Physicsaholics

DPP - 3 (Electrostatics)

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Q 1. Determine the electrostatic potential energy of a system consisting of two charges $7\mu C$ and $-2\mu C$ (and with no external field) placed at (−9 cm,0,0) and (9 cm,0,0) respectively.

(a) $-0.7\ J$ (b) $-1.4\ J$

(c) $0.7\ J$ (d) $1.4\ J$

Q 2. Two points charges a and b of values $5 \times 10^{-9} C$ and $3 \times 10^{-9} C$ are kept 6 cm apart in air. calculate the work done when charge B is moved 1 cm towards charge A:

(a) $4.5 \times 10^{-7} J$ (b) $5.4 \times 10^{-7} J$

(c) $4.5 \times 10^{-9} J$ (d) $5.4 \times 10^{-9} J$

Q 3. Three chargers $q_1 = -2C$, $q_2 = 4C$ and $q_3 = 2C$ are at the three corners of an equilateral triangle of side 9cm. Then the electric potential energy of the system is:

(a) $4 \times 10^{11} J$ (b) $-4 \times 10^{11} J$

(c) $4 \times 10^{9} J$ (d) $-4 \times 10^{9} J$

Q 4. Two identical charged particles having equal charge Q, are placed at a distance d apart, from where they are released. Find out kinetic energy of each particle when they are infinitely away from each other: $\left(k = \frac{1}{4\pi\varepsilon_0}\right)$

(a) $\frac{kQ^2}{d}$ (b) $\frac{2kQ^2}{d}$

(c) $\frac{3kQ^2}{2d}$ (d) $\frac{kQ^2}{2d}$

Q 5. Two equal charges q are placed at a distance 2a and a third charge −2q is placed at the midpoint. The potential energy of the system is

(a) $\frac{9q^2}{8\pi\varepsilon_0 a}$ (b) $\frac{q^2}{8\pi\varepsilon_0 a}$

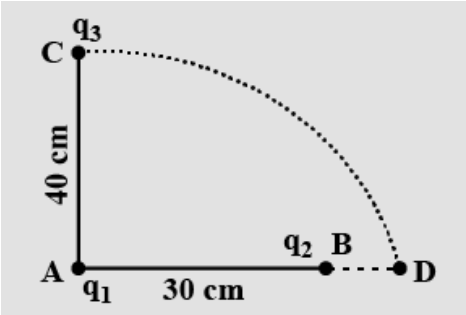
(c) $\frac{-7q^2}{8\pi\varepsilon_0 a}$ (d) $\frac{6q^2}{8\pi\varepsilon_0 a}$

Q 6. Identical charges -q each are placed at the eight corners of a cube of side a. Find the electrostatic potential energy of a charge +q placed at the center of the cube:

(a) $\frac{-\sqrt{2}q^2}{4\pi\varepsilon_0 a}$ (b) $\frac{-8\sqrt{2}q^2}{\pi\varepsilon_0 a}$

(c) $\frac{-\sqrt{3}q^2}{8\pi\varepsilon_0 a}$ (d) $\frac{-4q^2}{\pi\varepsilon_0\sqrt{3}a}$

Q 7. Two charges $q_1$and q_2 are placed 30cm apart as shown. A third charge q_3 is moved along the circle of radius 40cm from C to D. The change in the potential energy of the system is $\frac{q_3 K}{4\pi\varepsilon_0}$. Find K



