

$$1) \quad W = 6.5 \times 10^{-5} \text{ J}$$

$$q = 1.3 \times 10^{-7} \text{ C}$$

$$V = \frac{W}{q} = \frac{6.5 \times 10^{-5}}{1.3} \text{ V} = 500 \text{ V}$$

$$2) \quad q = 2.5 \times 10^{-6} \text{ C}$$

$$V_A - V_B = \frac{W}{q}$$

$$4 = \frac{W}{2.5 \times 10^{-6}}$$

$$W = 10 \times 10^{-6} = 10^{-5} \text{ J}$$

$$3) \quad W = 5 \text{ J}$$

$$q = 0.5 \text{ C}$$

$$V_A - V_B = \frac{W}{q}$$

$$= \frac{5}{0.5} = 10 \text{ V}$$

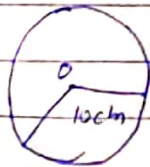
$$4) \quad \frac{+q}{4 \times 10^{-9} \text{ C}} \quad 0.1 \text{ m}$$

~~$V = \frac{q}{4\pi\epsilon_0 r}$~~

$$V = \frac{kq}{r} = \frac{(9 \times 10^9) (4 \times 10^{-9})}{0.1}$$

$$= 360 \text{ V}$$

5)



Intensity is zero at center

$$V = \frac{1}{4\pi\epsilon_0} \frac{q}{r} = \frac{9 \times 10^9 \times 250 \times 10^{-6}}{0.1}$$

$$= -2.25 \times 10^7 \text{ V}$$

$$6) i) \quad q_0 = 10^{-12} \text{ C}$$

$$V_A = \frac{1}{4\pi\epsilon_0} \frac{q}{r_A} = 0.9 \text{ V}$$

$$V_B = \frac{1}{4\pi\epsilon_0} \frac{q}{r_B} = 0.45 \text{ V}$$

$$ii) \quad P.W = (V_A - V_B) q_0$$

$$= 0.45 \times 10 \times 10^{-12}$$

$$= 4.5 \times 10^{-12} \text{ J}$$

7) Potential due to A @ C

$$= \frac{1}{4\pi\epsilon_0} \frac{q}{r} = \frac{9 \times 10^9 \times 10^{-6} \times 8}{0.5}$$

Potential due to B @ C

$$= \frac{1}{4\pi\epsilon_0} \frac{q}{r} = \frac{9 \times 10^9 \times -2 \times 10^{-6}}{0.5}$$

$$V_{AC} + V_{BC} = 1.08 \times 10^5 \text{ V}$$

Potential at D due to A & B

$$V_{DA} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{0.8} = 9 \times 10^4 \text{ V}$$

$$V_{DB} = \frac{9 \times 10^9 \times 2 \times 10^{-6}}{0.2} = -9 \times 10^4 \text{ V}$$

$$V_D = 0$$

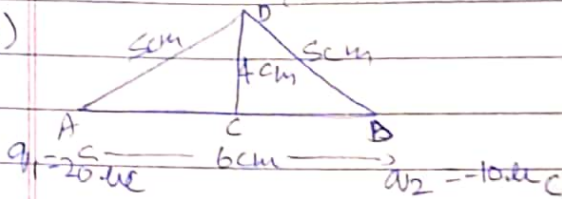
potent. diff. b/w D & C =  $1.08 \times 10^5 \text{ V}$

$$W = qd \times qv$$

$$= 1.08 \times 10^5 \times 0.02 \times 10^{-6}$$

$$= 2.16 \times 10^{-3} \text{ J}$$

8)



$$V_1 = \frac{9 \times 10^9 \times 20 \times 10^{-6}}{5 \times 10^{-2}}$$

$$= 36 \times 10^5 \text{ V}$$

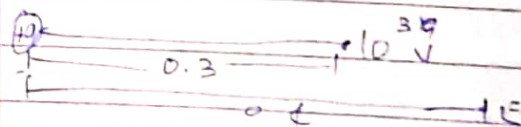
$$V_2 = \frac{9 \times 10^9 \times (-10) \times 10^{-6}}{5 \times 10^{-2}}$$

