DPP - Daily Practice Problems

Name :

Date :

Start Time :

End Time :

PHYSICS 34

SYLLABUS : ELECTROSTATICS -3 (Electrostatic Potential energy, conductors)

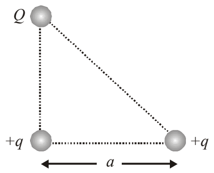
Max. Marks : 96 **Time : 60 min.**

GENERAL INSTRUCTIONS

- The Daily Practice Problem Sheet contains 24 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.
- You have to evaluate your Response Grids yourself with the help of solution booklet.
- Each correct answer will get you 4 marks and 1 mark shall be deduced for each incorrect answer. No mark will be given/ deducted if no bubble is filled. Keep a timer in front of you and stop immediately at the end of 60 min.
- The sheet follows a particular syllabus. Do not attempt the sheet before you have completed your preparation for that syllabus. Refer syllabus sheet in the starting of the book for the syllabus of all the DPP sheets.
- After completing the sheet check your answers with the solution booklet and complete the Result Grid. Finally spend time to analyse your performance and revise the areas which emerge out as weak in your evaluation.

DIRECTIONS (Q.1-Q.16) : There are 16 multiple choice questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** choice is correct.

Q.1 Three charges Q, $+q$ and $+q$ are placed at the vertices of right-angled isosceles triangle as shown in the figure. The net electrostatic energy of the configuration is zero if Q is equal to



(a) $\dfrac{-q}{1+\sqrt{2}}$ (b) $\dfrac{-2q}{2+\sqrt{2}}$

(c) –2q (d) $+q$

Q.2 Three charges of equal value 'q' are placed at the vertices of an equilateral triangle. What is the net potential energy, if the side of equilateral Δ is l ?

(a) $\dfrac{1}{4\pi\epsilon_0}\dfrac{q^2}{l}$ (b) $\dfrac{1}{4\pi\epsilon_0}\dfrac{2q^2}{l}$

(c) $\dfrac{1}{4\pi\epsilon_0}\dfrac{3q^2}{l}$ (d) $\dfrac{1}{4\pi\epsilon_0}\dfrac{4q^2}{l}$

Q.3 If identical charges $(-q)$ are placed at each corner of a cube of side b, then electric potential energy of charge $(+q)$ which is placed at centre of the cube will be

(a) $\dfrac{8\sqrt{2}q^2}{4\pi\epsilon_0 b}$ (b) $\dfrac{-8\sqrt{2}q^2}{\pi\epsilon_0 b}$

(c) $\dfrac{-4\sqrt{2}q^2}{\pi\epsilon_0 b}$ (d) $\dfrac{-4q^2}{\sqrt{3}\pi\epsilon_0 b}$

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ

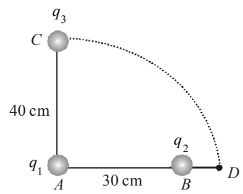
Q.4 Two charges q_1 and q_2 are placed 30 cm apart, shown in the figure. A third charge q_3 is moved along the arc of a circle of radius 40 cm from C to D. The change in the potential energy of the system is $\frac{q_3}{4\pi\epsilon_0}k$, here k is

(a) $8q_2$

(b) $8q_1$

(c) $6q_2$

(d) $6q_1$



Q.5 Three particles, each having a charge of $10\mu C$ are placed at the corners of an equilateral triangle of side 10 cm. The electrostatic potential energy of the system is (Given $\frac{1}{4\pi\epsilon_0} = 9\times10^9\, \mathrm{N\,m^2/C^2}$)

(a) Zero (b) Infinite (c) 27 J (d) 100 J

Q.6 Two equal charges q are placed at a distance of $2a$ and a third charge $-2q$ is placed at the midpoint. The potential energy of the system is

(a) $\frac{q^2}{8\pi\epsilon_0 a}$ (b) $\frac{6q^2}{8\pi\epsilon_0 a}$

(c) $-\frac{7q^2}{8\pi\epsilon_0 a}$ (d) $\frac{9q^2}{8\pi\epsilon_0 a}$

Q.7 An electric dipole has the magnitude of its charge is q and its dipole moment is p. It is placed in a uniform electric field E. If its dipole moment is along the direction of the field, the force on it and its potential energy are respectively

(a) $2q.E$ and minimum (b) $q.E$ and $p.E$

(c) Zero and minimum (d) $q.E$ and maximum

Q8 In bringing an electron towards another electron, electrostatic potential energy of the system:

(a) decreases (b) increases

(c) remains unchanged (d) becomes zero

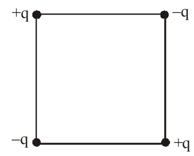
Q.9 Two identical charges are placed at the two corners of an equilateral triangle. The potential energy of the system is U. The work done in bringing an identical charge from infinity to the third vertex is

(a) U (b) 2U (c) 3U (d) zero

Q.10 Potential energy of two equal negative point charges $2\mu C$ held 1 m apart in air is

(a) 2 J (b) 2eV (c) 4 J (d) 0.036 J

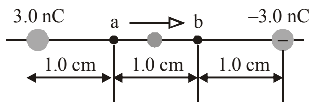
Q.11 Four charges + q, –q, + q and –q are put together on four corners of a square as shown in figure. The work done by external agent in slowly assembling this configuration is



(a) zero (b) $-2.59kq^2/a$

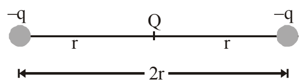
(c) $+2.59kq^2/a$ (d) none of these

Q.12 As shown in figure a dust particle with mass $m = 5.0 \times 10^{-9}$ kg and charge $q_0 = 2.0$ nC starts from rest at point a and moves in a straight line to point b. What is its speed v at point b?



(a) 26 ms^{-1} (b) 34 ms^{-1} (c) 46 ms^{-1} (d) 14 ms^{-1}

Q.13 Charges –q, Q and –q are placed at equal distance on a straight line. If the total potential energy of the system of three charges is zero, then find the ratio Q/q.



(a) 1/2 (b) 1/4 (c) 2/3 (d) 3/4

Q.14 When the separation between two charges is increased, the electric potential energy of the charges

(a) increases (b) decreases

(c) remains the same (d) may increase or decrease

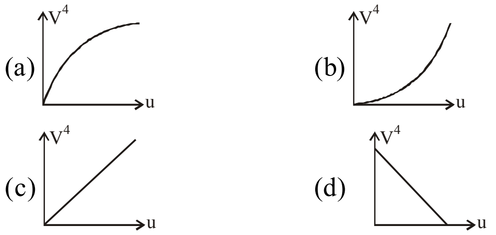
RESPONSE GRID

4. ⓐⓑⓒⓓ 5. ⓐⓑⓒⓓ 6. ⓐⓑⓒⓓ 7. ⓐⓑⓒⓓ 8. ⓐⓑⓒⓓ
9. ⓐⓑⓒⓓ 10. ⓐⓑⓒⓓ 11. ⓐⓑⓒⓓ 12. ⓐⓑⓒⓓ 13. ⓐⓑⓒⓓ
14. ⓐⓑⓒⓓ

Q.15 A positive charge is moved from a low potential point A to high potential point B. Then the electric potential energy of the system

(a) increases
(b) decreases
(c) will remain the same
(d) nothing definite can be predicted

Q.16 If V and u are electric potential and energy density, respectively, at a distance r from a positive point charge, then which of the following graph is correct ?

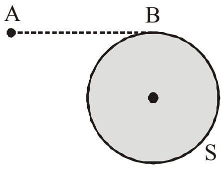


DIRECTIONS (Q.17-Q.18) : In the following questions, more than one of the answers given are correct. Select the correct answers and mark it according to the following codes:

Codes :

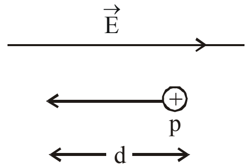
(a) 1, 2 and 3 are correct **(b)** 1 and 2 are correct
(c) 2 and 4 are correct **(d)** 1 and 3 are correct

Q.17 S is a solid neutral conducting sphere. A point charge q of 1×10^{-6} C is placed at point A. C is the centre of sphere and AB is a tangent. BC = 3m and AB = 4m.



(1) The electric potential of the conductor is 1.8 kV
(2) The electric potential of the conductor is 2.25 kV
(3) The electric potential at B due to induced charges on the sphere is – 0.45 kV
(4) The electric potential at B due to induced charges on the sphere is 0.45 kV

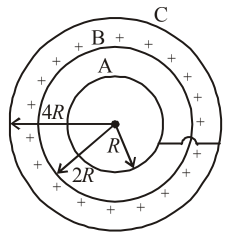
Q.18 A proton moves a distance d in a uniform electric field $\vec{E}$ as shown in the figure. Then which of the following statements are correct ?