(a) $8q_2$ (b) $8q_1$
(c) $6q_2$ (d) $6q_1$

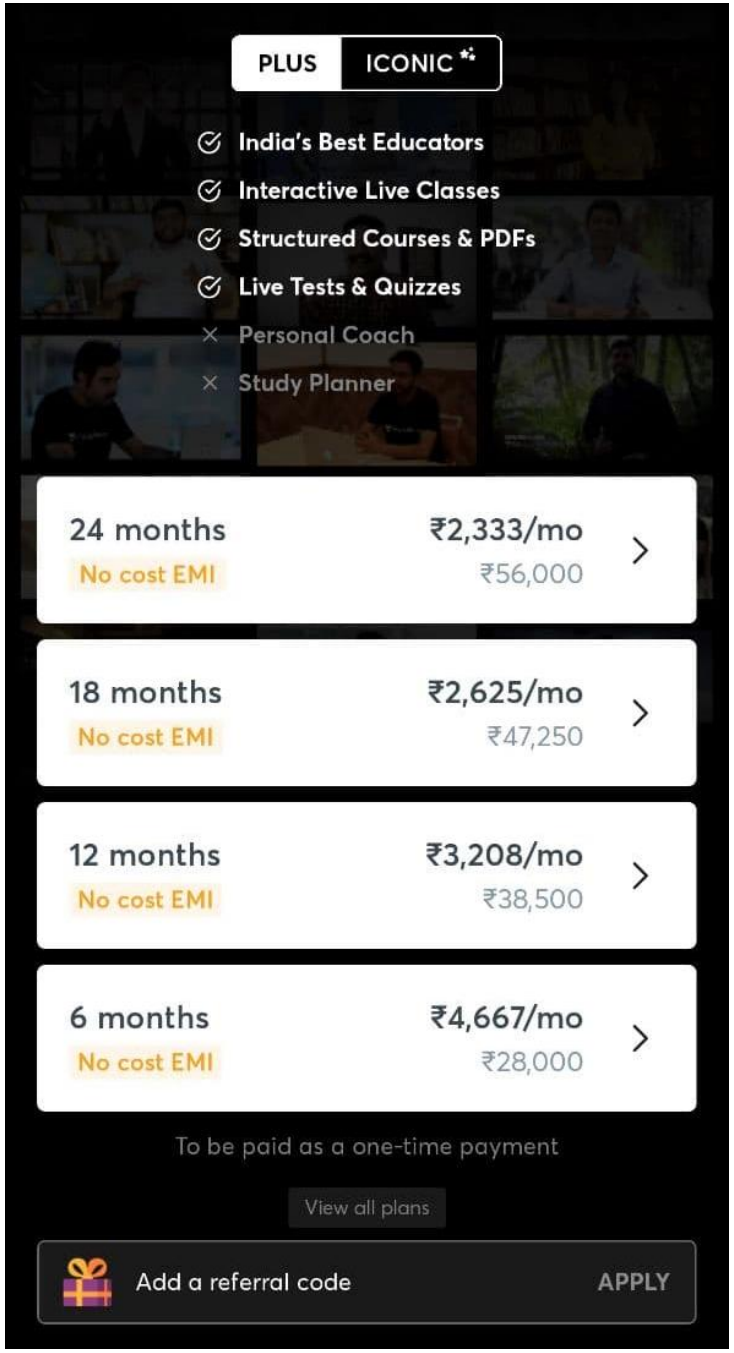
Q 8. A system consists of two charges $4\mu C$ and $-3\mu C$ with no external field placed at (-5 cm, 0, 0) and (5 cm, 0, 0) respectively. The amount of work required to separate the two charges (slowly) infinitely away from each other is
(a) 1.1 J (b) 2 J (c) 2.5 J (d) 3 J

Q 9. Calculate the electrostatic potential energy of an electron-proton system of hydrogen atom. In the first Bohr orbit of hydrogen atom, the radius of the orbit is $5.3 \times 10^{-11} m$:
(a) $-4.35 \times 10^{-18} J$ (b) $-2.175 \times 10^{-18} J$
(c) $-4.35 \times 10^{-19} J$ (d) $-2.175 \times 10^{-19} J$

Q 10. point charge $q_1 = +2.4\ \mu C$ is held stationary at the origin. A second point charge $q_2 = -4.3\ \mu C$ moves from the point x = 0.15m, y = 0 to the point x = 0.250m, y = 0.250m. The amount of work is done by the electric force on q_2 is nearly $-356 \times 10^{-x} J$. Find x:
(a) 2 (b) 3 (c) 4 (d) 5

Answer Key

Q.1 a	**Q.2 a**	**Q.3 b**	**Q.4 d**	**Q.5 c**
Q.6 d	**Q.7 a**	**Q.8 a**	**Q.9 a**	**Q.10 b**



