Q1: A parallel plate capacitor with plates of area 1 m^2 each are at a separation of 0.1 m. If the electric field between the plates is 100 N C^{-1}, the magnitude of charge on each plate is

(Taken $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N\ m^2$)

(a) 8.85×10^{-10} C

(b) 7.85×10^{-10} C

(c) 9.85×10^{-10} C

(d) 6.85×10^{-10} C

Solution

The electric field between two plates is

$E = \sigma/\varepsilon_0 = q/A\varepsilon_0 \Rightarrow q = EA\varepsilon_0$

$q = (100)(1)(8.85 \times 10^{-12}) = 8.85 \times 10^{-10}$ C

Answer: (a) 8.85×10^{-10} C

Q2: The parallel combination of two air filled parallel plate capacitors of capacitance C and nC is connected to a battery of voltage, V. When the capacitors are fully charged, the battery is removed and after that a dielectric material of dielectric constant K is placed between the two plates of the first capacitor. The new potential difference of the combined system is

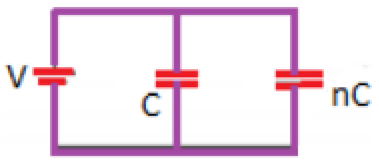
(a) V

(b) (n+1)V/(K+n)

(c) (nV)/(K+n)

(d) V/(K+n)

Solution



For parallel combination, $C_{eq} = C + nC = C(n + 1)$

Charge on capacitor, $q = C_{eq}V = CV(n + 1)$

Now, after removing the battery, dielectric material is placed.

Then, $C_{eq} = KC + nC = C(K + n)$

New potential difference, $V' = q/C_{eq} = V(n+)/(K+n) = (n+1)V/(K+n)$

Answer: (b) (n+1)V/(K+n)

Q3: A parallel plate capacitor is made by stacking n equally spaced plates connected alternatively. If the capacitance between any two adjacent plates is C then the resultant capacitance is

(a) C

(b) nC

(c) (n – 1)C

(d) (n + 1)C

Solution

n plates connected alternately give rise to (n – 1) capacitors connected in parallel

Resultant capacitance = (n – 1)C.

Answer: (c) (n – 1)C

Q4: Capacitance (in F) of a spherical conductor with radius 1 m is

(a) 1.1×10^{-10}

(b) 10^{-6}

(c) 9×10^{-9}

(d) 10^{-3}

Solution

$C = 4\pi\varepsilon_0 R = 1/9 \times 10^{9} = 1.1 \times 10^{-10}$ F

Answer: (a) 1.1×10^{-10}

Q5: If there are n capacitors in parallel connected to V volt source, then the energy stored is equal to

(a) CV

(b) (½)nCV^2

(c) CV^2

(d) (1/2n)CV^2

Solution

Total capacity =nC

∴ Energy =½ nCV^2

Answer: (b) (½)nCV^2

Q6: A parallel plate capacitor with air between the plates has a capacitance of 9 pF. The separation between its plates is d. The space between the plates is now filled with two dielectrics. One of the dielectrics has dielectric constant k_1 = 3 and thickness d/3 while the other one has dielectric constant k_2 = 6 and thickness 2d/3. Capacitance of the capacitor is now

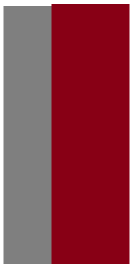
(a) 20.25 pF

(b) 1.8 pF

(c) 45 pF

(d) 40.5 pF

Solution



$C = \varepsilon_0 A/d = 9 \times 10^{-12}$ F

With dielectric,$C = \varepsilon_0 Ak/d$

$C_1 = \varepsilon_0 A3/(d/3) = 9C$

$C_2 = \varepsilon_0 A6/(2d/3) = 9C$

$C_{total} = C_1C_2/(C_1 + C_2)$ as they are in series

$C_{total} = (9C \times 9C)/!8C = (9/2)C = (9/2)(9 \times 10^{-12}$ F)

$C_{total} = 40.\%$ pF

Answer: (d) 40.5 pF

Q7: A parallel plate condenser with a dielectric of dielectric constant K between the plates has a capacity C and is charged to a potential V volt. The dielectric slab is slowly removed from between the plates and then reinserted. The net work done by the system in this process is

(a) zero

(b) 1/2 (K – 1) CV^2

(c) $CV^2(K-1)/K$

(d) (K – 1) CV^2

Solution

The potential energy of a charged capacitor

$Ui = q^2/2C$

where U_i is the initial potential energy.

If a dielectric slab is slowly introduced, the energy = $q^2/2KC$

Once it is taken out, again the energy increases to the old value.Therefore after it is taken out, the potential energy comes back to the old value.