(1) Electric field do a negative work on the proton
(2) Electric potential energy of the proton increases
(3) Electric field do a positive work on the proton
(4) Electric potential energy of the proton decreases

DIRECTIONS (Q.19-Q.21) : Read the passage given below and answer the questions that follows :

Three concentric spherical conductors A, B and C of radii R, 2R and 4R respectively. A and C is shorted and B is uniformly charged.



Q.19 Charge on conductor A is

(a) $Q/3$ (b) $-Q/3$
(c) $2Q/3$ (d) None of these

Q.20 Potential at A is

(a) $\dfrac{Q}{4\pi\varepsilon_0 R}$ (b) $\dfrac{Q}{16\pi\varepsilon_0 R}$
(c) $\dfrac{Q}{20\pi\varepsilon_0 R}$ (d) None of these

Q.21 Potential at B is

(a) $\dfrac{Q}{4\pi\varepsilon_0 R}$ (b) $\dfrac{Q}{16\pi\varepsilon_0 R}$
(c) $\dfrac{5Q}{48\pi\varepsilon_0 R}$ (d) None of these

RESPONSE GRID					
	15. ⓐⓑⓒⓓ	**16.** ⓐⓑⓒⓓ	**17.** ⓐⓑⓒⓓ	**18.** ⓐⓑⓒⓓ	**19.** ⓐⓑⓒⓓ
	20. ⓐⓑⓒⓓ	**21.** ⓐⓑⓒⓓ			

DIRECTIONS (Q. 22-Q.24) : Each of these questions contains two statements: Statement-1 (Assertion) and Statement-2 (Reason). Each of these questions has four alternative choices, only one of which is the correct answer. You have to select the correct choice.

(a) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(b) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.
(c) Statement -1 is False, Statement-2 is True.
(d) Statement -1 is True, Statement-2 is False.

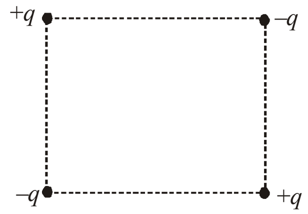
Q.22 **Statement-1 :** No work is done in taking a small positive charge from one point to other inside a positively charged metallic sphere while outside the sphere work is done in taking the charge towards the sphere. Neglect induction due to small charge.

Statement-2 : Inside the sphere electric potential is same at each point, but outside it is different for different points.

Q.23 **Statement-1 :** Electric potential of earth is taken to be zero as a reference.

Statement-2 : The electric field produced by earth in surrounding space is zero.

Q.24 **Statement - 1 :** The electric potential and the electric field intensity at the centre of a square having four fixed point charges at their vertices as shown in figure are zero.



Statement - 2 : If electric potential at a point is zero then the magnitude of electric field at that point must be zero.

RESPONSE GRID	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ	24. ⓐⓑⓒⓓ

DAILY PRACTICE PROBLEM SHEET 34 - PHYSICS			
Total Questions	24	Total Marks	96
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	22	Qualifying Score	39
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

1. **(b)** Net electrostatic energy

$$U = \frac{kQq}{a} + \frac{kq^2}{a} + \frac{kQq}{a\sqrt{2}} = 0$$

$$\Rightarrow \frac{kq}{a}\left(Q + q + \frac{Q}{\sqrt{2}}\right) = 0 \Rightarrow Q = -\frac{2q}{2+\sqrt{2}}$$

2. **(c)** Electric field is perpendicular to the equipotential surface and is zero every where inside the metal.

3. **(c)** $\Rightarrow \frac{kq}{l}(Q+q+Q) = 0 \Rightarrow Q = -\frac{q}{2}$ net potential energy

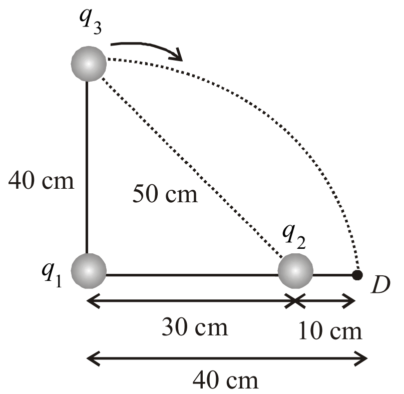
$$U_{net} = 3 \times \frac{1}{4\pi\varepsilon_0}.\frac{q^2}{l}$$

4. **(d)** Length of the diagonal of a cube having each side b is $\sqrt{3}b$. So distance of centre of cube from each vertex is $\frac{\sqrt{3}b}{2}$.

