

Unit-2 : Numericals

Q1 A free pith-ball A of 8g carries a positive charge of $5 \times 10^{-8} \text{ C}$. What must be the nature & magnitude of charge that should be given to a second pith ball B fixed 5cm below the former ball so that the upper ball is stationary? Ans: $4.36 \times 10^{-7} \text{ C}$ [+ve]

Q2 Two ^{+ve} point charges of $5 \times 10^{-19} \text{ C}$ & $20 \times 10^{-19} \text{ C}$ are separated by a distance of 2m. Find the point on the line joining them at which electric field intensity is 0.
Ans $x = +\frac{2}{3} \text{ m}$

Q3 Find the electric field b/w 2 metal plates 3mm apart, connected to a 12V battery. Ans: $4 \times 10^3 \text{ V/m}$

Q4 If the potential in the region of the space around the point $(-1, 2, 3) \text{ m}$ is given by $V = 10x^2 + 5y^2 - 3z^2 \text{ V}$ calculate the three components of electric field at that point.
Ans: 20, -20, 18 V/m

Q5 The electric field outside a charged long straight wire is given by $E = 1000/r \text{ V/m}$, and is directed outwards. What is the sign of the charge on the wire? If 2 points A & B are situated such that $r_A = 0.2 \text{ m}$ & $r_B = 0.4 \text{ m}$, find the value of $(V_B - V_A)$.
Ans: ~~+~~ Positive, -693.1V

Q6 An electric dipole consists of 2 opposite charges each of magnitude $1 \mu\text{C}$ separated by 2cm. The dipole is placed in an external electric field of 10^5 N/C . Find (1) Maximum Torque exerted by the field on the dipole (2) work which the external agent will have to do in turning the dipole through 180° starting from the position $\theta = 0^\circ$.
Ans: $2 \times 10^{-3} \text{ Nm}$, $4 \times 10^{-3} \text{ Joules}$.

Q7 Two electric dipoles of moments p_1 & p_2 are in a straight line. Show that the potential energy of each in the presence of other is $\frac{1}{2\pi\epsilon_0} \frac{p_1 p_2}{r^3}$ where r is distance b/w dipoles. (Assume $r \gg 2a$)

Q8 Assuming the earth to be a spherical conductor of radius 6400 km, calculate its capacitance.
Ans = 711 μF

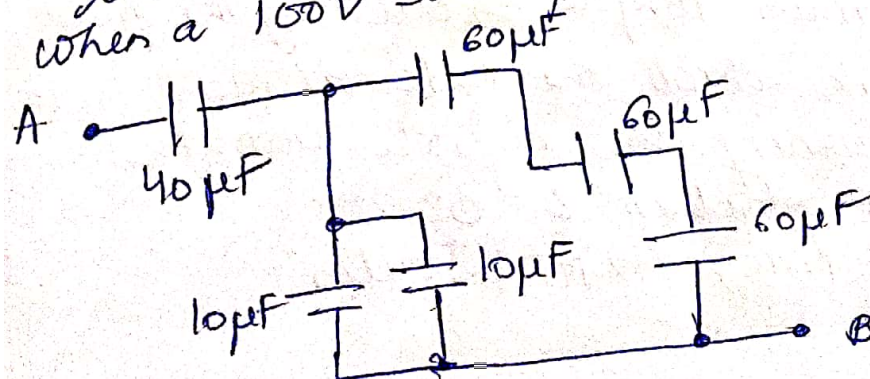
Q9 27 spherical drops of radius 3mm & carrying $10^{-12} C$ of charge are combined to form a single drop. Find the capacitance & potential of bigger drop.
Ans: 1pF, 27V

Q10 Show that the net capacitance of a spherical capacitor is $\frac{4\pi\epsilon_0 ab}{b-a}$; a, b = radius of inner & outer sphere.

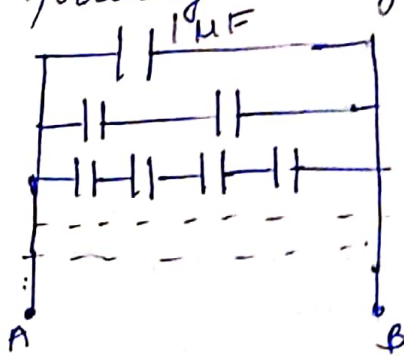
Q11 Two identical metal plates are given charges q_1 & q_2 given that $q_2 < q_1$. If they are now brought close together to form a parallel plate capacitor with capacitance C , what will be the pot diff b/w the plates?
Ans = $\frac{q_1 - q_2}{2C}$ Volts.