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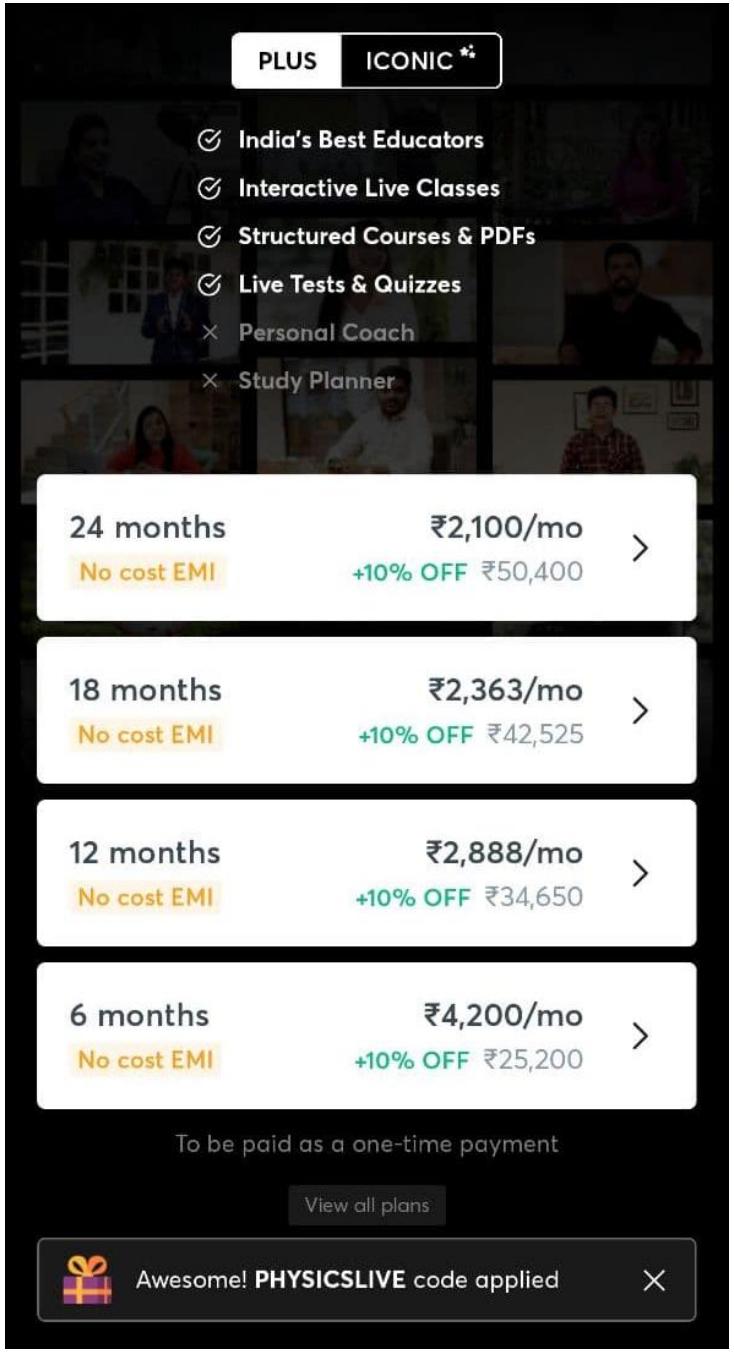
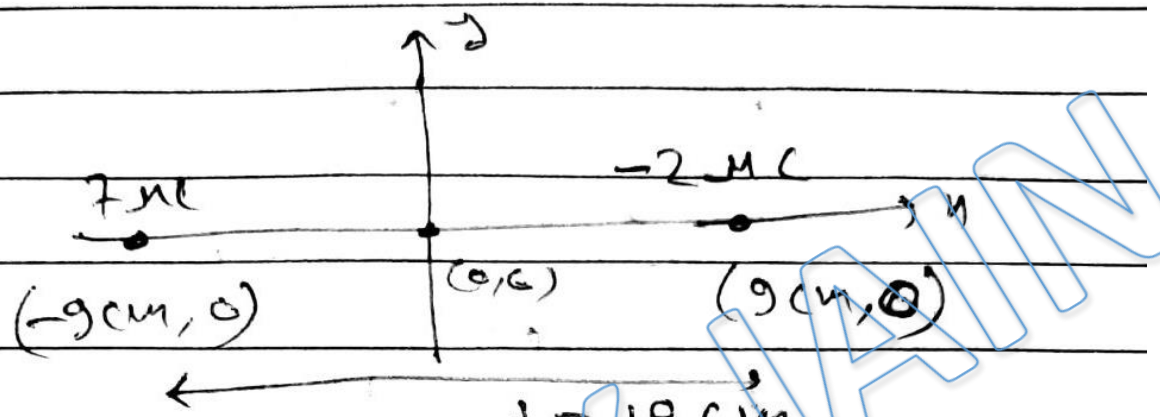


