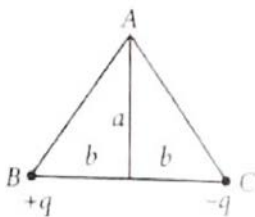


Electrostatic potential and capacitance

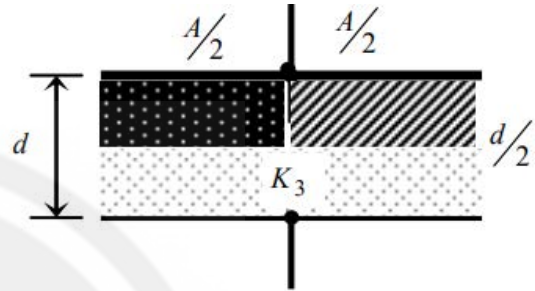
- Q1** On moving a charge of 20 C by 2 cm, 2 J of work is done, then the potential difference between the points is  
 (A) 0.1 V (B) 8 V  
 (C) 2 V (D) 0.5 V

- Q2** As shown in the figure, charges  $+q$  and  $-q$  are placed at the vertices B and C of an isosceles triangle. The potential at the vertex A is



- (A)  $\frac{1}{4\pi\epsilon_0} \cdot \frac{2q}{\sqrt{a^2+b^2}}$   
 (B) zero  
 (C)  $\frac{1}{4\pi\epsilon_0} \cdot \frac{q}{\sqrt{a^2+b^2}}$   
 (D)  $\frac{1}{4\pi\epsilon_0} \cdot \frac{(-q)}{\sqrt{a^2+b^2}}$
- Q3** A mass of 1kg carrying a charge of 2C is accelerated through a potential of 1 V. The velocity acquired by it is  
 (A)  $\frac{1}{2} \text{ m s}^{-1}$   
 (B)  $\sqrt{2} \text{ m s}^{-1}$   
 (C)  $2 \text{ m s}^{-1}$   
 (D)  $\frac{1}{\sqrt{2}} \text{ m s}^{-1}$

- Q4** A parallel plate capacitor of area A, plate separation  $d$  and capacitance C is filled with three different dielectric materials having dielectric constants  $k_1$ ,  $k_2$  and  $k_3$  as shown in the figure



(each slab has thickness  $d/2$ ). If single dielectric is used to fill in the capacitor to have the same capacitance C in this capacitor then dielectric constant  $k$  is given by

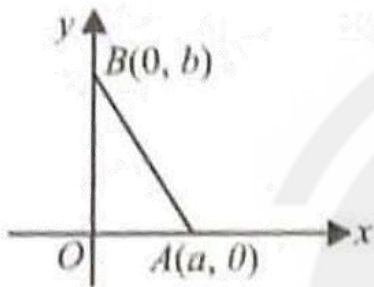
- (A)  $\frac{1}{k} = \frac{1}{k_1} + \frac{1}{k_2} + \frac{1}{k_3}$   
 (B)  $\frac{1}{k} = \frac{1}{k_1+k_2} + \frac{1}{2k_3}$   
 (C)  $k = \frac{k_1 k_2}{k_1+k_2} + \frac{1}{2k_3}$   
 (D)  $k = \frac{k_1 k_3}{k_1+k_3} + \frac{k_2 k_3}{k_2+k_3}$
- Q5** One Volt is equal to -  
 (A) 1 Joule  
 (B) 1 Newton/Coulomb  
 (C) 1 Joule/Coulomb  
 (D) 1 Coulomb/Newton
- Q6** The charge of a parallel plate capacitor is varying as  $q = q_0 \sin 2\pi ut$ . The plates are very large and close together. Neglecting edge effects, the displacement current through the capacitor is  
 (A)  $\frac{q}{A\epsilon_0}$   
 (B)  $\frac{q}{\epsilon_0} \sin 2\pi ut$   
 (C)  $2\pi \nu q_0 \cos 2\pi ut$   
 (D)  $\frac{2\pi \nu q_0}{\epsilon_0} \cos 2\pi ut$