$$= -18 \times 10^5 \text{ V}$$

$$V = V_1 + V_2$$

$$= 18 \times 10^5 \text{ V}$$

9)



$$r_1 = 0.5 \text{ m}$$

$$r_2 = 0.8 \text{ m}$$

$$E = \frac{1}{4\pi\epsilon_0} \times \frac{q}{r^2}$$

$$= \frac{1}{4\pi\epsilon_0} \times \frac{q \times 4\pi\epsilon_0}{r^2}$$

$$= \frac{10^9 \times 0.3}{(0.4)^2} = 1875 \text{ V/m}$$

10)  $E = 20 \text{ N/C}$   
 $V = 10 \text{ J/C} = 10 \text{ V}$   
 $r = ?$   
 $q = ?$   
 $E = \frac{V}{r}$

$$20 = \frac{1}{4\pi\epsilon_0} \times \frac{q}{(0.5)^2} = 5.55 \times 10^{-10} \text{ C}$$

11)  $q = 6 \times 10^{-8} \text{ C}$

$r_1 = 3 \text{ m}$  ;  $r_2 = 6 \text{ m}$

$$V_1 - V_2 = 9 \times 10^9 \left[ \frac{q}{r_1} - \frac{q}{r_2} \right]$$

$$= 9 \times 10^9 \times 6 \times 10^{-8} \left[ \frac{2-1}{6} \right]$$

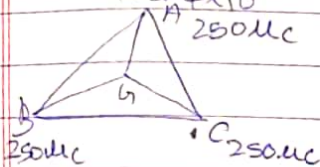
$$= 90 \text{ V}$$

$$W = V \times q$$

$$= 16 \times 10^{-18} \times 90$$

$$= 1.44 \times 10^{-17}$$

12)



$$V_{\text{net}} = \frac{qV}{4\pi\epsilon_0 r} \times 3$$

$$= \frac{3 \times 9 \times 10^9 \times 250 \times 10^{-6}}{0.18}$$

$$= 3.75 \times 10^7 \text{ V}$$

13)  $q = 100 \times 10^{-6} \text{ C}$

diagonal = 2 m

$$V_D = \frac{4 \times 100 \times 10^{-6}}{4 \times \pi \times \epsilon_0 \times 1} = 3.6 \times 10^6 \text{ V}$$

