_g = k_f - k_i$$

$$Mg\ L\ \sin\theta = k_f - k_i$$

K.E. in pure rolling $\frac{1}{2}mV_{cm}^2 + \frac{1}{2}I_{cm}\omega^2$

$$= \frac{1}{2}mV^2 + \frac{1}{2} \times \frac{2}{5}mR^2 \frac{V^2}{R^2}$$

$$mgL\sin\theta = \frac{7}{10}mV_f^2 - 0$$

$$V_f^2 \propto \sin\theta$$

$$\left(\frac{V_1}{V_2}\right)^2 = \frac{\sin\theta_1}{\sin\theta_2} = \frac{\sin 30^\circ}{\sin 45^\circ} = \frac{1}{\sqrt{2}}$$

[:Q.13] Consider a circular disc of radius 20 cm with centre located at the origin. A circular hole of radius 5 cm is cut from this disc in such a way that the edge of the hole touches the edge of the disc. The distance of centre of mass of residual or remaining disc from the origin will be

[:A] 2.0 cm

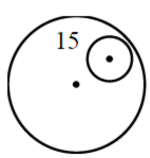
[:B] 1.5 cm

[:C] 0.5 cm

[:D] 1.0 cm

[:ANS] **D**

[:SOLN]



mass of disc = m

mass of cut part = $\frac{m}{16}$

$$X_{com} = \frac{m \times 0 - \frac{m}{16} \times 15}{m - \frac{m}{16}} = 1 \text{ cm.}$$

[:Q.14] Refer to the circuit diagram given in the figure. which of the following observation are correct?

(a) Total resistance of circuit is $6\,\Omega$

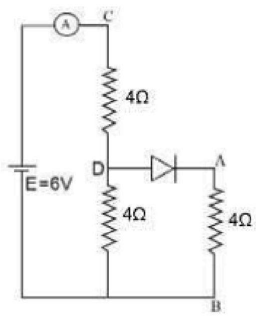
(b) Current in Ammeter is 1A

(c) Potential across AB is 4 Volts

(d) Potential across CD is 4 Volts

(e) Total resistance of the circuit is $8\,\Omega$

Choose the correct answer from the option given below.



[:A] a, c and d only

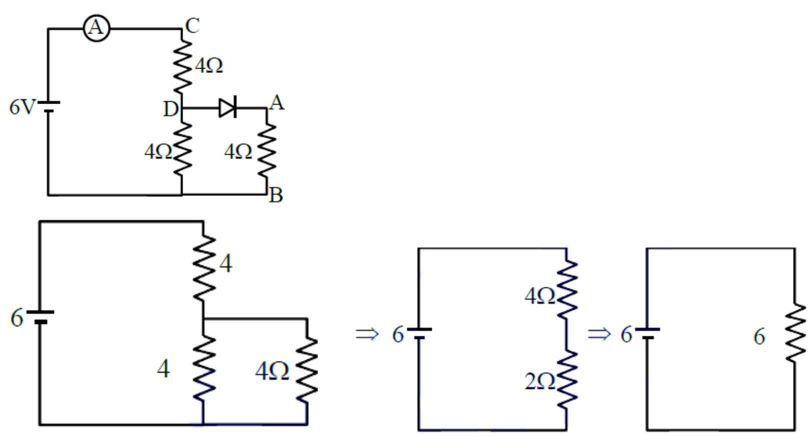
[:B] a, b and c only

[:C] a, b and d only

[:D] b, c and e only

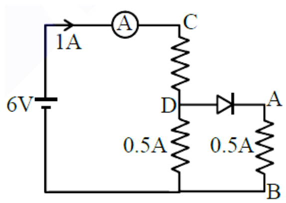
[:ANS] **C**

[:SOLN]



Current through ammeter = 1 A

$R_{net} = 6\Omega$



$V_{AB} = 0.5 \times 4 = 2$ volt

$V_{CD} = 1 \times 4 = 4$ volt

A, B & D are correct

[:Q.15] What is the lateral shift of a ray refracted through a parallel-sided glass slab of thickness 'h' in terms of the angle of incidence 'i' and angle of refraction 'r', if the glass slab is placed in air medium?