Total work done = zero.

Answer: (a) zero

Q8: A battery is used to charge a parallel plate capacitor till the potential difference between the plates becomes equal to the electromotive force of the battery. The ratio of the energy stored in the capacitor and the work done by the battery will be

(a) 1/2

(b) 1

(c) 2

(d) 1/4

Solution

Let E be emf of the battery

Work done by the battery $W = CE^2$

Energy stored in the capacitor

$U = \frac{1}{2}CE^2$

$U/W = \frac{1}{2}CE^2 / CE^2 = \frac{1}{2}$

Answer: (a) 1/2

Q9: A sheet of aluminium foil of negligible thickness is introduced between the plates of a capacitor. The capacitance of the capacitor

(a) decreases

(b) remains unchanged

(c) becomes infinite

(d) increases

Solution

Aluminium is a good conductor. Its sheet introduced between the plates of a capacitor is of negligible thickness. The capacity remains unchanged.

With air as dielectric, $C = \varepsilon_0 A/d$

With space partially filled, $C' = \varepsilon_0 A/(d-t) = \varepsilon_0 A/d = C$

Answer: (b) remains unchanged

Q10: If the electric flux entering and leaving an enclosed surface respectively is Φ_1 and Φ_2, the electric charge inside the surface will be

(a) $(\Phi_2 - \Phi_1)\varepsilon_0$

(b) $(\Phi_1 + \Phi_2)/\varepsilon_0$

(c) $(\Phi_2 - \Phi_1)/\varepsilon_0$

(d) $(\Phi_1 + \Phi_2)\varepsilon_0$

Solution

According to Gauss theorem,

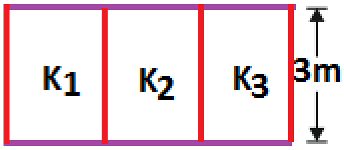
$(\Phi_2 - \Phi_1) = Q/\varepsilon_0$

$\Rightarrow Q = (\Phi_2 - \Phi_1)\varepsilon_0$

The flux enters the enclosure if one has a negative charge ($-q_2$) and flux goes out if one has a +ve charge ($+q_1$). As one does not know whether $\Phi_1 > \Phi_2$, $\Phi_2 > \Phi_1$, Q = q1 ~ q2

Answer: (a) $(\Phi_2 - \Phi_1)\varepsilon_0$

Q11: A parallel plate capacitor is of area 6 cm² and a separation 3 mm.The gap is filled with three dielectric materials of equal thickness (see figure) with dielectric constants $K_1 = 10$, $K_2 = 12$ and $K_3 = 14$.The dielectric constant of a material which when fully inserted in the given capacitor, gives same capacitance would be



(a) 36

(b) 12

(c) 4

(d) 14

Solution

The given system can be considered to be a parallel combination of three capacitors C_1, C_2 and C_3. The equivalent capacitance, $C = C_1 + C_2 + C_3$

Hence, $C_1 = K_1\varepsilon_0 A/3d$

$C_2 = K_2\varepsilon_0 A/3d$

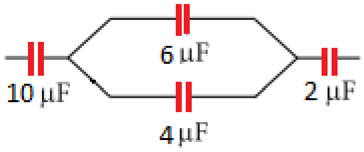
$C_3 = K_3\varepsilon_0 A/3d$

$(K'\varepsilon_0 A/d) = (K_1 + K_2 + K_3/3)(\varepsilon_0 A/d)$

Hence $K' = (K_1 + K_2 + K_3/3) = (10 + 12 + 14/3) = 12$

Answer: (b) 12

Q12: In the figure shown below, the charge on the left plate of the 10 F capacitor is –30 C. The charge on the right plate of the 6 F capacitor is



(a) –18 μC

(b) –12 μC

(c) +12 μC

(d) +18 μC

Solution

Let q_1 and q_2 be the charge on 6μF and 4μF respectively

$q_1 + q_2 = q$——-(1)

Also, $(q_1/C_1) = (q_2/C_2)$——-(2)

($\because$ C_1 and C_2 are in parallel combination)

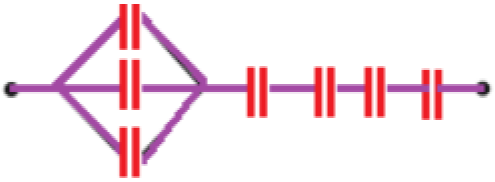
$\Rightarrow q_2 = (C_2/C_1)\ q_1 = (4/6)q_1$