**Q7** A slab of material of dielectric constant  $K$  has the same area as the plates of a parallel plate capacitor but has a thickness  $(3/4)d$ , where  $d$  is the separation of the plates. The ratio of the capacitance  $C$  (in the presence of the dielectric) to the capacitance  $C_0$  (in the absence of the dielectric) is

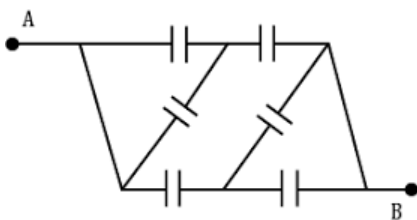
- (A)  $\frac{3K}{K+4}$  (B)  $\frac{3K}{4}$   
 (C)  $\frac{4K}{K+3}$  (D)  $\frac{4}{3}K$

**Q8** A charge  $+q$  is placed at the origin  $O$  of  $x$ - $y$  axes as shown in the figure. The work done in taking a charge  $Q$  from  $A$  to  $B$  along the straight line  $AB$  is



- (A)  $\frac{qQ}{4\pi\epsilon_0} \left( \frac{a-b}{ab} \right)$   
 (B)  $\frac{qQ}{4\pi\epsilon_0} \left( \frac{b-a}{ab} \right)$   
 (C)  $\frac{qQ}{4\pi\epsilon_0} \left( \frac{b}{a^2} - \frac{1}{b} \right)$   
 (D)  $\frac{qQ}{4\pi\epsilon_0} \left( \frac{a}{b^2} - \frac{1}{b} \right)$

**Q9** A network of six identical capacitors, each of value  $C$ , is made as shown in the figure. Equivalent capacitance between points  $A$  and  $B$  is



- (A)  $C/4$  (B)  $3C/4$   
 (C)  $4C/3$  (D)  $3C$

**Q10** A parallel plate capacitor is charged to  $60\text{mC}$ . Due to a radioactive source, the plate loses charge at the rate of  $1.8 \times 10^{-8} \text{ Cs}^{-1}$ . The magnitude of displacement current is

- (A)  $1.8 \times 10^{-8} \text{ Cs}^{-1}$   
 (B)  $3.6 \times 10^{-8} \text{ Cs}^{-1}$   
 (C)  $4.1 \times 10^{-11} \text{ Cs}^{-1}$   
 (D)  $5.7 \times 10^{-2} \text{ Cs}^{-1}$

**Q11** Two metal plates are separated by  $2 \text{ cm}$ . The potentials of the plates are  $-10 \text{ V}$  and  $+30 \text{ V}$ . The electric field between the two plates is

- (A)  $1000 \text{ V/m}$   
 (B)  $3000 \text{ V/m}$   
 (C)  $500 \text{ V/m}$   
 (D)  $2000 \text{ V/m}$

**Q12** The electrostatic potential on the surface of a charged conducting sphere is  $100 \text{ V}$ . Two statements are made in this regard:

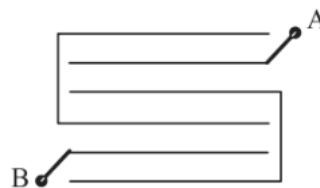
$S_1$ : At any point inside the sphere, electric intensity is zero.

$S_2$ : At any point inside the sphere, the electrostatic potential is  $100 \text{ V}$ .

Which of the following is a correct statement?

- (A)  $S_1$  is true but  $S_2$  is false.  
 (B) Both  $S_1$  and  $S_2$  are false.  
 (C)  $S_1$  is true,  $S_2$  is also true and  $S_1$  is the cause of  $S_2$ .  
 (D)  $S_1$  is true,  $S_2$  is also true but the statements are independent.