Written Solution

DPP-3 Electric Potential Energy

By Physicsaholics Team

Solution: 1



$d = 18\ cm.$

$$U = \frac{Kq_1q_2}{d}$$

$$U = \frac{9\times10^{9} \times 7\times10^{-6} \times (-2\times10^{-6})}{18\times10^{-2}}$$

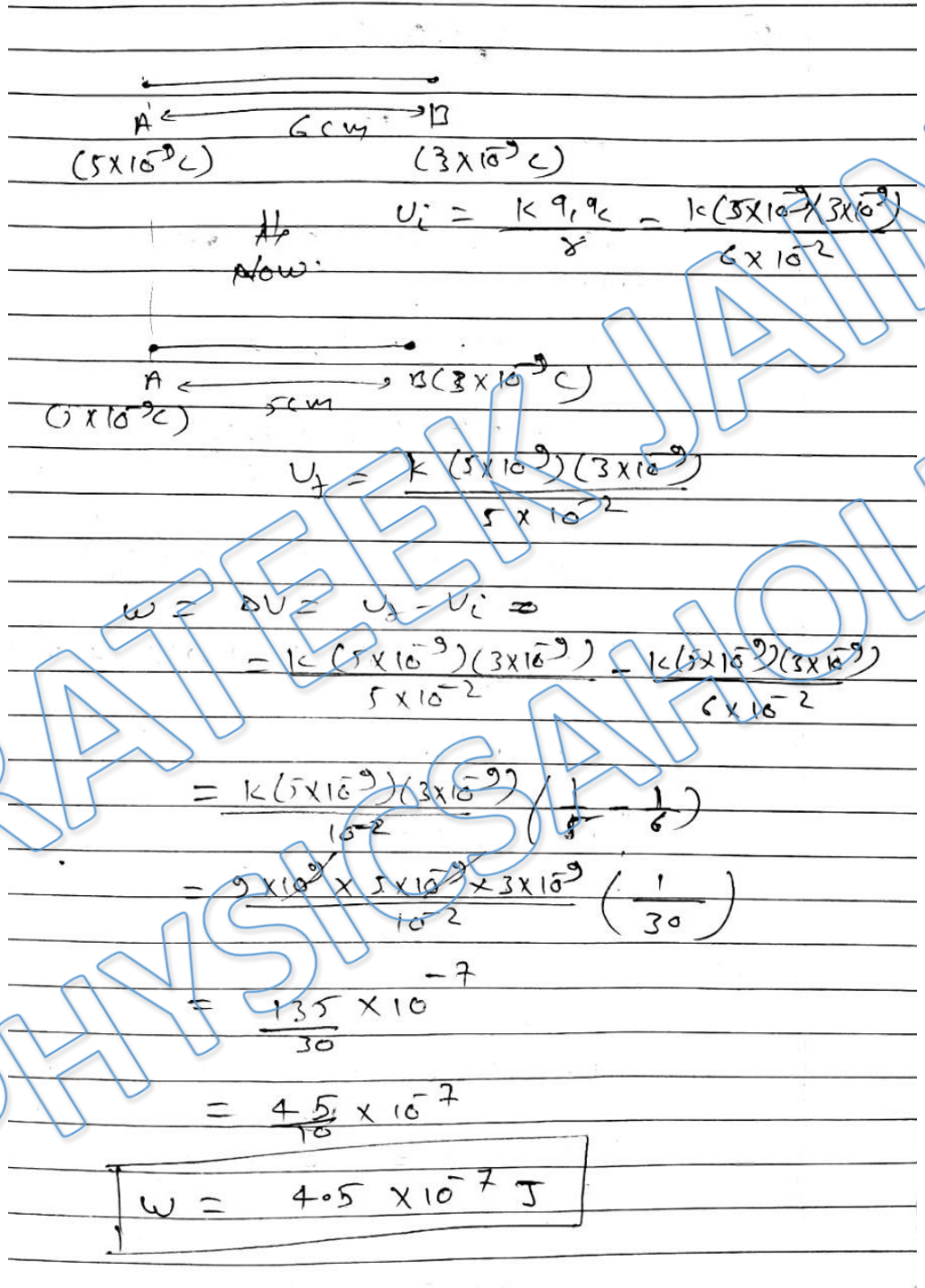
$$U = -\frac{63\times2}{18} \times 10^{-1}$$