Q12 Two parallel plate air capacitors have their plate areas 100 & 500 cm^2 resp. If they have the same charge & potential & distance b/w the plates of first capacitor is 0.5mm, what is the distance b/w plates of second capacitor? Ans: 2.5mm.

Q13 Find equivalent capacitance b/w A & B. Also calculate total charge that flows in the circuit when a 100V battery is connected b/w the points A & B.
Ans: 20 μF , 2mC



Q14 Determine the equivalent capacitance of the following arrangement of n no. of capacitors of $1\mu F$ each.



Ans: $2\mu F$

Q15 Find the length of the paper used in a capacitor of capacitance $2\mu F$, if the dielectric constt of the paper is 2.5 & its width & thickness are 50 mm & 0.05 mm respectively.

Ans: 90 m

Q16 An ebonite plate ($k=3$), 6 mm thick is introduced b/w the parallel plates of a capacitor of plate area of $2 \times 10^{-2}\text{ m}^2$ & plate separation 0.01 m . Find the capacitance

Ans: 29.5 pF

Q17 An electric field $E_0 = 3 \times 10^4\text{ V/m}$ is established b/w the plates, 0.05 m apart of a parallel plate capacitor. After removing the charging battery, an uncharged metal plate of thickness $t = 0.01\text{ m}$ is inserted b/w capacitor plates. Find the pd across the capacitor (1) before (2) after the introduction of the plate. (3) pd after dielectric slab ($k=2$) were introduced in a place of metal plate.

Ans: 1500 V , 1200 V , 1350 V

Q18 A $2\mu F$ parallel-plate capacitor with a dielectric slab ($k=5$) b/w the plates is charged to 100 V and then isolated.

(1) What will be pd when dielectric is removed?

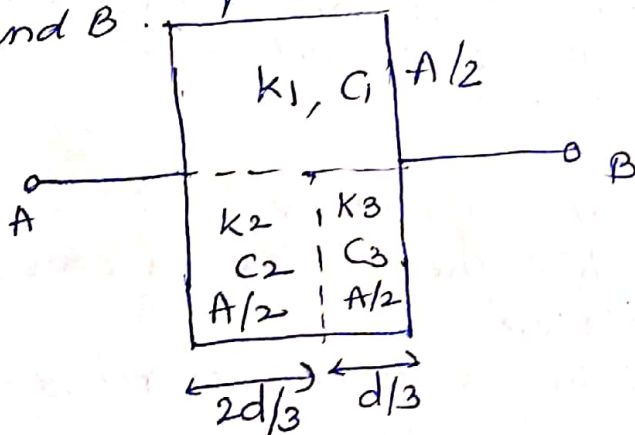
(2) How much work would be done in removing the dielectric?

Ans: $10^3\text{ }\mu\text{C}$, 500 V , 0.20 J .

Q19 Area of parallel plates of an air-filled capacitor is 0.20 m^2 and distance b/w them is 0.01 m . The pd across the plates is 3000 V . When a 0.01 m thick dielectric sheet is placed b/w the plates, the pd decreases to 1000 V . Determine (1) Capacitance of the capacitor before placing sheet. (2) Charge on each plate (3) Dielectric Constant of the material (4) Capacitance of the capacitor after placing the dielectric (5) Permittivity of the dielectric
Given $\epsilon_0 = 8.85 \times 10^{-12} \text{ Fm}^{-1}$

Q20 The capacitance of a parallel plate capacitor is 50 pF and distance b/w plates is 4 mm . It is charged to 200 V and then the charging battery is removed. Now a dielectric slab ($k=4$) of thickness 2 mm is placed. Determine (1) final charge on each plate (2) final pd b/w the plates (3) final energy in the capacitor (4) energy loss.
Ans: 10^{-8} C , 125 V , $6.25 \times 10^{-7} \text{ J}$, $3.75 \times 10^{-7} \text{ J}$

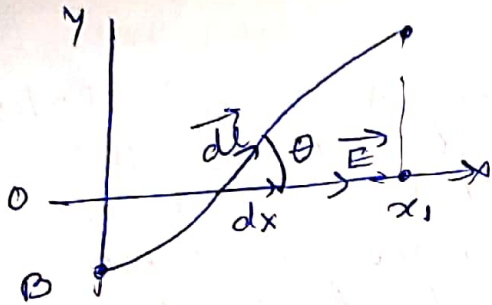
Q21 A parallel plate capacitor consists of three dielectrics. It has plate area $A = 1 \text{ cm}^2$ & plate separation $d = 2 \text{ mm}$. If $k_1 = 4$, $k_2 = 6$ and $k_3 = 2$ find the capacitance of this arrangement b/w points A and B.



