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Answers Key:

Assertion and reason

1. **(b)**: If a material contain polar molecules, they will generally be in random orientations when no electric field is applied. An applied electric field will polarize the material by orienting the dipole moment of polar molecules.
2. (c) If the Assertion is correct but Reason is incorrect.

5 Marks

3. (i) We have, initial voltage, V_1 = V volt
and charge stored, Q_1 = 360 μC
$Q_1 = CV_1$ ....(i)
Charged potential, V_2 = V - 120
Q_2 = 120 μC
$\Rightarrow Q_2 = CV_2 = C(V - 120)$ ....(ii)
By dividing Eq. (ii) from Eq. (i), we get
$\frac{Q_1}{Q_2} = \frac{CV_1}{CV_2} \Rightarrow \frac{360}{120} = \frac{V}{V-120}$
$\Rightarrow$ V = 180 V
$\therefore \quad C = \frac{Q_1}{V_1} = \frac{360\times10^{-6}}{180} = 2 \times 10^{-6}$ F
= 2 μF
Hence, the potential, V = 180 V and unknown capacitance is 2 μF.
(ii) If the voltage applied had increased by 120 V, then V_3 = 180 + 120 = 300 V
Hence, charge stored in the capacitor,
$Q_3 = CV_3 = 2 \times 10^{-6} \times 300 = 600$ μC

3 Marks

4. Given, length, 2a = 4 cm = 4 $\times 10^{-2}$ m
Angle, θ= 60°
Toeque, $\tau = 4\sqrt{3}N - m$
Charge, q = 8 $\times 10^{-9}$ C
We know that, τ= pE sin θ
$\Rightarrow$ Electric field, $E = \frac{\tau}{psin\theta}$ ...(i)
$\because$ Potential energy, U = - p.E = - pE cos θ
From Eq. (i), we get
$U = -\frac{p.\tau}{p.sin\ \theta}.cos\theta$
$= -\tau cot\theta = -4\sqrt{3}.cot60°$
$= -4\sqrt{3} \times \frac{1}{\sqrt{3}} \quad \left(\because cot60° = \frac{1}{\sqrt{3}}\right)$
= -4 J
5. If n identical capacitors, each of capacitance C are connected in series combination give equivalent capacitance, $C_s = \frac{C}{n}$ and when connected in parallel combination, then equivalent capacitance, C_p = nC. Also, for same voltage, energy stored in the capacitor is given by
$U = \frac{1}{2}CV^2$ [for V = constant]
$\Rightarrow \quad U \propto C$
In series combination, $C_s = \frac{C}{n}$
$\Rightarrow \quad C_s = 1\mu F \quad [\because n = 3]$
$\Rightarrow \quad C = nC_s = 3 \times 1\mu F = 3\mu F$
In parallel combination, C_p = nC = 3 $\times$3 = 9 μF
For same voltage, U $\propto$C
$\Rightarrow \quad \frac{U_s}{U_p} = \frac{C_s}{C_p}$
$\Rightarrow \quad \frac{U_s}{U_p} = \frac{C/n}{nC} = \frac{1}{n^2}$
$\Rightarrow \quad \frac{U_s}{U_p} = \frac{1}{(3)^2} = \frac{1}{9}$
or $U_s : U_p$ = 1 : 9
6. Let the equivalent capacitance of the series combination be C. Then,
$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} = \frac{1}{10} + \frac{1}{15} + \frac{1}{30}F$
$= \frac{3+2+1}{30} = \frac{6}{30} = \frac{1}{5} \Rightarrow C = 5\mu$
Charge stored on the combination is
q = CV = 5 x 60 = 300μC
Since, the capacitor are in series, the charge on each capacitor is 300μC.
The potential difference across the three capacitors are
$V_1 = \frac{q}{C_1} = \frac{300}{10} = 30V$
$V_2 = \frac{q}{C_2} = \frac{300}{15} = 20V$
$V_3 = \frac{q}{C_3} = \frac{300}{30} = 10V$
Energy of the capacitors are
$U_1 = \frac{1}{2}qV_1 = \frac{1}{2} \times 300 \times 30 = 4500\mu J$

$U_2 = \frac{1}{2}qV_2 = \frac{1}{2} \times 300 \times 20 = 3000\mu J$

$U_3 = \frac{1}{2}qV_3 = \frac{1}{2} \times 300 \times 10 = 1500\mu J$

7. Given $q_1 = +10\mu\text{C}, q_2 = -10\mu\text{C}, r = 40\text{ cm}$

$U = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r} = \frac{9\times10^9\times(-10)\times10\times10^{-12}}{0.4} = -2.25\text{ J}$

2 Marks

8. Work done = charge x potential difference = zero, because the potential difference between any two points on an equipotential surface is zero.
9. The electric potential energy at any point lying at a distance r from the source charge q is equal to the amount of work done in moving unit positive test charge from infinity to that point without any acceleration against electrostatic force.
10. $C_o = \frac{\epsilon_o A}{d} = 8pFC = K.\frac{\epsilon_o A}{d/2} = 2KC_o = 2 \times 5 \times 8pF$
11. (a) As Q = CV, if V doubles, charge also gets doubled.
    (b) As $U = \frac{1}{2}CV^2$, if V is doubled, U is quadrupled.

Multiple Choice Question

12. (d) Zero
13. (c) 12
14. (d) Both (a) and (b)

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