$$U = -7 \times 10^{-1}\ J$$

$$\boxed{U = -0.7\ J}$$

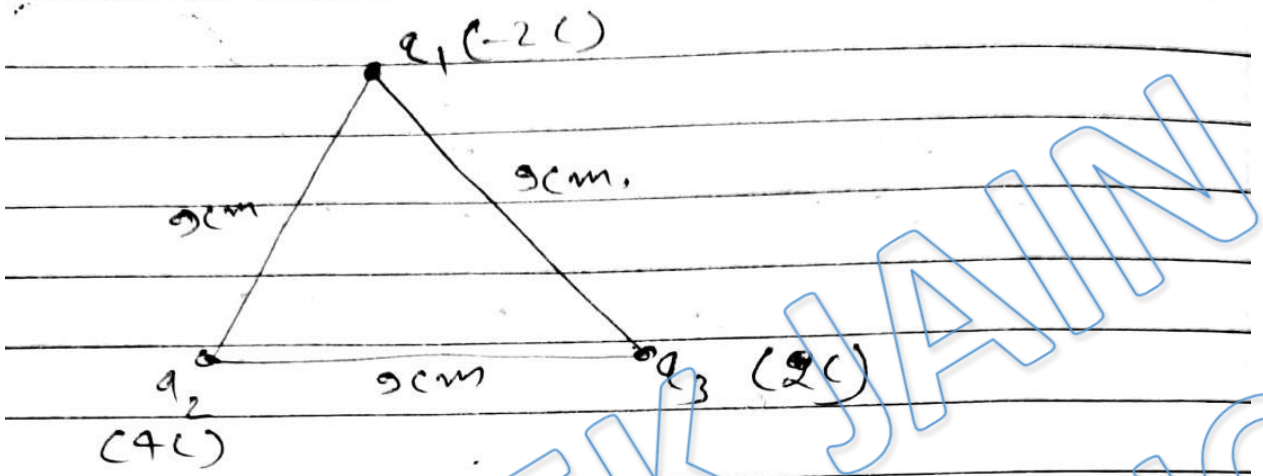
Ans. a

Solution: 2



Ans. a

Solution: 3



$$U = U_{12} + U_{13} + U_{23}$$

$$= \frac{k(q_1 q_2)}{d} + \frac{k(q_1 q_3)}{d} + \frac{k(q_2 q_3)}{d}$$

$$= \frac{k}{d}(q_1 q_2 + q_1 q_3 + q_2 q_3)$$

$$= \frac{9\times10^9}{9\times10^{-2}}\left[(-2)(4) + (-2)(2) + (4)(2)\right]$$

$$= 10^{11}\times[-8 - 4 + 8]$$

$$\boxed{U = -4\times10^{11}\ J}$$

Ans. b

Solution: 4

Energy conservation.

$U_i + KE_i = U_f + KE_f$ distance

$U_f = 0$ [infinite away from each other]

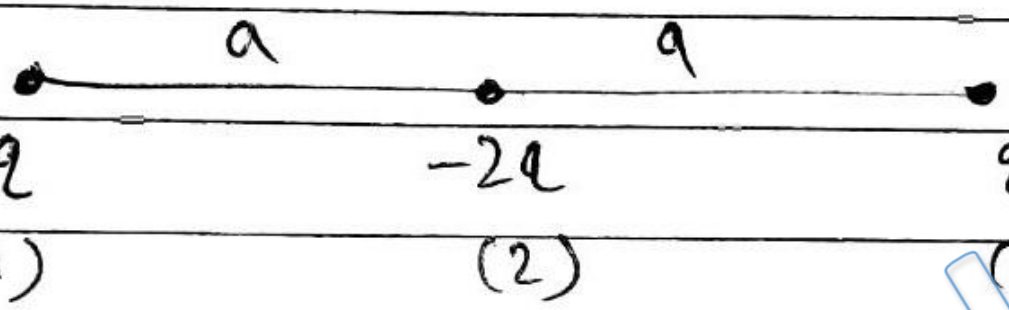
$\frac{kq^2}{d} + 0 = 0 + 2(KE)$

∴ Both are identical, so KE will be same for both

$\therefore \boxed{KE = \frac{kq^2}{2d}} = \frac{1}{2} \cdot \frac{1}{4\pi\epsilon_0} \cdot \frac{q^2}{d}$