[:A] h

[:B] $\frac{h\tan(i-r)}{\tan r}$

[:C] $\frac{h\sin(i-r)}{\cos r}$

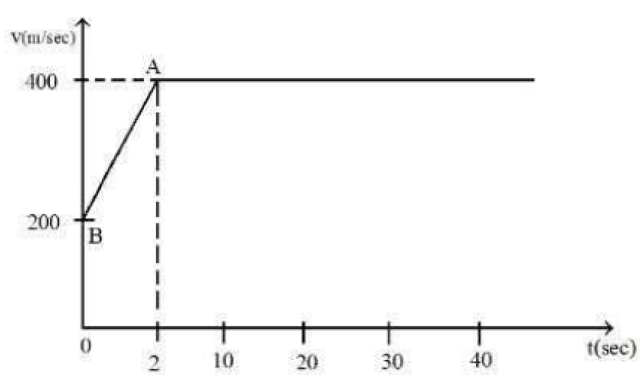
[:D] $\frac{h\cos(i-r)}{\sin r}$

[:ANS] **C**

[:SOLN] Formula base

$$\frac{h\sin(i-r)}{\cos r}$$

[:Q.16] The motion of an airplane is represented by velocity time graph as shown below. The distance covered by airplane in the first 30.5 second is ____km.



[:A] 3

[:B] 9

[:C] 6

[:D] 12

[:ANS] **D**

[:SOLN] Total Area under curve

[:Q.17] Given a thin convex lens (refractive index μ_2), kept in a liquid (refractive index $\mu_1, \mu_1 < \mu_2$) having radii of curvatures $|R_1|$ and $|R_2|$. Its second surface is silver polished. Where should an object be placed on the optic axis so that a real and inverted image is formed at the same place?

[:A] $\dfrac{(\mu_2 + \mu_1)|R_1|}{(\mu_2 - \mu_1)}$

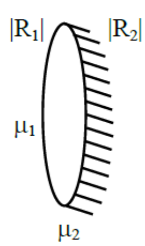
[:B] $\dfrac{\mu_1 |R_1|.|R_2|}{\mu_2 (|R_1| + |R_2|) - \mu_1 |R_2|}$

[:C] $\dfrac{\mu_1 |R_1|.|R_2|}{\mu_2 (|R_1| + |R_2|) - \mu_1 |R_1|}$

[:D] $\dfrac{\mu_1 |R_1|.|R_2|}{\mu_2 (2|R_1| + |R_2|) - \mu_1 \sqrt{|R_1|}.\sqrt{|R_2|}}$

[:ANS] **B**

[:SOLN]



$$\frac{1}{f_{eq}} = \frac{2}{f_L} - \frac{1}{f_m}$$

$$f_m = -\frac{|R_2|}{2}$$

$$\frac{1}{f_L} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

$$\frac{1}{f_{eq}} = 2\left(\frac{\mu_2-\mu_1}{\mu_1}\right)\left(\frac{R_1+R_2}{R_1R_2}\right)+\frac{2}{R_2}$$

$$= \frac{2}{R_2}\left[\frac{(\mu_2-\mu_1)(R_1+R_2)+\mu_1R_1}{\mu_1R_1}\right]$$

$$= \frac{2}{R_2}\left[\frac{\mu_2R_1+\mu_2R_2-\mu_1R_1-\mu_1R_2+\mu_1R_1}{\mu_1R_1}\right]$$

$$\frac{1}{f_{eq}} = \frac{2[\mu_2R_1+\mu_2R_2-\mu_1R_2]}{\mu_1R_1R_2}$$

For same size of image

u = 2f

$$= \frac{\mu_1R_1R_2}{\mu_2R_1+\mu_2R_2-\mu_1R_2}$$

[:Q.18] Match the List - I with List - II

	List - I		**List -II**
a.	Pressure varies inversely with volume of an ideal gas.	I.	Adiabatic process
b.	Heat absorbed goes party to increase internal energy and partly to do work	II.	Isochoric process
c.	Heat is neither absorbed nor released by a system	III.	Isothermal process
d.	No work is done on or by a gas.	IV.	Isobaric process

Choose the correct answer from the options given below.