**Q13** If each plate has area  $A$  and separation between successive plates is  $d$  from equivalent capacitance between  $A$  and  $B$  is -



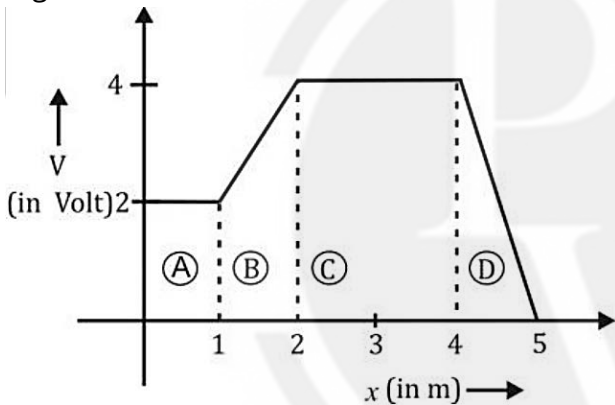
- (A)  $\frac{A\epsilon_0}{d}$  (B)  $\frac{A\epsilon_0}{2d}$   
 (C)  $\frac{4A\epsilon_0}{d}$  (D)  $\frac{3A\epsilon_0}{d}$



**Q14** The Work done to move a charge on an equipotential surface is  
 (A) Infinity  
 (B) Less than 1  
 (C) greater than 1  
 (D) Zero

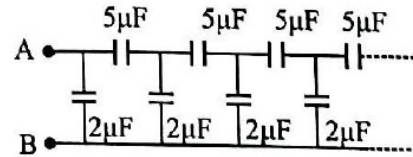
**Q15** When a dielectric is inserted between the plates of a capacitor connected to a battery, what happens to the capacitance?  
 (A) Increases (B) Decreases  
 (C) Remains same (D) Becomes zero

**Q16** The figure gives the electric potential  $V$  as a function of distance through four regions on  $x$ -axis. Which of the following is true for the magnitude of the electric field  $E$  in these regions?



- (A)  $E_A = E_C$  and  $E_B < E_D$
- (B)  $E_A < E_B < E_C < E_D$
- (C)  $E_A > E_B > E_C > E_D$
- (D)  $E_B = E_D$  and  $E_A < E_C$

**Q17** Find the capacitance of the infinite ladder between point A and B



- (A)  $4.3 \mu F$
- (B)  $10 \mu F$
- (C)  $8.6 \mu F$
- (D)  $3 \mu F$

**Q18** The dielectric constant of air is 1.006. The speed of electromagnetic wave travelling in air is  $a \times 10^8 \text{ ms}^{-1}$ , where  $a$  is about  
 (A) 3.88 (B) 3.2  
 (C) 2.5 (D) 3

**Q19** Three charges  $-q$ ,  $+Q$  and  $-q$  are placed at equal distances along a straight line. If the total P.E. of the system is zero, the ratio  $Q/q$  becomes  
 (A)  $1/8$  (B)  $1/6$   
 (C)  $1/4$  (D)  $1/2$

**Q20** The potential at a point  $x$  (measured in  $\mu\text{m}$ ) due to some charges situated on the  $x$ -axis is given by  
 $V(x) = \frac{20}{x^2 - 4}$  volts.

- The electric field  $E$  at  $x = 4 \mu\text{m}$  is given by
- (A)  $5/3 \text{ V}/\mu\text{m}$  and is in positive  $x$ -direction
  - (B)  $10/9 \text{ V}/\mu\text{m}$  and is in negative  $x$ -direction
  - (C)  $10/9 \text{ V}/\mu\text{m}$  and is in positive  $x$ -direction
  - (D)  $5/3 \text{ V}/\mu\text{m}$  and is in negative  $x$ -direction

**Q21** If the gap between the plates of a parallel plate capacitor is filled with medium of dielectric constant  $k = 2$ , then the field between them  
 (A) Increases by a factor 2  
 (B) Increases by a factor  $\sqrt{2}$   
 (C) Decreased by a factor  $\sqrt{2}$   
 (D) Decreased by a factor  $1/2$