14) A B

-2000 C

i) Since work is being done on charge; B has higher potential

ii)  $W = V \times q$

$$V = \frac{10 \text{ J}}{200} = 0.05 \text{ V}$$

iii)  $V_B - V_A = -0.05 \text{ V}$

$$E = \frac{-dV}{dV} = \frac{0.05}{4 \times 10^{-2}} = 1.25 \text{ V/m}$$



$$15) E = \frac{dV}{dr}$$

$$W = 3.28 \times 10^{-4} \text{ J}$$

$$q = 3.0 \times 10^{-8} \text{ C}$$

$$r = 0.12 \text{ m}$$

$$dV = \frac{W}{q} = 1.08 \times 10^4 \text{ V}$$

$$E = -\frac{dV}{dr} = 9 \times 10^4 \text{ V}$$

$$16) E = -\frac{dV}{dr} = \frac{1000}{0.02} = 5 \times 10^4 \text{ V/m}$$

$$F = Eq = 5 \times 10^4 \times 1.6 \times 10^{-19} \text{ C}$$

$$= 8 \times 10^{-15} \text{ N}$$

$$17) E = -\frac{dV}{dr} = \frac{120}{0.02} = 6 \times 10^3 \text{ V/m}$$

$$F = Eq = 6 \times 10^3 \times 1.6 \times 10^{-19}$$

$$= 9.6 \times 10^{-16} \text{ N}$$

$$W = F r d$$

$$= 9.6 \times 10^{-16} \times 0.02$$

$$= 1.92 \times 10^{-17} \text{ J}$$

$$1a) i) q = 2 \times 1.6 \times 10^{-19} \text{ C}$$

$$K = qV$$

$$= 2 \times 1.6 \times 10^{-19} \times 10^6$$

$$= 3.2 \times 10^{-13} \text{ J}$$

$$ii) \text{ If the proton } = 1.6 \times 10^{-13} \text{ J}$$

$$iii) \text{ proton as it is lighter.}$$

$$21) r = 5.3 \times 10^{-11} \text{ m}$$

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

$$V = \frac{q \times 10^9}{5.3 \times 10^{-11}} \times 1.6 \times 10^{-19}$$

$$= 27.16 \text{ V}$$

$$U = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r} = \frac{9 \times 10^9 \times (1.6 \times 10^{-19})}{5.3 \times 10^{-11}} = 27.2 \text{ eV}$$

$$V_{He} = \frac{9 \times 10^9 \times 1.6 \times 10^{-19} \times 2}{5.3 \times 10^{-11}}$$

$$= 54.4 \text{ V}$$

$$21) F_{12} = \frac{k q_1 q_2}{r^2} = \frac{2k \times 10^{-12}}{1} = 2k \times 10^{-12}$$

$$F_{23} = \frac{k q_2 q_3}{r^2} = \frac{2k \times 10^{-12}}{1} = 2k \times 10^{-12}$$

$$F_{13} = \frac{k q_1 q_3}{r^2} = \frac{k \times 10^{-12}}{1} = k \times 10^{-12}$$

$$\begin{aligned} \text{Net force on } q_3 &= 2k \times 10^{-12} - \frac{k \times 10^{-12}}{1} \\ &= (2k/1) \times 10^{-12} \\ &= 15.75 \times 10^{-12} \text{ N} \end{aligned}$$

$$22) q = 50 \mu\text{C}$$

$$r = 0.04 \text{ m} = 0.04 \text{ m}$$

$$\begin{aligned} \text{Potential energy} &= \frac{k q_1 q_2}{r} + \frac{k q_2 q_3}{r} + \frac{k q_1 q_3}{r} \\ &= \frac{12k}{r} q^2 \\ &= 3 \times \left( \frac{1}{0.04} \times \frac{1}{0.04} \times (5 \times 10^{-6})^2 \right) \\ &= 3 \times 0.0009 \times 25 \times 10^{-10} \\ &= 1.5 \times 10^{-9} \text{ J} \end{aligned}$$

$$23) W = k q_1 q_2 \left[ \frac{1}{r_1} - \frac{1}{r_2} \right]$$

$$= k q_1 q_2 \left[ \frac{1}{0.05} - \frac{1}{0.15} \right] = k q_1 q_2 \left( \frac{2}{3} \right)$$

$$\begin{aligned} &= 9 \times 10^9 \times 10 \times 10^{-6} \times 10 \times 10^{-6} \times \frac{2}{3} \\ &= 2.25 \times 10^{-1} \\ &= 2.25 \text{ J} \end{aligned}$$

$$24) -q \xrightarrow{\quad} +q$$

$$q = 1.5 \times 10^{-9} \text{ C}$$

$$V = \frac{1}{4\pi\epsilon_0} \frac{q}{r}$$

$$V = \frac{9 \times 10^9 \times 1.5 \times 10^{-9}}{10^{-10}} = 1.5 \times 10^9 \text{ V}$$

$$k = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2} \quad V = 2.30 \times 10^9 \text{ J}$$

