UNIT I – Electrostatics

Topics: Part II and Part III

Number of Questions 30

Time: 1 hour **Max. Marks 120**

(i) Each question is allotted 4 (four) marks for each correct response.

(ii) 1/4 (one fourth) marks will be deducted for indicating incorrect response of each question.

(iii) No deduction from the total score will be made if no response is indicated for an item in the answer sheet.

(iv) There is only one correct (most suitable) response for each question out of four responses given. The others are distractions,

(v) Do not use calculator.

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1. Net capacitance of three identical capacitors in series is 1μF. What will be their net capacitance if connected in parallel?

(A) 3μF

(B) 1/3 μF

(C) 6 μF

(D) 9 μF

2. When three identical capacitors are connected in series and connected across a constant voltage source of V volts, the energy stored in each capacitor is U_1 . When these capacitors are connected in parallel and connected to the same voltage source, the energy stored in each capacitor is U_2 . Then the ratio U_2/U_1 ,

(A) 1

(B) 3

(C) 9

(D) 18

3. A hollow metal sphere of radius 5 cm is charged such that the potential on its surface is 10 V. What is the potential at the center of the sphere?

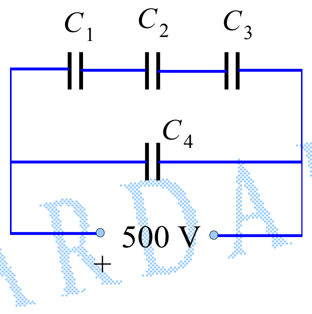
(A) 5 V

(B) 10 V

(C) 2 V

(D) 0 V

4. A network of four capacitors, each of 15 pF capacitance, is connected to a 500 V supply as shown in the Fig. The charge on the capacitor C_2 is



(A) 2.5 nC

(B) 5.0 nC

(C) 7.5 nC

(D) 0.83 nC

5. A charge Q=40 μC is paced at the origin and another charge q = 9 μC is placed at (x=0.80 m, y =0 m, z= 0.60 m). The electric potential energy of the system is

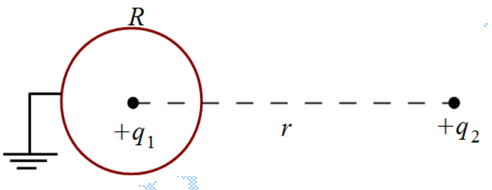
(A) 0 J

(B) 2.31 J

(C) 3.24 J

(D) 16.2 J

6. A conducting spherical shell of radius R is earthed and a positive charge $+q_1$ is placed at the center of the shell. Another positive charge $+q_2$ is placed outside at a distance r (> R) from the center of the shell. Then the Coulomb force on the q_2 is



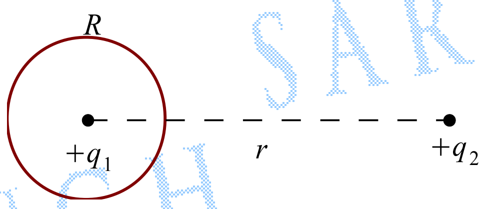
(A) zero

(B) $\frac{q_1 q_2}{4\pi\epsilon_0 r^2}$

(C) $\frac{q_1 q_2}{4\pi\epsilon_0 (R-r)^2}$

(D) $\frac{q_1 q_2}{4\pi\epsilon_0 (R^2-r^2)}$

7. A conducting spherical shell of radius R is uncharged. Now a positive charge $+q_1$ is placed at the center of the shell. Another positive charge $+q_2$ is placed outside at a distance r (> R) from the center of the shell. Then the Coulomb force on the q_2 is



(A) zero

(B) $\frac{q_1 q_2}{4\pi\epsilon_0 r^2}$

(C) $\frac{q_1 q_2}{4\pi\epsilon_0 (R-r)^2}$

(D) None of the above

8. A thin straight infinitely long conducting wire having charge density λ is enclosed by a cylindrical surface of radius r and length l, its axis coinciding with the length of the wire. The expression for the electric flux through the surface of the cylinder is

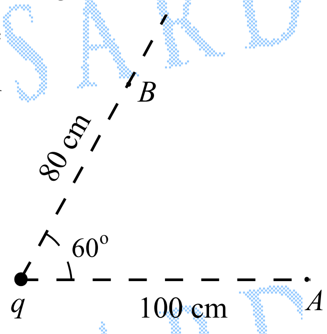
(A) $\frac{\lambda}{2\pi r^2}$

(B) $\frac{\lambda}{2\pi\epsilon_0 r}$

(C) $\frac{\lambda}{2\pi r l}$

(D) $\frac{\lambda l}{\epsilon_0}$

9. If the charge q is 2μC in the figure shown here, then the work required to move a charge of 1.32μC from point B to point A is



(A) 5.94 mJ

(B) 4.50 kJ

(C) – 5.94 mJ

(D) – 4.50 kJ

10. Mark the wrong statement:

(A) The electric field lines are everywhere perpendicular to the equipotential surface.