# Answer Key

Q1 A  
Q2 B  
Q3 C  
Q4 B  
Q5 C  
Q6 C  
Q7 C  
Q8 A  
Q9 C  
Q10 A  
Q11 D

Q12 C  
Q13 A  
Q14 D  
Q15 A  
Q16 A  
Q17 A  
Q18 D  
Q19 C  
Q20 C  
Q21 D



# Hints & Solutions

Note: scan the QR code to watch video solution

## Q1 Text Solution:

$$p \cdot d = \frac{\text{work done}}{\text{charge}} = \frac{2}{20} = 0.1V$$

## Video Solution:



## Q2 Text Solution:

$$V_A = \frac{K(+q)}{\sqrt{a^2+b^2}} + \frac{K(-q)}{\sqrt{a^2+b^2}} = 0$$

## Video Solution:



## Q3 Text Solution:

Here,  $q = 2C$ ,  $m = 1 \text{ kg}$ ,  $V = 1 \text{ V}$

Let the velocity acquired by the mass be  $v$ .

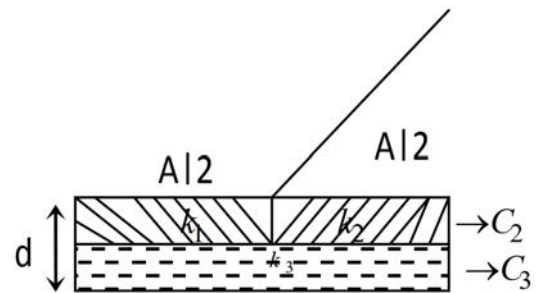
Then

$$\frac{1}{2}mv^2 = qV \text{ or } v = \sqrt{\frac{2qV}{m}} = \sqrt{\frac{2(2C)(1V)}{1\text{kg}}} = 2\text{ms}^{-1}$$

## Video Solution:



## Q4 Text Solution:



$$\begin{aligned} \frac{1}{C_{\text{eff}}} &= \frac{1}{C_3} + \frac{1}{C_1+C_2} \\ &= \frac{1}{\frac{k_3 \epsilon_0 A}{d}} + \frac{1}{\frac{k_1 \epsilon_0 A/2}{d} + \frac{k_2 \epsilon_0 A/2}{d}} \\ \text{or } \frac{d}{k_{\text{eff}} \epsilon_0 A} &= \frac{d}{\epsilon_0 A} \left[ \frac{1}{2k_3} + \frac{1}{k_1+k_2} \right] \\ \therefore \frac{1}{k_{\text{eff}}} &= \frac{1}{2k_3} + \frac{1}{k_1+k_2} \end{aligned}$$

## Video Solution:



## Q5 Text Solution:

Volt is the electrical unit of voltage or potential difference (V)

V is related to Change in Potential Energy  $\Delta U$  as

$$V = \frac{U}{q}$$

From above formula, We get 1 Volt potential difference when a change of 1 joule of Potential energy is there in moving a charge of 1 Coulomb.

$$\text{Therefore, } 1 \text{ Volt} = \frac{1 \text{ Joule}}{\text{Coulomb}}$$

## Video Solution:



**Q6 Text Solution:**

$$I = \frac{dq}{dt} = \frac{d}{dt}(q_0 \sin 2\pi vt) = q_0 2\pi v \cos 2\pi vt$$

**Video Solution:**



**Q7 Text Solution:**

The capacitance of a parallel plate capacitor in the absence of the dielectric is,

$$C_0 = \frac{\epsilon_0 A}{d} \dots\dots\dots(i)$$

where A is the area of each plate and d is the distance between them. The capacitance of a parallel plate capacitor in the presence of dielectric slab of thickness t and dielectric constant K, is

$$C = \frac{\epsilon_0 A}{(d-t) + \frac{t}{K}} = \frac{\epsilon_0 A}{(d - \frac{3}{4}d) + \frac{3d}{4K}}$$

$$= \frac{\epsilon_0 A}{\frac{d}{4} + \frac{3d}{4K}} = \frac{4K\epsilon_0 A}{d(k+3)} \dots\dots\dots(ii)$$