Hence potential energy of the given system of charge is

$$U = 8 \times \left\{\frac{1}{4\pi\varepsilon_0}.\frac{(-q)(q)}{\sqrt{3}b/2}\right\} = \frac{-4q^2}{\sqrt{3}\pi\varepsilon_0 b}$$

5. **(a)** Change in potential energy $(\Delta U) = U_f - U_i$



$$\Rightarrow \Delta U = \frac{1}{4\pi\varepsilon_0}\left[\left(\frac{q_1q_3}{0.4} + \frac{q_2q_3}{0.1}\right) - \left(\frac{q_1q_3}{0.4} + \frac{q_2q_3}{0.5}\right)\right]$$

$$\Rightarrow \Delta U = \frac{1}{4\pi\varepsilon_0}[8q_2q_3] = \frac{q_3}{4\pi\varepsilon_0}(8q_2)$$

$$\therefore k = 8q_2$$

6. **(c)** For pair of charge $U = \frac{1}{4\pi\varepsilon_0}.\frac{q_1q_2}{r}$

$$U_{System} = \frac{1}{4\pi\varepsilon_0}\left[\frac{10\times10^{-6}10\times10^{-6}}{10/100} + \frac{10\times10^{-6}\times10\times10^{-6}}{10/100} + \frac{10\times10^{-6}\times10\times10^{-6}}{10/100}\right]$$

$$= 3\times9\times10^9\times\frac{100\times10^{-12}\times100}{10} = 27J$$

7. **(c)** $U_{System} = \frac{1}{4\pi\varepsilon_0}\frac{(q)(-2q)}{a} + \frac{1}{4\pi\varepsilon_0}\frac{(-2q)(q)}{a} + \frac{1}{4\pi\varepsilon_0}\frac{(q)(q)}{2a}$

$$U_{System} = -\frac{7q^2}{8\pi\varepsilon_0 a}$$

8. **(c)** In the given condition angle between $\vec{p}$ and $\vec{E}$ is zero. Hence potential *energy* $U = -pE\cos 0 = -pE = \text{min}$. Also in uniform *electric* field $F_{net} = 0$

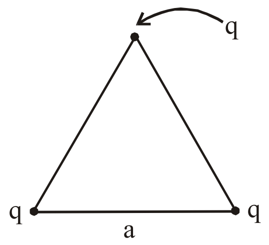
9. **(b)** $U = \frac{1}{4\pi\epsilon_0}\frac{(-e)(-e)}{r^2}$ As r decreases then U increases and sign of U is '+ve' so, U increases.

10. **(c)** $U = 2kq^2\left[-\frac{1}{a} + \frac{1}{2a} - \frac{1}{3a} + \frac{1}{4a} + ...\right]$

$$= -\frac{2q^2}{4\pi\varepsilon_0 a}\left[1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} + ...\right]$$

$$= -\frac{2q^2\log_e 2}{4\pi\varepsilon_0 a}$$

11. **(b)** The initial energy of the system



$$U_i = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{a} = U$$

The final energy of the system

$$U_f = \frac{1}{4\pi\varepsilon_0}\left[\frac{q^2}{a} + \frac{q^2}{a} + \frac{q^2}{a}\right] = 3U$$

Thus work done, $W = U_f - U_i = 3U - U = 2U$

12. **(d)** $U = \frac{kq_1q_2}{r}$

13. **(c)** As potential at A and B is same, $V_A = V_B = \frac{kQ}{d}$. So, work done in both cases will be same.

14. **(b)** $U = \varepsilon\frac{kq_1q_2}{r}$. There will be 6 pairs, 4 on a side of square and 2 as diagonal.

15. (c) Apply conservation of mechanical energy between point a and b : $(K.E. + P.E.)_a = (K.E. + P.E.)_a$

$$\Rightarrow 0 + \frac{k(3\times10^{-9})q_0}{0.01} - \frac{k(3\times10^{-9})q_0}{0.02}$$

$$= \frac{1}{2}mv^2 + \frac{k(3\times10^{-9})q_0}{0.02} - \frac{k(3\times10^{-9})q_0}{0.01}$$

Put the values we get : $v = 12\sqrt{15} = 46$ m/s

16. (b) $U = -\frac{kqQ}{r} - \frac{kqQ}{r} + \frac{kq^2}{2r} = 0 \Rightarrow Q/q = 1/4$

17. (b) Find potential at A and C due to charge at B, then required work done is $W = q(V_A - V_C)$

18. (d) It depends whether both charges are of same or opposite sign.

19. (a) Because work is to be done by an external agent in moving a positive charge from low potential to high potential and this work gets stored in the form of potential energy of the system. Hence, it increases.