[:A] a - III, b - I, c - IV, d - II

[:B] a - I, b - III, c - II, d - IV

[:C] a - I, b - IV, c - II, d - III

[:D] a - III, b - IV, c - I, d - II

[:ANS] **D**

[:SOLN] $A \rightarrow P \propto \frac{1}{V}$

PV = constant

nRT = const. = T = const

Hence Isothermal III

B $\rightarrow$ IV

$W \neq 0, \Delta U \neq 0, \Delta Q \neq 0$ [only isobaric]

$C \rightarrow I \Delta Q = 0$ Adiabatic

$D \rightarrow II\, w \;= 0$ Isochoric

III IV I II

[:Q.19] Consider a moving coil galvanometer (MCG)

(a) The torsional constant in moving coil galvanometer has dimentions $\left[ML^2T^{-2}\right]$

(b) Increasing the current sensitivity may not necessarily increases the voltage sensitivity

(c) If we increase number of turns (N) to its double (2N), then the voltage sensitivity doubles

(d) MCG can be converted into an ammeter by introducing a shunt resistance of large value in parallel with galvanometer.

(e) Current sensitivity of MCG depends inversely on number of turns of coil

Choose the correct answer from the options given below:

[:A] A, D only

[:B] B, D, E only

[:C] A, B, E only

[:D] A, B only

[:ANS] **D**

[:SOLN] (A) $\tau = C\theta \Rightarrow [ML^2T^{-2}] = [C][1]$

(B) C.S = $\frac{\theta}{I} = \frac{BNA}{C}$;

$V.S. = \frac{BNA}{RC}$ [R also depends on 'N']

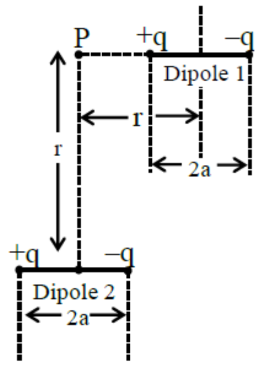
(C) $V.S. \propto \frac{NAB}{CR}$ $\quad R \rightarrow NR$

(D) False [Theory]

(E) E [False] $\quad C.S \propto N$

$\Rightarrow \because C.S. = \frac{NAB}{c}$

[:Q.20] A point particle of charge Q is located at P along the axis of an electric dipole 1 at a distance r as shown in the figure. The point P is also on the equatorial plane of a second electric dipole 2 at a distance r. The dipoles are made of opposite charge q separated by a distance 2a. For the charge particle at P not to experience any net force, which of the following correctly describes the situation?



[:A] $\frac{a}{r} \sim 10$

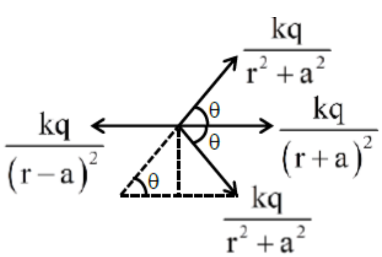
[:B] $\frac{a}{r} \sim 3$

[:C] $\frac{a}{r} \sim 20$

[:D] $\frac{a}{r} \sim 0.5$

[:ANS] **B**

[:SOLN]



$$\frac{kq}{(r-a)^2} = \frac{kq}{(r+a)^2} + \frac{2kq}{(r^2+a^2)}\cos\theta$$

$$\frac{1}{(r-a)^2} = \frac{1}{(r+a)^2} + \frac{2a}{(r^2+a^2)^{\frac{3}{2}}}$$

$$\frac{1}{(r-a)^2} - \frac{1}{(r+a)^2} = \frac{2a}{(r^2+a^2)^{\frac{3}{2}}}$$

$$\frac{4ra}{(r^2-a^2)^2} = \frac{2a}{(r^2+a^2)^{\frac{3}{2}}}$$

$$\Rightarrow \frac{2r}{(r^2-a^2)^2} = \frac{1}{(r^2+a^2)^{\frac{3}{2}}}$$

$$\frac{4r^2}{(r^2-a^2)^4} = \frac{1}{(r^2+a^2)^3}$$

$$4r^8\left(1+\frac{a^2}{r^2}\right)^3 = r^8\left(1-\frac{a^2}{r^2}\right)^4$$

$$4\left(1+\frac{a^2}{r^2}\right)^3 = \left(1-\frac{a^2}{r^2}\right)^4$$

$$\left|\frac{a}{r}\right| > 1 \Rightarrow a > r$$

a/r~3.