(B) The equipotential lines are everywhere perpendicular to the electric field lines.

(C) The magnitude of electric field at a point is equal to the magnitude of the gradient of electric potential at that point.

(D) The surface of a charged but grounded conductor is not an equipotential surface.

11. A conducting sphere of radius R is given a total charge Q. The amount of work done in charging the sphere is

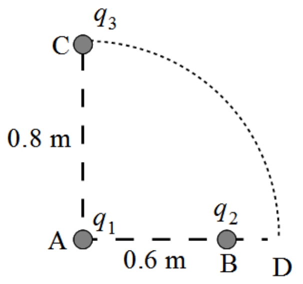
(A) zero

(B) $\frac{Q^2}{2\pi\epsilon_0 R}$

(C) $\frac{Q^2}{4\pi\epsilon_0 R}$

(D) $\frac{Q^2}{8\pi\epsilon_0 R}$

12. Three charges $q_1 = 20\,\text{nC}$, $q_2 = -4\,\text{nC}$ and $q_3 = 2\,\text{nC}$ are placed as shown. The charge q_3 is taken from C to D along the arc of radius 0.8 m (AC = 0.08 m and AB = 0.6 m). Then the potential energy of q_3



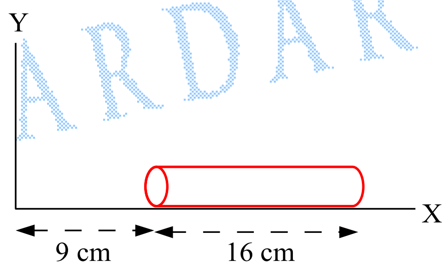
(A) does not change

(B) decreases by about 76%

(C) decreases by about 36 %

(D) increases by about 76%

13. The electric field in a certain region is given by $\vec{E} = 400\sqrt{x}\,\hat{i}$ volt/meter. A cylinder of radius 1 cm and length 16 cm is lying in this field, with axis parallel to the X-axis (as shown in figure below). Then the net outward flux through the cylinder is (in SI units)



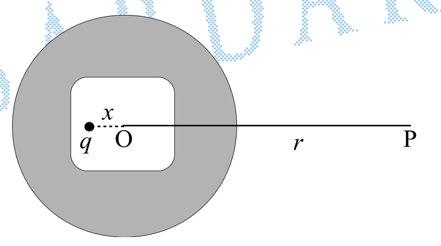
(A) zero

(B) 0.008π

(C) 0.016π

(D) 800π

14. A point charge q is placed within an electrically neutral conducting shell whose outer surface has spherical shape. The center of the outer surface is shown as O in the figure. The distance of the charge from the center O is x. What is the potential ϕ at a point P lying outside the shell at a distance r from the center O? (All physical quantities are measured in SI units.)



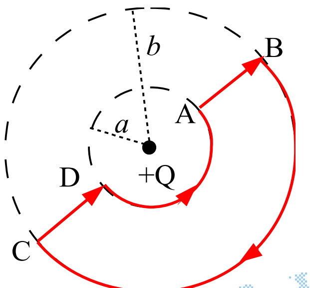
(A) $\phi = \frac{q}{4\pi\epsilon_0 r}$

(B) $\phi = \frac{qx}{4\pi\epsilon_0 r}$

(C) $\phi = \frac{q}{4\pi\epsilon_0 (r+x)}$

(D) $\phi = 0$

15. Two circles are drawn with centers at charge $+Q$. Now a small test charge q is taken from point A to point D along the path ABCD. If the radii of the circles are a and b, then the amount of work done is



(A) $kqQ\left(\frac{1}{a} - \frac{1}{b}\right)$

(B) $kqQ\left(\frac{1}{a} + \frac{1}{b}\right)$

(C) zero

(D) nothing can be predicted

16. A parallel plate capacitor with air between the plates has a capacitance of 8 pF. What will be the capacitance if the distance between the plates is reduced by half, and the space between them is filled with a substance of dielectric constant 6?

