

Electrostatic Potential and Capacitance — NEET Physics PYQ (2006-2021)

Class 12 Physics · 26 real NEET & AIPMT questions, year-tagged · answers checked by RankUp

NEET 2021

1. A parallel plate capacitor has a uniform electric field 'E' in the space between the plates. If the distance between the plates is 'd' and the area of each plate is 'A', the energy stored in the capacitor is : (ϵ_0 = permittivity of free space)

- (A) $(1/2) \epsilon_0 E^2$
- (B) $\epsilon_0 E A d$
- (C) $(1/2) \epsilon_0 E^2 A d$
- (D) $E^2 A d / \epsilon_0$

NEET 2021

2. Two charged spherical conductors of radius R_1 and R_2 are connected by a wire. Then the ratio of surface charge densities of the spheres (σ_1/σ_2) is :

- (A) R_1/R_2
- (B) R_2/R_1
- (C) $\sqrt{R_1/R_2}$
- (D) R_1^2/R_2^2

NEET 2021

3. Twenty seven drops of same size are charged at 220 V each. They combine to form a bigger drop. Calculate the potential of the bigger drop.

- (A) 660 V
- (B) 1320 V
- (C) 1520 V
- (D) 1980 V

NEET 2020 · Q152

4. In a certain region of space with volume 0.2 m^3 , the electric potential is found to be 5 V throughout. The magnitude of electric field in this region is :

- (A) zero
- (B) 0.5 N/C
- (C) 1 N/C
- (D) 5 N/C

NEET 2020 · Q166

5. The capacitance of a parallel plate capacitor with air as medium is $6 \mu\text{F}$. With the introduction of a dielectric medium, the capacitance becomes $30 \mu\text{F}$. The permittivity of the medium is : ($\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$)

- (A) $0.44 \times 10^{-13} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$
- (B) $1.77 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$
- (C) $0.44 \times 10^{-10} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$
- (D) $5.00 \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$

NEET 2020 · Q170

6. A short electric dipole has a dipole moment of $16 \times 10^{-9} \text{ C m}$. The electric potential due to the dipole at a point at a distance of 0.6 m from the centre of the dipole, situated on a line making an angle of 60° with the dipole axis is : ($1/4\pi\epsilon_0 = 9 \times 10^9 \text{ N m}^2/\text{C}^2$)

- (A) 50 V
- (B) 200 V
- (C) 400 V
- (D) zero

NEET 2018 · Q23

7. The electrostatic force between the metal plates of an isolated parallel plate capacitor C having a charge Q and area A, is

- (A) proportional to the square root of the distance between the plates.
- (B) linearly proportional to the distance between the plates.
- (C) independent of the distance between the plates.
- (D) inversely proportional to the distance between the plates.

NEET 2017 · Q152

8. A capacitor is charged by a battery. The battery is removed and another identical uncharged capacitor is connected in parallel. The total electrostatic energy of resulting system:

- (A) increases by a factor of 4
- (B) decreases by a factor of 2
- (C) remains the same
- (D) increases by a factor of 2

NEET 2017 (Gujarati paper) · Q145

9. A parallel-plate capacitor is to be designed, using a dielectric of dielectric constant 5, so as to have a dielectric strength of 10^9 V m^{-1} . If the voltage rating of the capacitor is 12 kV, the minimum area of each plate required to have a capacitance of 80 pF is:

- (A) $21.7 \times 10^{-6} \text{ m}^2$
- (B) $25.0 \times 10^{-5} \text{ m}^2$
- (C) $12.5 \times 10^{-5} \text{ m}^2$
- (D) $10.5 \times 10^{-6} \text{ m}^2$

AIPMT 2015

10. A parallel plate air capacitor of capacitance C is connected to a cell of emf V and then disconnected from it. A dielectric slab of dielectric constant K, which can just fill the air gap of the capacitor, is now inserted in it. Which of the following is incorrect?

- (A) The charge on the capacitor is not conserved
- (B) The potential difference between the plates decreases K times
- (C) The energy stored in the capacitor decreases K times
- (D) The change in energy stored is $(1/2)CV^2(1/K - 1)$

AIPMT 2014

11. A conducting sphere of radius R is given a charge Q. The electric potential and the electric field at the centre of the sphere respectively are:

- (A) $Q/(4\pi\epsilon_0 R)$ and Zero
- (B) $Q/(4\pi\epsilon_0 R)$ and $Q/(4\pi\epsilon_0 R^2)$
- (C) Both are zero
- (D) Zero and $Q/(4\pi\epsilon_0 R^2)$

AIPMT 2014

12. In a region, the potential is represented by $V(x, y, z) = 6x - 8xy - 8y + 6yz$, where V is in volts and x, y, z are in meters. The electric force experienced by a charge of 2 coulomb situated at point (1, 1, 1) is:

- (A) 30 N
- (B) 24 N
- (C) $4\sqrt{35}$ N
- (D) $6\sqrt{5}$ N

AIPMT 2012 Mains

13. A parallel plate capacitor has a uniform electric field E in the space between the plates. If the distance between the plates is d and area of each plate is A , the energy stored in the capacitor is

- (A) $(1/2)\epsilon_0 E^2$
- (B) $E^2 Ad/\epsilon_0$
- (C) $(1/2)\epsilon_0 E^2 Ad$
- (D) $\epsilon_0 EAd$

AIPMT 2012 Mains

14. Two metallic spheres of radii 1 cm and 3 cm are given charges of -1×10^{-2} C and 5×10^{-2} C, respectively. If these are connected by a conducting wire, the final charge on the bigger sphere is

- (A) 2×10^{-2} C
- (B) 3×10^{-2} C
- (C) 4×10^{-2} C
- (D) 1×10^{-2} C

AIPMT 2012 Prelims

15. An electric dipole of moment p is placed in an electric field of intensity E . The dipole acquires a position such that the axis of the dipole makes an angle θ with the direction of the field. Assuming that the potential energy of the dipole to be zero when $\theta = 90^\circ$, the torque and the potential energy of the dipole will respectively be

- (A) $pE \cos \theta$, $-pE \sin \theta$
- (B) $pE \sin \theta$, $-pE \cos \theta$
- (C) $pE \sin \theta$, $-2pE \cos \theta$
- (D) $pE \sin \theta$, $2pE \cos \theta$

AIPMT 2012 Prelims

16. Four point charges $-Q$, $-q$, $2q$ and $2Q$ are placed, one at each corner of a square. The relation between Q and q for which the potential at the centre of the square is zero is

- (A) $Q = 1/q$
- (B) $Q = -q$
- (C) $Q = -1/q$
- (D) $Q = q$

AIPMT 2011 Mains

17. The electric potential V at any point (x, y, z) , in meters in space is given by $V = 4x^2$ volt. The electric field at the point $(1, 0, 2)$ in volt/meter, is

- (A) 16 along positive X-axis
- (B) 8 along negative X-axis
- (C) 8 along positive X-axis
- (D) 16 along negative X-axis

AIPMT 2011 Prelims

18. A parallel plate condenser has a uniform electric field E (V/m) in the space between the plates. If the distance between the plates is d (m) and area of each plate is A (m^2) the energy (joules) stored in the condenser is

- (A) $(1/2)\epsilon_0 E^2 Ad$
- (B) $E^2 Ad/\epsilon_0$
- (C) $(1/2)\epsilon_0 E^2$
- (D) $\epsilon_0 EAd$

19. Two parallel metal plates having charges $+Q$ and $-Q$ face each other at a certain distance between them. If the plates are now dipped in kerosene oil tank, the electric field between the plates will

- (A) Become zero
- (B) Increase
- (C) Decrease
- (D) Remain same

20. A series combination of n_1 capacitors, each of value C_1 , is charged by a source of potential difference $4V$. When another parallel combination of n_2 capacitors, each of value C_2 , is charged by a source of potential difference V , it has the same (total) energy stored in it, as the first combination has. The value of C_2 , in terms of C_1 , is then

- (A) $16C_1/(n_1n_2)$
- (B) $2C_1/(n_1n_2)$
- (C) $16(n_2/n_1)C_1$
- (D) $2(n_2/n_1)C_1$

21. Three concentric spherical shells have radii a , b and c ($a < b < c$) and have surface charge densities σ , $-\sigma$ and σ respectively. If V_A , V_B and V_C denote the potentials of the three shells, then for $c = a + b$, we have:

- (A) $V_C = V_B \neq V_A$
- (B) $V_C \neq V_B \neq V_A$
- (C) $V_C = V_B = V_A$
- (D) $V_C = V_A \neq V_B$

22. Three capacitors each of capacitance C and of breakdown voltage V are joined in series. The capacitance and breakdown voltage of the combination will be:

- (A) $3C$, $V/3$
- (B) $C/3$, $3V$
- (C) $3C$, $3V$
- (D) $C/3$, $V/3$

23. The electric potential at a point (x, y, z) is given by $V = -x^2y - xz^3 + 4$. The electric field E at that point is:

- (A) $E = \hat{i} 2xy + \hat{j}(x^2 + y^2) + \hat{k}(3xz - y^2)$
- (B) $E = \hat{i} z^3 + \hat{j} xyz + \hat{k} z^2$
- (C) $E = \hat{i}(2xy - z^3) + \hat{j} xy^2 + \hat{k} 3z^2x$
- (D) $E = \hat{i}(2xy + z^3) + \hat{j} x^2 + \hat{k} 3xz^2$

24. The energy required to charge a parallel plate condenser of plate separation d and plate area of cross-section A such that the uniform electric field between the plates is E , is

- (A) $(1/2)\epsilon_0 E^2 Ad$
- (B) $(1/2)\epsilon_0 E^2/Ad$
- (C) $\epsilon_0 E^2/Ad$
- (D) $\epsilon_0 E^2 Ad$