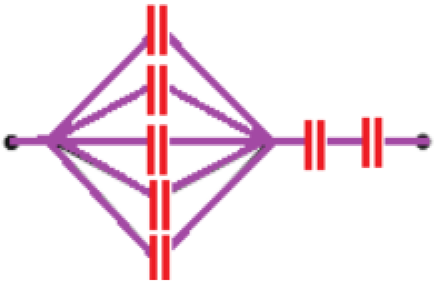
Using (1) and (2)

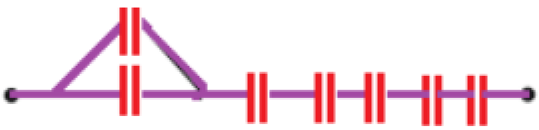
$(10/6)q_1 = q \Rightarrow q = (5/3)q_1 \Rightarrow (3/5)(30) = 18\ \mu C$

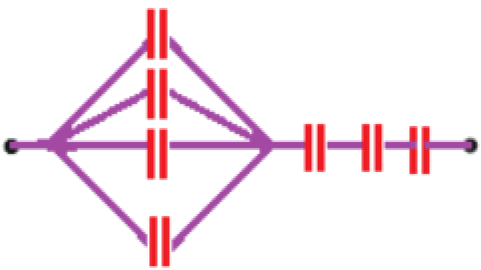
Answer: (d) +18 μC

Q13: Seven capacitors, each of capacitance 2 F, are to be connected in a configuration to obtain an effective capacitance of (6/13) F. Which of the combinations, shown in figures below, will achieve the desired value?

(a) 

(b) 

(c) 

(d) 

Solution

C_1 is given by

$(1/C_1) = (1/3C) + (1/C) + (1/C) + (1/C) + 1/C) = (1/6) + (4/2)$

$C_1 = (6/13)\ \mu F$

C_2 is given by

$(1/C_1) = (1/5C) + (2/C) = (1/10) + (1) = 11/10 \Rightarrow C_2 = (10/11)\ \mu F$

$C_2 = (6/13)\ \mu F$

C_3 is given by

$(1/C_3) = (1/4C) + (3/C) = (1/8) + (3/2) = 26/16 = 13/8 \Rightarrow C_3 = (8/13)\ \mu F$

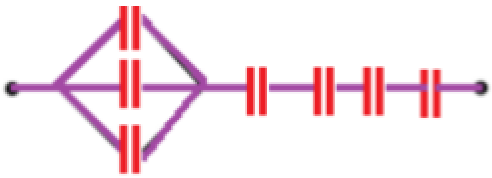
$C_3 = (8/13)\ \mu F$

C_4 is given by

$(1/C_4) = (1/2C) + (5/C) = (1/4) + (5/2) = 11/4 \Rightarrow C_4 = (4/11)\ \mu F$

$C_3 = (4/11)\ \mu F$

Answer:

(a) 

Q14: Voltage rating of a parallel plate capacitor is 500 V. Its dielectric can withstand a maximum electric field of 106 V m^{-1}. The plate area is 10^{-4} m^2. What is the dielectric constant if the capacitance is 15 pF? (given 0 = 8.86 × 10^{-12} C^2 N^{-1} m^{-2})

(a) 3.8

(b) 8.5

(c) 6.2

(d) 4.5

Solution

$C = K\varepsilon_0 A/d$ or $K = CV/\varepsilon_0 AE_{max}$

$K = (15 \times 10^{-12} \times 500)/(8.86 \times 10^{-12} \times 10^{-4} \times 10^{6}) = 8.5$

Answer: (b) 8.5

Q15: In free space, a particle A of charge 1 C is held fixed at a point P. Another particle B of the same charge and mass 4 g is kept at a distance of 1 mm from P. If B is released, then its velocity at a distance of 9 mm from P is

(take $1/4\pi\varepsilon_0 = 9 \times 10^9$ Nm^2C^{-2})

(a) 3.0×10^4 m/s

(b) 1.0 m/s

(c) 1.5×10^2 m/s

(d) 2.0×10^3 m/s

Solution

Using work energy theorem

$W_E = U_i - U_f = (½)mv^2$ or $kq_1q_2[(1/r_1) - (1/r_2)] = (½)mv^2$

$W_E = (9 \times 10^9) \times (1 \times 10^{-6})^2 \{(1/10^{-3}) - (1/(9 \times 10^{-3})\} = (½)mv^2$

$\Rightarrow (9 \times 10^9 \times 2 \times 10^{-12})/(4 \times 10^{-6}) = v^2 \Rightarrow v = 2.0 \times 10^3$ ms^{-1}

Answer: (d) 2.0 × 10^3 m/s