Ans. d

Solution: 5



$$U = U_{12} + U_{23} + U_{31}$$

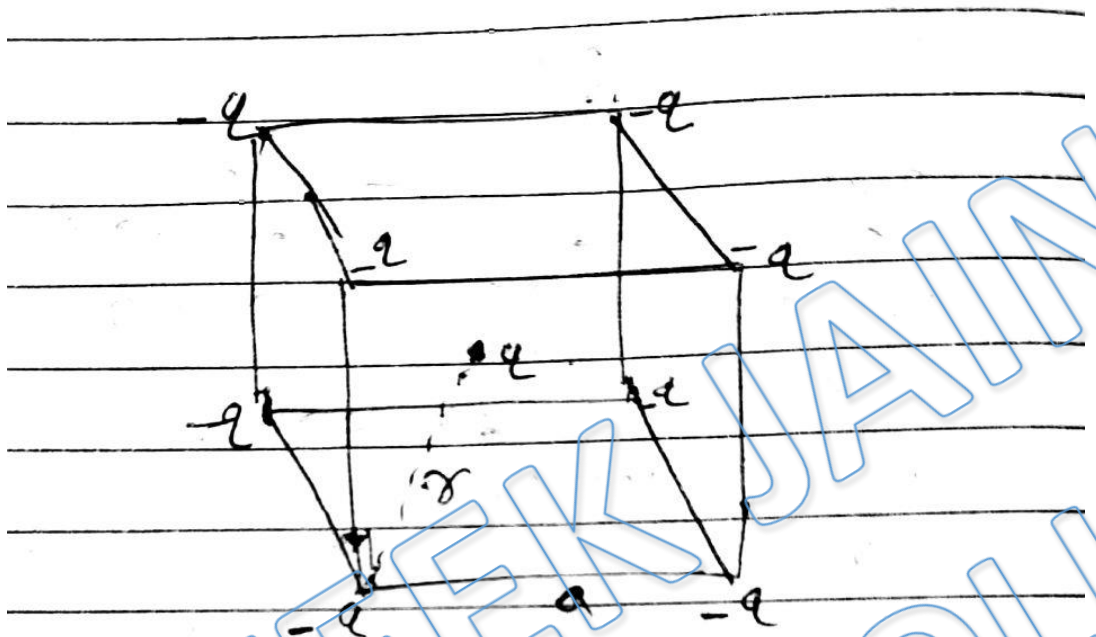
$$= \frac{k(q)(-2q)}{a} + \frac{k(-2q)(q)}{a} + \frac{k(q)(q)}{2a}$$

$$U = \frac{-7kq^2}{2a}$$

$$U = \frac{-7q^2}{8\pi\epsilon_0 a} \Rightarrow \boxed{U = \frac{-7q^2}{8\pi\epsilon_0 a}}$$

Ans. c

Solution: 6



$$r = \frac{\sqrt{3}a}{2}$$

$$U_f = 8U_1 = 8\left(\frac{-kq^2}{r}\right)$$

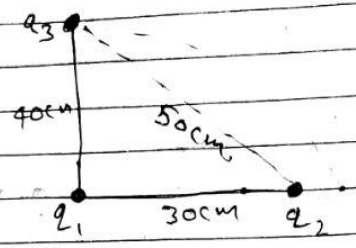
$$= -\frac{8}{4\pi\epsilon_0}\frac{q^2 2}{(\sqrt{3}a)}$$

$$\boxed{U_f = -\frac{4q^2}{\pi\epsilon_0\sqrt{3}a}}$$

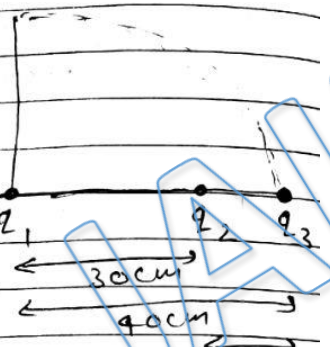
Ans. d

Solution: 7

initial Situation



∴ final Situation,



∴ Path of q_3 is circular so, radius 40cm, will remain same.