Dividing eqn. (ii) by eqn. (i), we get

$$\frac{C}{C_0} = \frac{4K\epsilon_0 A}{d(K+3)} \times \frac{d}{\epsilon_0 A} = \frac{4K}{k+3}$$

**Video Solution:**



**Q8 Text Solution:**

Potential at point A is  $V_A = \frac{1}{4\pi\epsilon_0} \frac{q}{a}$

Potential at point B is  $V_B = \frac{1}{4\pi\epsilon_0} \frac{q}{b}$

Work done in taking a charge Q from A to B is

$$W = Q(V_B - V_A) = \frac{Qq}{4\pi\epsilon_0} \left[ \frac{1}{b} - \frac{1}{a} \right]$$

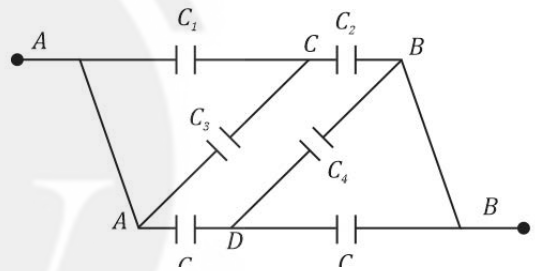
$$= \frac{Qq}{4\pi\epsilon_0} \left[ \frac{a-b}{ab} \right]$$

**Video Solution:**

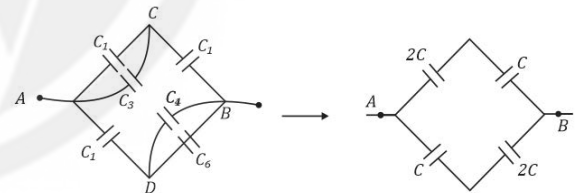


**Q9 Text Solution:**

Let us label the capacitors and potential points.



As  $C_1 = C_2 = C_3 = C_4 = C_5 = C_6 = C$



$$\Rightarrow C_{eq} = \left[ \frac{2C \cdot C}{2C + C} \right] + \left[ \frac{2C \cdot C}{2C + C} \right] = \frac{2}{3}C + \frac{2}{3}C$$

$$= \frac{4C}{3}$$

**Video Solution:**



**Q10 Text Solution:**

$$\frac{dq}{dt} = 1.8 \times 10^{-8} \text{ cS}^{-1}$$

$$WKT \quad I_D = I_C$$

$$\therefore I_D = \frac{dr}{dt}$$

$$= 1.8 \times 10^{-8} \text{ cS}^{-1}$$

**Video Solution:**



**Q11 Text Solution:**

$$|E| = \frac{dv}{dx}$$

$$|E| = \frac{-10-30}{2 \times 10^{-2}}$$

$$|E| = \frac{40}{2 \times 10^{-2}} = 20 \times 10^{+2}$$

$$= 2000 \text{ V/m}$$

**Video Solution:**



**Q12 Text Solution:**

$$E = -\frac{dV}{dr} \Rightarrow E = 0 \text{ then, } \frac{dV}{dr} = 0$$

$$\Rightarrow V = \text{constant}$$

Thus,  $E = 0$  inside the charged conducting sphere causes, the same electrostatic potential 100 V at any point inside the sphere.

**Video Solution:**



**Q13 Video Solution:**



**Q14 Video Solution:**



**Q15 Text Solution:**

Increases

**Video Solution:**



**Q16 Text Solution:**

In region A,  $V$  constant

$$E_A = 0 \text{ As } E = \frac{dV}{dx}$$

$$\text{In region B, } E_B = \frac{4-2}{2-1} \Rightarrow E_B = 2 \text{ V/m}$$

In region C,  $V \rightarrow$  Constant  $\therefore E_C = 0$

$$\text{In Region D, } E_D = \frac{4-0}{5-4} \Rightarrow E_D = 4 \text{ V/m}$$

$$E_A = E_C \text{ \& } E_D > E_B.$$

**Video Solution:**



**Q17 Text Solution:**

Let  $C$  be the capacitance of infinite ladder

$$\frac{1}{C'} = \frac{1}{C} + \frac{1}{5} = \frac{5+C}{5C} \Rightarrow C' = \frac{5C}{5+C}$$