(A) 16 pF

(B) 48 pF

(C) 96 pF

(D) 24 pF

17. In a parallel plate capacitor with air between the plates, each plate has an area of 0.006 m² and the distance between the plates is 3 mm. This capacitor is connected to a 100 V dc supply. Now a 3 mm thick mica sheet of dielectric constant K=6 is inserted between the plates to fill the gap between the plates. Then, the charge on the positive plate is about

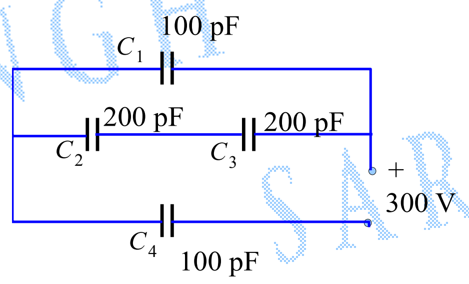
(A) $2\times10^{-9}\,\text{C}$

(B) $1\times10^{-8}\,\text{C}$

(C) $2\times10^{-12}\,\text{C}$

(D) $3\times10^{-10}\,\text{C}$

18. Consider the following network of capacitors. The charge on the positive plate of the capacitor C_3 is



(A) 10 nC

(B) 5 nC

(C) 1 nC

(D) 0.01 nC

19. A 600 pF capacitor is charged by a 200 V supply. The stored energy is U_1. The capacitor is then disconnected from the supply and is connected to another uncharged 600 pF capacitor. Now the energy stored in the assembly is U_2. Then

(A) $U_1 = U_2 = 12\,\mu\text{J}$

(B) $U_1 > U_2$ and $U_1 - U_2 = 6\,\mu\text{J}$

(C) $U_1 < U_2$ and $U_2 - U_1 = 6\,\mu\text{J}$

(D) $U_1 \neq U_2$ and $\frac{U_2}{U_1} = 2$.

20. The dielectric strength of air is 3000 kV/m. Up to what maximum potential a 3 mm radius copper sphere could be charged, just before dielectric breakdown of air begins?

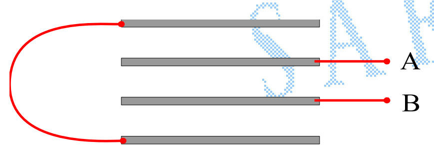
(A) 3 kV

(B) 6 kV

(C) 9 kV

(D) 12 kV

21. Four identical metal plates, each of area A on one side, and each separated by a distance d, are connected as shown below. The capacitance of the system between the points A and B is



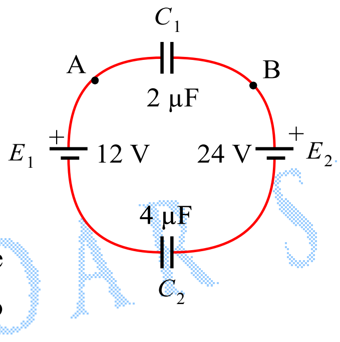
(A) $\frac{\epsilon_0 A}{d}$

(B) $\frac{3\epsilon_0 A}{d}$

(C) $\frac{2\epsilon_0 A}{3d}$

(D) $\frac{3\epsilon_0 A}{2d}$

22. Two capacitors C_1 and C_2 are connected in a circuit as shown in Fig. The potential difference $V_A - V_B$ is



(A) 8 V

(B) – 8 V

(C) 12 V

(D) – 12 V

23. A parallel plate capacitor is connected to a battery whose potential is constant. If the plates of the capacitor are shifted apart then the intensity of electric field between the plates

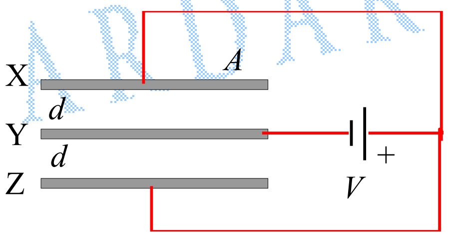
(A) decreases and the charge on the plates also decreases.

(B) remains constant but the charge on the plates decreases.

(C) remains constant but the charge on the plates increases.

(D) increases but the charge on the plates remains constant.

24. Consider the arrangement of three plates X, Y and Z each of area A and separation d. The energy stored, when the plates are fully charged, is