$$U_i = \frac{kq_1q_2}{(30\times10^{-2})} + \frac{kq_2q_3}{(50\times10^{-2})} + \frac{kq_1q_3}{(40\times10^{-2})}$$

$$U_f = \frac{kq_1q_2}{(30\times10^{-2})} + \frac{kq_2q_3}{(40\times10^{-2})} + \frac{kq_1q_3}{(40\times10^{-2})}$$

$$W = \Delta U = U_f - U_i$$

$$W = \frac{kq_2q_3}{10\times10^{-2}} - \frac{kq_2q_3}{(50\times10^{-2})}$$

$$W = 10kq_2q_3 - 2kq_2q_3$$

$$W = 8kq_2q_3 = \frac{8q_2q_3}{4\pi\epsilon_0} = \frac{Kq_3}{4\pi\epsilon_0}$$

$$\therefore \boxed{K = 8q_2}$$

Ans. a

Solution: 8

$$W = \Delta U = U_f - U_i$$

$$U_i = \frac{k(q_1 q_2)}{d}$$

$$d = 10\,cm.$$

$$U_i = \frac{9\times10^9 \times 4\times10^{-6} \times (-3\times10^{-6})}{10\times10^{-2}}$$

$$U_i = -\frac{9\times4\times3}{10\times10^{-2}} \times 10^{9}\times10^{-12}$$

$$U_i = -9\times4.\times3\times10^{-2}$$

$$U_i = -1.08\ J \simeq -1.1\ J.$$

$\because U_f = 0\ J.$ [$\because$ infinitely away from each other]

$\therefore W = U_f - U_i$

$W = 0 - (-1.1)$

$$\boxed{W = 1.1\ J}$$

Ans. a

Solution: 9

$$U = \frac{k q_1 q_2}{r^2}$$

$q_1 = 1.6 \times 10^{-19}$

$q_2 = -1.6 \times 10^{-19}$

$r = 5.3 \times 10^{-11}$ m,

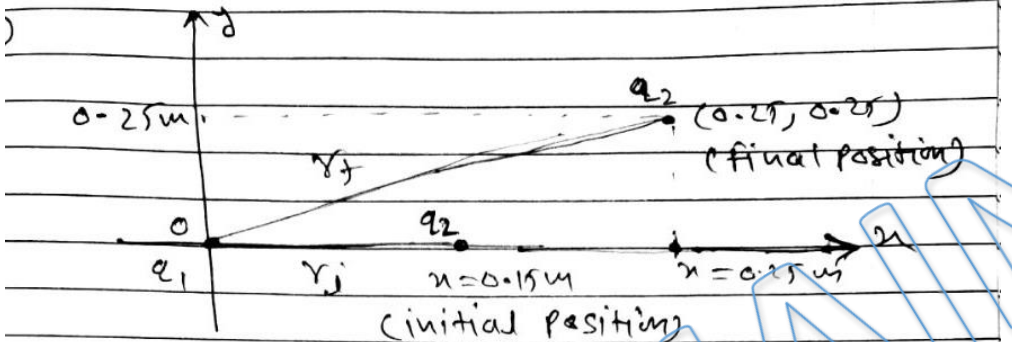
$$U = \frac{9 \times 10^9 \times 1.6 \times 10^{-19} \times (-1.6 \times 10^{-19})}{5.3 \times 10^{-11}}$$

$$U = \frac{-9 \times 10^9 \times (1.6)^2 \times 10^{-38}}{5.3 \times 10^{-11}}$$

$$\boxed{U = -4.34 \times 10^{-18} \text{ J}}$$

Ans. a

Solution: 10



$$U_i = \frac{kq_1q_2}{r_i} = \frac{9\times10^9 \times 2.4\times10^{-6} \times (-4.3\times10^{-6})}{0.15}$$

$$= \frac{-9\times10^9 \times 2.4\times4.3\times10^{-12}}{15\times10^{-2}}$$

$$\boxed{U_i = -0.6192\ \text{J.}}$$

$$U_f = \frac{kq_1q_2}{r_f^2} = \frac{9\times10^9 \times 2.4\times10^{-6} \times (-4.3\times10^{-6})}{\left(\sqrt{(0.25)^2+(0.25)^2}\right)^2}$$

$$= \frac{-9\times10^9 \times 2.4\times4.3\times10^{-12}}{\left(\sqrt{\left(\frac{1}{4}\right)^2+\left(\frac{1}{4}\right)^2}\right)^2} = -0.743\ \text{J.}$$

$$\boxed{U_f = -0.263\ \text{J.}}$$

work done by electric field :-

$$W = -\Delta U = -(U_f - U_i) = -[-0.263 - (-0.619)]\ \text{J.}$$

$$W = 0.356$$

$$W = 356\times10^{-3} = 3.56\times10^{-1}$$

$$\therefore \boxed{n = 3}$$

Ans. b

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