Electrostatic Potential and Capacitance

Standard difficulty · 20 questions · 40 marks · Time: 36 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer — 8 × 1 = 8 marks

1. The potential 15 cm from a point charge of −2 μC is: ($k = 9 \times 10^9$ N m^2/C^2)
(a) 1.2×10^5 V **(b)** -8×10^5 V **(c)** −1,200 V **(d)** -1.2×10^5 V

2. The work needed to carry a charge of 9 μC from a point at 470 V to a point at 500 V is:
(a) 2.7×10^{-4} J **(b)** -2.7×10^{-4} J **(c)** 8.73×10^{-3} J **(d)** 0.27 J

3. The equivalent capacitance of 1 μF, 10 μF joined in series is:
(a) 10 μF **(b)** 11 μF **(c)** 0.91 μF **(d)** 1.82 μF

4. A 1 μF capacitor is charged to 270 V. The energy stored in it is:
(a) 0.03645 J **(b)** 0.0729 J **(c)** 1.35×10^{-4} J **(d)** 36.45 J

5. The SI unit of electric potential is the:
(a) volt **(b)** farad **(c)** newton **(d)** coulomb

6. A 12 μF air capacitor is filled with a dielectric of constant 4. Its capacitance becomes:
(a) 192 μF **(b)** 3 μF **(c)** 48 μF **(d)** 16 μF

7. The electrostatic potential energy of charges −5 μC and 5 μC, 3 cm apart, is: ($k = 9 \times 10^9$ N m^2/C^2)
(a) −7.5 J **(b)** −75 J **(c)** 7.5 J **(d)** −2.5 J

8. Assertion (A): 7 μF and 2 μF capacitors in series have an equivalent capacitance of 9 μF.
Reason (R): For capacitors in series, $1/C = 1/C_1 + 1/C_2$.
(a) Both A and R are true, and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false, but R is true.

Section B — Short answer — 8 × 2 = 16 marks

9. Charges of −2 μC and −8 μC are at x = 0 and x = 24 cm. Find the potential at x = 16 cm. ($k = 9 \times 10^9$ N m^2/C^2)

10. 9 μF and 5 μF capacitors in parallel are joined in series with a 7 μF capacitor across 190 V. Find the equivalent capacitance and the charge on the 7 μF capacitor.

11. A 16 μF capacitor is charged to 170 V. A dielectric of constant 6 is then slid in after the battery is removed. Find the energy stored before and after.

12. How much work is done in moving a charge of 3 μC from 3 cm to 15 cm from a fixed charge of 4 μC? ($k = 9 \times 10^9$ N m^2/C^2)

13. A parallel-plate capacitor has plates of area 17×10^{-2} m^2, 2 mm apart, in air. Find its capacitance. ($\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/N m^2)

14. A 12 μF capacitor charged to 140 V is joined to an uncharged 10 μF capacitor. Find the common potential and the energy lost.

15. Charges of +8 μC and −3 μC are 44 cm apart. Where on the line between them is the potential zero?

16. Two parallel plates 4 mm apart are kept at a potential difference of 150 V. Find the field between them and the force on a charge of 2 μC there.

Section C — Word problems — 4 × 4 = 16 marks

17. 11 μF and 12 μF capacitors in series are joined in parallel with 8 μF; this group is in series with 11 μF, across 160 V. Find the equivalent capacitance, the total charge and the energy stored.

18. A parallel-plate capacitor (plate area 18×10^{-2} m^2, gap 3 mm, air) is charged to 180 V and the battery is removed. A dielectric of constant 5 then fills the gap. Find the capacitance, charge and potential difference after this. ($\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/N m^2)

19. Charges of 5 μC, 9 μC and −7 μC sit at the corners of an equilateral triangle of side 9 cm. Find the potential energy of the system. ($k = 9 \times 10^9$ N m^2/C^2)

20. A 5 μF capacitor at 20 V and a 1 μF capacitor at 50 V are joined positive to positive. Find the common potential, the charge on each, and the energy lost.

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Answer key

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Q	Answer	Working
1	**(d) -1.2×10^5 V**	$V = kq/r$
2	**(a) 2.7×10^{-4} J**	$W = q(V_B - V_A) = 9 \times 10^{-6} \times (30)$
3	**(c) 0.91 μF**	$1/C = \Sigma\, 1/C_i$
4	**(a) 0.03645 J**	$U = \frac{1}{2}CV^2$
5	**(a) volt**	—
6	**(c) 48 μF**	$C = KC_0$
7	**(a) −7.5 J**	$U = kq_1q_2/r = 9 \times 10^9 \times -5 \times 10^{-6} \times 5 \times 10^{-6} \div (3 \times 10^{-2})$
8	**(d) A is false, but R is true.**	A is false: 1/C = 1/7 + 1/2, so C = 1.56 μF. R is true.
9	**-1.0125×10^6 V**	$V = k(q_1/r_1 + q_2/r_2)$, with r_1 = 16 cm and r_2 = 8 cm
10	**4.67 μF; 8.87×10^{-4} C**	parallel pair 14 μF; series with 7 μF; Q = CV
11	**before 0.2312 J; after 0.0385 J**	Q stays 2720 μC, C becomes 96 μF, so $U = Q^2/2C$ falls 6 times
12	**−2.88 J**	$W = q(V_B - V_A)$; $V = kQ/r$
13	**7.5225×10^{-10} F**	$C = \varepsilon_0 A/d = 8.85 \times 10^{-12} \times 17 \times 10^{-2} \div (2 \times 10^{-3})$
14	**76.36 V; 0.0535 J**	$V = C_1V_1/(C_1 + C_2)$; loss = $\frac{1}{2}C_1V_1^2 - \frac{1}{2}(C_1 + C_2)V^2$
15	**32 cm from the +8 μC charge**	$8/x = 3/(44 - x)$
16	**3.75×10^4 V/m; 0.075 N**	$E = V/d$; $F = qE$
17	**6.11 μF; 9.77×10^{-4} C; 0.0782 J**	group = 5.74 + 8 = 13.74 μF
18	**C = 2.655×10^{-9} F; Q = 9.558×10^{-8} C (unchanged); V = 36 V**	$C_0 = 5.31 \times 10^{-10}$ F; $Q = C_0V$; $C = KC_0$; $V = Q/C$
19	**−5.3 J**	$U = k(q_1q_2 + q_2q_3 + q_3q_1)/a$; $q_1q_2 + q_2q_3 + q_3q_1 = -53$
20	**25 V; 125 μC and 25 μC; 3.75×10^{-4} J**	$V = (C_1V_1 + C_2V_2)/(C_1 + C_2)$

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