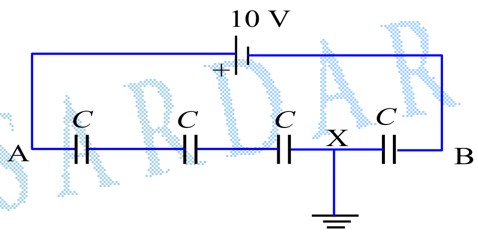
(A) $\frac{\epsilon_0 A V^2}{2d}$

(B) $\frac{\epsilon_0 A V^2}{d}$

(C) $\frac{2\epsilon_0 A V^2}{d}$

(D) $\frac{\epsilon_0 A V^2}{4d}$

25. Four identical capacitors are connected in series with a battery of emf 10 V. The point X is earthed.



Then the potential of point A is

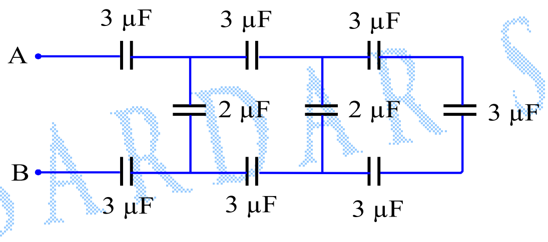
(A) 10 V

(B) 7.5 V

(C) 5.0 V

(D) 2.5 V

26. The resultant capacitance between A and B in the combination of capacitors shown in the figure below is



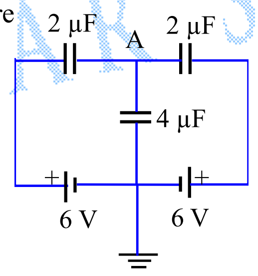
(A) 1 μF

(B) 1.5 μF

(C) 2 μF

(D) 3 μF

27. Three capacitors are connected as shown in the figure. Then, the potential at point A is



(A) 3 V

(B) 4.5 V

(C) 6.0 V

(D) 7.5 V

28. An electrical technician requires a capacitance of 2 μF in a circuit across a potential difference of 1 kV. A large number of 1μF capacitors are available to him each of which can withstand a potential difference of not more than 400V. A possible arrangement that requires the minimum number of capacitors is

(A) two capacitors in parallel

(B) three rows in parallel, each containing three capacitors in series.

(C) six rows in parallel each containing three capacitors in series.

(D) three rows in parallel each containing six capacitors in series.

29. A large number of identical metal sheets, each of area A are available to you, along with a roll of oil soaked paper to be used as a dielectric separator. If two such metal sheets are used with paper placed in between then the capacitance is found to be C. The minimum number of sheets required to make a capacitor of value $10C$, using these sheets and paper, is

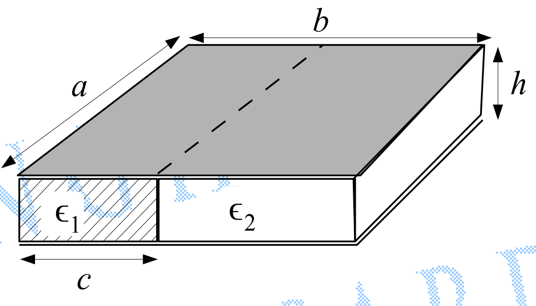
(A) 21

(B) 20

(C) 11

(D) 9

30. A parallel plate capacitor is filled with two dielectrics of permittivity ϵ_1 and ϵ_2 as shown in the figure below. Then the equivalent capacitance of the arrangement is



(A) $\frac{\epsilon_1 ac}{h}$

(B) $\frac{\epsilon_2 a(b-c)}{h}$

(C) $\frac{a\{c(\epsilon_1-\epsilon_2)+b\epsilon_2\}}{h}$

(D) $\frac{(\epsilon_1+\epsilon_2)ab}{h}$

End

ANSWERS

UNIT I – Electrostatics

Topics: Part II and Part III

Number of Questions 30

1. (D) 9 μF
2. (C) 9
3. (B) 10 V
4. (A) 2.5 nC
5. (C) 3.24 J
6 (A) zero (use Gauss law to show that E at the location of the second charge is zero)

7. (B) $\frac{q_1 q_2}{4\pi\epsilon_0 r^2}$

8. (D) $\frac{\lambda l}{\epsilon_0}$

9. (C) – 5.94 mJ

10. (D) wrong (The surface of conductor charged, uncharged, grounded or not grounded is always an equipotential surface).

11. (D) $\frac{Q^2}{8\pi\epsilon_0 R}$

12. (B) decreases by about 76%

13. (B) 0.008π

14. (A) $\phi=\frac{q}{4\pi\epsilon_0 r}$

15. (C) zero

16. (C) 96 pF

17. (B) $1\times10^{-8}\,C$

18. (A) 10 nC

19.(B) $U_1>U_2$ and $U_1-U_2=6\mu J$

20. (C) 9 kV

21. (D) $\frac{3\epsilon_0 A}{2d}$

22. (B) – 8 V

23. (A) decreases and the charge on the plates also decreases.

24. (B) $\frac{\epsilon_0 A V^2}{d}$

25. (B) 7.5 V

26. (A) 1 μF

27. (A) 3 V

28. (C) six rows in parallel each containing three capacitors in series.

29. (C) 11

30. (C) $\frac{a\{c(\epsilon_1-\epsilon_2)+b\epsilon_2\}}{h}$

End