$$1 \text{ pF cond.} = 2.30 \times 10^9 \text{ J}$$

$$1 \text{ pF free} = \frac{2.30 \times 10^9}{2} = 1.15 \times 10^9 \text{ J}$$

$$22) KE = 2 + \frac{1}{2} mv^2$$

$$U = \frac{ke^2}{r}$$

$$ke^2 = 0$$

$$2 \times \frac{1}{2} mv^2 = \frac{ke^2}{r}$$

$$r = \frac{ke^2}{mv^2}$$

$$r = \frac{9 \times 10^9 \times (1.6 \times 10^{-19})^2 \times 10^{-16} \text{ m}}{9.1 \times 10^{-31} \times (10^6)^2}$$

$$= 2.63 \text{ \AA}$$

$$29) i) \tau = p \sin \alpha$$

$$8\sqrt{3} = p \times 10^5 \times \sin 60^\circ \quad (\because \sin 60^\circ = \sqrt{3}/2)$$

$$p = \frac{8\sqrt{3} \times 2}{\sqrt{3} \times 10^5}$$

$$p = 1.6 \times 10^{-4} \text{ cm}$$

$$p = q \times 2a$$

$$1.6 \times 10^{-4} = q \times 2 \times 10^{-2}$$

$$1.6 \times 10^{-4} = q$$

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

$$0.8 \times 10^{-2} = q$$

$$ii) U = -pe \cos \theta$$

$$U = -1.6 \times 10^4 \times 10^5 \times \frac{1}{2}$$

$$U = -0.8 \times 10^9$$

$$U = -1.6 \times 10^4 \times 10^5 \times \frac{1}{2}$$

$$= -0.8 \times 10^9$$

$$= -8 \text{ J}$$

$$31) V = \frac{k (ze)}{r}$$

$$= \frac{9 \times 10^9 \times 47 \times 1.6 \times 10^{-19}}{3.4 \times 10^{-14}}$$

$$= 2.0 \times 10^6 \text{ V}$$

$$32) V_s = \frac{1}{4\pi\epsilon_0} \frac{Q}{r}$$

potential at the center of the sphere is same as that of the surface.

$$V_s = \frac{9 \times 10^9 \times 12}{0.1}$$

$$= 1.08 \times 10^6 \text{ V}$$

$$33) i) V = \frac{kq}{r}$$

$$V = \frac{9 \times 10^9 \times 2.4 \times 10^{-9}}{0.12}$$

$$V = \frac{9 \times 2.4 \times 10}{12}$$

$$= 180 \text{ V}$$

$$ii) E = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2}$$

$$= \frac{9 \times 10^9 \times 2.4 \times 10^{-9}}{16}$$

$$= 1.35 \text{ V/m}$$

$$34) V_b = \frac{9 \times 10^9 \times q}{0.6}$$

$$\frac{100 \times 0.6}{9 \times 10^9} = q$$

$$q = 6.7 \times 10^{-9}$$

$$V_s = \frac{9 \times 10^9 \times 6.7 \times 10^{-9}}{0.12}$$

$$= \frac{9 \times 6.7}{0.12}$$

$$= 502.5 \text{ V}$$



$$24) U_0 = -10^{-6} \times 10^5 \times 0.02$$

$$= -2 \times 10^{-3}$$

$$U = -\vec{P} \cdot \vec{E}$$

$$= -PE \cos \theta$$

$$= -2 \times 10^{-3} \times -1 = 2 \times 10^{-3} \text{ N}\cdot\text{m}$$

$$W = PE(1 - \cos 180)$$

$$= 2 \times 2 \times 10^{-3}$$

$$= 4 \times 10^{-3} \text{ J}$$

$$25) \text{ dip } p = q \times 2d$$

$$= 2 \times 2 \times 10^{-6}$$

$$= 4 \times 10^{-6}$$

$$i) U = -\vec{P} \cdot \vec{E}$$

$$= -PE \cos \theta$$

$$= -(4 \times 10^{-6} \times 4 \times 10^5)$$

$$= -4 \times 10^{-1}$$

$$ii) W = PE(\cos 0 - \cos 180)$$

$$= 2PE$$

$$= 2 \times 4 \times 10^{-1}$$

$$= 0.8$$