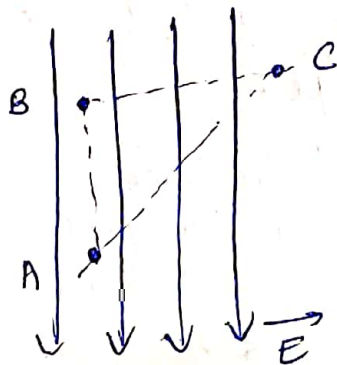
Ans: 1.454 pF .

Q22 Find the force per unit area with which plates of parallel plate capacitor attract each other if they are separated by 1mm and maintained at 100V pd and the electric constt of medium is unity.
Ans: 0.044 N/m^2

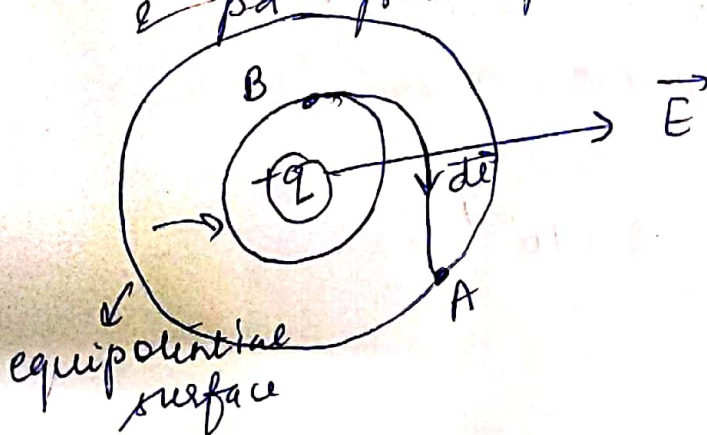
Q23 $\vec{E}$ is everywhere in the positive x-direction and equal to 10 V/m . If $x_1 = 1\text{m}$, calculate
(a) V_{AB} (b) V_{BA} (c) V_{AB}
Ans: $10, -10, -10 \text{ V}$



Q24 Prove that potential diff is path independent
(Test charge is moved from A to B over the path ACB & AB resp)

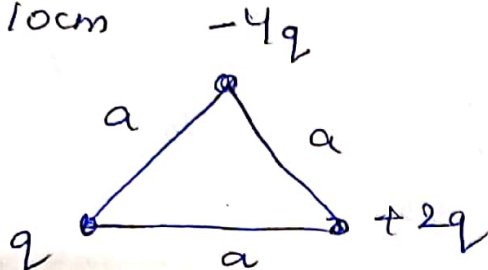


Q25 Imagine a positive charge of value $2.23 \times 10^{-10} \text{ C}$ in air. Calculate the potential at the distance 10 cm & 40 cm from the point charge & pd from points A & B.
Ans: $5 \text{ V}, 15 \text{ V}$



Q26 Find the gradient of potential $V = \frac{10}{x^2+y^2}$ at $(2,1)$
 Also find the electric field intensity at this point.
 Ans: $-\frac{20}{25} (2\hat{i} + \hat{j})$ Ans: -1.79 V/cm

Q27 3 charges are arranged like shown. Calculate their mutual potⁿ energy where $q = 10^{-7} \text{ C}$ & $a = 10 \text{ cm}$
 Ans: $-9 \times 10^{-3} \text{ J}$



Q28 For a parallel plate capacitor, $A = 100 \text{ cm}^2$, $d = 1 \text{ cm}$. A potⁿ diff of 100 V is applied with no dielectric present. A dielectric slab of $k = 7$ & $t = 0.5 \text{ cm}$ is introduced. Calculate ① free charge ② electric field strength in gap ③ electric field strength in dielectric, ④ p.d b/w plates ⑤ capacitance with dielectric
 Ans: $8.9 \times 10^{-10} \text{ C}$, 10^4 V/m , $0.14 \times 10^4 \text{ V/m}$, 57 V , $16 \mu\text{F}$

Q29 Given an electric field in a limited region, surrounding an origin in XY plane for which the potential is represented as $V = ax^2 + by^2$, $a, b = +ve$. Find ① Components of field intensity ② Position where E & V are minimum
 Ans: $-2ax, 2by, 0$; $(0,0) (0,0)$

Q30 The potⁿ @ a certain distance from a point charge is 600 V & $E = 200 \text{ N/C}$.
 ① What is distance of point charge?
 ② Magnitude of charge.
 Ans: 3 m , $2 \times 10^{-7} \text{ C}$

X — X