20. (a) $U = kq^2\left(-\frac{3}{d} + \frac{3}{\sqrt{2}d} - \frac{1}{\sqrt{3}d}\right)$

$$+kq^2\left(-\frac{2}{d} + \frac{3}{\sqrt{2}d} - \frac{1}{\sqrt{3}d}\right) + kq^2\left(-\frac{2}{d} + \frac{2}{\sqrt{2}d} - \frac{1}{\sqrt{3}d}\right)$$

$$+kq^2\left(-\frac{1}{d} + \frac{2}{\sqrt{2}d} - \frac{1}{\sqrt{3}d}\right) + kq^2\left(-\frac{2}{d} + \frac{1}{\sqrt{2}d}\right)$$

$$+kq^2\left(-\frac{1}{d} + \frac{2}{\sqrt{2}d}\right) + kq^2\left(-\frac{1}{d}\right)$$

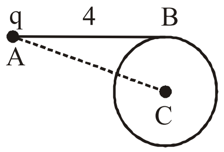
$$U = kq^2\left(-\frac{12}{d} + \frac{12}{\sqrt{2}d} - \frac{4}{\sqrt{3}d}\right)$$

$$= -\frac{12kq^2}{d}\left(1 - \frac{1}{\sqrt{2}} + \frac{1}{3\sqrt{3}}\right)$$

21. (c) $V = \frac{kQ}{r} \Rightarrow u = \frac{1}{2}\varepsilon_0 E^2 = \frac{1}{2}\frac{\varepsilon_0 k^2 Q^2}{r^4}$

$V^4 \propto u$

22.



$AC = 5\text{m},\ V = \frac{kq}{AC} = \frac{9\times10^9 \times 1\times10^{-6}}{5}$

$= 1.8 \times 10^3 = 1.8$ kV

$V_B = (V_B)_{\text{due to q}} + (V_B)_i$, where $(V_B)_i$ = Potential at B due to induced charge

$\therefore\ 1.8 \times 10^3 = \frac{kq}{AB} + (V_B)_i$

$\Rightarrow 1.8 \times 10^3 = 2.25 \times 10^3 + (V_B)_i$

$\Rightarrow (V_B)_i = -0.45$ kV

23. (b) Force = eE

Work done = force × distance

Force and distance are in opposite direction, so work is negative.

$W = -eE \times d$

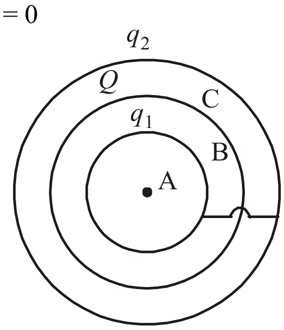
Here, distance increases so, potential energy increases.

24. (d) Under electrostatic condition, all points lying on the conductor are in same potential. Therefore, potential at A = potential at B.

From Gauss's theorem, total flux through the surface of the cavity will be q/ε_0.

Note : Instead of an elliptical cavity, if it would and been a spherical cavity then options (a) and (b) were also correct.

25. (b) $q_1 + q_2 = 0$



$$V_A = \frac{kq_1}{R} + \frac{kQ}{2R} + \frac{kq_2}{4R}$$

$$V_C = \frac{kq_1}{4R} + \frac{kQ}{4R} + \frac{kq_2}{4R}$$

$V_A = V_C$

$\therefore\ q_1 = -Q/3$ and $q_2 = Q/3$

26. (b) $V_A = k\left[\frac{-Q}{3R} + \frac{Q}{2R} + \frac{Q}{12R}\right] = \frac{Q}{16\pi\varepsilon_0 R}$

27. (c) $V_B = k\left[\frac{-Q}{6R} + \frac{Q}{2R} + \frac{Q}{12R}\right] = \frac{5Q}{48\pi\varepsilon_0 R}$

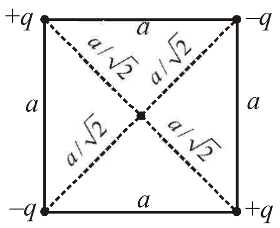
28. (a) Inside electric field is zero but not outside.

29. (c) Earth also has some surface charge density due to which it produces electric field in the surrounding space.

30. (d) Net potential at centre

$$+\frac{kq}{a/\sqrt{2}} - \frac{kq}{a/\sqrt{2}} + \frac{kq}{a/\sqrt{2}} - \frac{kq}{a/\sqrt{2}} = 0$$

and field is zero due to symmetry.



If electric potential at a point is zero then the magnitude of electric field at that point is not necessarily to be zero.