SECTION-2

[:Q.21] Two particle are located at equal distance from origin. The position vectors of those are represented by $\vec{A} = 2\hat{i} + 3n\hat{j} + 2\hat{k}$ and $\vec{B} = 2\hat{i} - 2\hat{j} + 4p\hat{k}$, respectively. If both the vectors are at right angle to each other, the value of n^{-1} is ______.

[:ANS] **3**

[:SOLN] $\vec{A} \cdot \vec{B} = 0$

$4 - 6n + 8P = 0 \quad \ldots \text{(I)}$

$|\vec{A}| = |\vec{B}|$

$4 + 9n^2 + 4 = 4 + 4 + 16P^2$

$9n^2 = 16P^2$

$\therefore\ P = \pm\frac{3}{4}n$

From (I) :

$4 - 6n \pm 6n = 0$

$n = \frac{1}{3}$

[:Q.22] A force f = $x^2 y\hat{i} + y^2\hat{j}$ acts on a particle in a plane x + y = 10. The work done by this force during a displacement from (0, 0) to (4m, 2m) is ______ Joule (round off to the nearest integer)

[:ANS] **152**

[:SOLN] $\int_0^4 x^2(10-x)dx + \int_0^2 y^2 dy$

$= \left[\frac{10x^3}{3} - \frac{x^4}{4}\right]_0^4 + \left[\frac{y^3}{3}\right]_0^2 = \frac{640}{3} - 64 + \frac{8}{3} = 152$

[:Q.23] An ideal gas initially at 0ºC temperature, is compressed suddenly to one fourth of its volume. If the ratio of specific heat at constant pressure to that at constant volume is 3/2, the change in temperature due to the thermodynamic process is ______K.

[:ANS] **273**

[:SOLN] $\gamma = \frac{3}{2}$

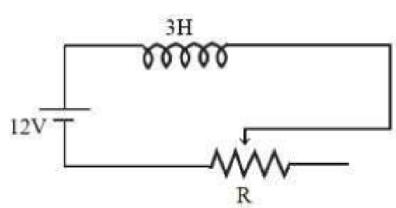
$Tv^{\gamma-1} = C$

$273\ V_0^{0.5} = T\left(\frac{V_0}{4}\right)^{0.5}$

$T = 273 \times 2 = 546$

$\Delta T = 273$

[:Q.24] In the given circuit the sliding contact is pulled outwards such that electric current in the circuit changes at the rate of 8 A/s. At an instant when R is 12 Ω, the value of the current in the circuit will be ______A.



[:ANS] **3**

[:SOLN] $\varepsilon - \frac{LdI}{dt} - IR = 0$

$12 - 3 \times (-8) - I \times 12 = 0$

I = 3

[:Q.25] A positive ion A and a negative ion B has charge 6.67×10^{-19} C and 9.6×10^{-10}C and masses 19.2×10^{-27} kg and 9×10^{-27} kg respectively. At an instant, the ions are separated by a certain distance r. At that instant the ratio of the magnitudes of electrostatic force to gravitational force is $P \times 10^{-13}$, where the value of P is _______.

(Take $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 Nm^2C^{-1}$ and universal gravitational constant as $6.67 \times 10^{-11} Nm^2kg^{-2}$)

[:ANS] **BONUS**

[:SOLN] $\frac{9 \times 10^9 \times 6.67 \times 10^{-19} \times 9.6 \times 10^{-10}}{6.67 \times 10^{-11} \times 19.2 \times 10^{-27} \times 9 \times 10^{-27}}$

$\frac{1}{2} \times 10^{45}$

Charge is not integral multiple of electron