$$C'' = 2 + C'$$

$$C = 2 + \frac{5C}{5+C}$$



$C'' = C$  (Addition of one or more  $5 \mu\text{F}$  and  $2 \mu\text{F}$  do not change the total capacitance. So, overall capacitance should be  $C$ )

$$C = \frac{10+2C+5C}{5+C} \quad 5C + C^2 = 10 + 7C$$

$$C^2 = 10 + 2C \quad C^2 - 2C - 10 = 0$$

$$D = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \quad \therefore C = \frac{2 \pm \sqrt{44}}{2}$$

$$C = \frac{2+6.6}{2}, C = \frac{2-6.6}{2} \quad C = \frac{8.6}{2}, C = \frac{-4.6}{2}$$

$$C = -2.3, \quad C = 4.3$$

-ve value neglected So, total capacitance is  $4.3 \mu\text{F}$

**Video Solution:**



**Q18 Text Solution:**

For an electromagnetic wave,

$$\text{Velocity } C = \frac{1}{\sqrt{\mu_0 \epsilon_0}} = 3 \times 10^8 \text{ ms}^{-1}$$

Air acts almost as vacuum.

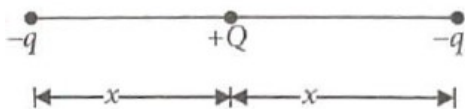
$\therefore a = 3$  Approximately.

**Video Solution:**



**Q19 Text Solution:**

Total potential energy of the system is



$$U = \frac{1}{4\pi\epsilon_0} \left[ \frac{(-q)(+Q)}{x} + \frac{(+Q)(-q)}{x} + \frac{(-q)(-q)}{2x} \right]$$

$$0 = \frac{1}{4\pi\epsilon_0} \left[ -\frac{qQ}{x} - \frac{qQ}{x} + \frac{q^2}{2x} \right]$$

$$= \frac{1}{4\pi\epsilon_0} \left[ -\frac{2qQ}{x} + \frac{q^2}{2x} \right]$$

$$\therefore -\frac{2qQ}{x} + \frac{q^2}{2x} = 0; \frac{2qQ}{x} = \frac{q^2}{2x} \text{ or } \frac{Q}{q} = \frac{1}{4}$$

**Video Solution:**



**Q20 Text Solution:**

$$V = \frac{20}{n^2 - 4}$$

$$WKT E = -\frac{dv}{dx}$$

$$E = -\frac{d}{dx} \left( \frac{20}{n^2 - 4} \right)$$

$$E = -20 \left[ \frac{-1}{(x^2 - 4)^2} \right]^{2x}$$

$$\text{At } x = 4 \mu\text{m}$$

$$E = \frac{40 \times 4}{(16 - 4)^2}$$

$$E = \frac{40 \times 4}{144}$$

$$E = \frac{+14}{36}$$

$$E = \frac{+10}{9} \text{ V/mm}$$

Along + x - axis

$$\frac{d}{dx} \left( \frac{1}{x} \right) = -\frac{21}{x^2}$$

**Video Solution:**



**Q21 Text Solution:**

between the plates of a capacitor intensity of

field =  $E$

$$E = \frac{\sigma}{\epsilon_0 K} = \frac{q}{\epsilon_0 K A}$$

$$\frac{E_{\text{air}}}{E} = K \Rightarrow E = \frac{E_{\text{air}}}{K} = \frac{E_{\text{air}}}{2}$$

$\Rightarrow$  Intensity is decreases by a factor of  $\frac{1}{2}$ .

**Video Solution:**[Android App](#)[iOS App](#)[PW Website](#)