25. The electric potential at a point in free space due to a charge Q coulomb is $Q \times 10^{11}$ volts. The electric field at that point is

- (A) $12\pi\epsilon_0 Q \times 10^{22}$ volt/m
- (B) $4\pi\epsilon_0 Q \times 10^{22}$ volt/m
- (C) $12\pi\epsilon_0 Q \times 10^{20}$ volt/m
- (D) $4\pi\epsilon_0 Q \times 10^{20}$ volt/m

26. A parallel plate air capacitor is charged to a potential difference of V volts. After disconnecting the charging battery the distance between the plates of the capacitor is increased using an insulating handle. As a result the potential difference between the plates :

- (A) decreases
- (B) does not change
- (C) becomes zero
- (D) increases

Answer key and explanations

1. Answer: (C) $(1/2) \epsilon_0 E^2 Ad$

Energy density in the field is $(1/2)\epsilon_0 E^2$, and the field fills a volume Ad between the plates. So $U = (1/2)\epsilon_0 E^2 Ad$. The expression $(1/2)\epsilon_0 E^2$ alone is only energy per unit volume.

2. Answer: (B) R_2/R_1

Connected conductors reach a common potential: $kQ_1/R_1 = kQ_2/R_2$, so $Q \propto R$. Since $\sigma = Q/(4\pi R^2) \propto 1/R$, $\sigma_1/\sigma_2 = R_2/R_1$. Charge is proportional to R , but surface density is inversely proportional to R .

3. Answer: (D) 1980 V

Volume conservation: $R = 27^{1/3} r = 3r$; charge $Q = 27q$. $V = kQ/R = (27/3)kq/r = 9 \times 220 = 1980$ V. Multiplying by 3 (660 V) uses the radius ratio instead of $n^{2/3}$.

4. Answer: (A) zero

$E = -dV/dr$, and a potential that is the same everywhere in the region has zero gradient, so the field is zero. Dividing the potential by the volume or any length has no physical meaning here.

5. Answer: (C) $0.44 \times 10^{-10} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$

The dielectric constant is $K = 30/6 = 5$, so $\epsilon = K\epsilon_0 = 5 \times 8.85 \times 10^{-12} = 4.425 \times 10^{-11} \approx 0.44 \times 10^{-10} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$. The value 5.00 is the dimensionless K , not the permittivity, and dividing ϵ_0 by 5 gives 1.77×10^{-12} .

6. Answer: (B) 200 V

$V = kp \cos \theta / r^2 = 9 \times 10^9 \times 16 \times 10^{-9} \times \cos 60^\circ / (0.6)^2 = 144 \times 0.5 / 0.36 = 200$ V. Leaving out $\cos 60^\circ$ gives 400 V, and zero applies only on the equatorial line ($\theta = 90^\circ$).

7. Answer: (C) independent of the distance between the plates.

Each plate sits in the uniform field $\sigma/2\epsilon_0$ of the other, so $F = Q^2/(2\epsilon_0 A)$, which contains no separation term. For an isolated capacitor Q is fixed, so the force does not change with distance.

8. Answer: (B) decreases by a factor of 2

With the battery removed, charge Q is conserved and is shared over capacitance $2C$. Energy goes from $Q^2/2C$ to $Q^2/(2 \times 2C)$, i.e. it halves; the lost half is dissipated during charge flow. Energy cannot stay the same even though charge is conserved.

9. Answer: (A) $21.7 \times 10^{-6} \text{ m}^2$

The minimum plate separation is $d = V/E_{\text{max}} = 12 \times 10^3 / 10^9 = 1.2 \times 10^{-5} \text{ m}$. Then $A = Cd/(K\epsilon_0) = (80 \times 10^{-12} \times 1.2 \times 10^{-5}) / (5 \times 8.85 \times 10^{-12}) \approx 2.17 \times 10^{-5} \text{ m}^2 = 21.7 \times 10^{-6} \text{ m}^2$. Leaving out the dielectric constant would make the area five times larger.

10. Answer: (A) The charge on the capacitor is not conserved

After disconnection the plates are isolated, so the charge stays constant; the statement that charge is not conserved is the incorrect one. With Q fixed, $V = Q/KC$ falls K times and $U = Q^2/2KC$ falls K times, so the change is $\frac{1}{2}CV^2(1/K - 1)$.

11. Answer: (A) $Q/(4\pi\epsilon_0 R)$ and Zero

The charge sits on the surface and the field inside a conductor is zero, so the field at the centre is zero. Since $E = 0$ inside, the potential is constant throughout and equals the surface value $Q/(4\pi\epsilon_0 R)$; a zero potential at the centre is the common trap.

12. Answer: (C) $4\sqrt{35}$ N

$E = -\nabla V$: $E_x = -(6 - 8y) = 2$, $E_y = -(-8x - 8 + 6z) = 10$, $E_z = -6y = -6$ at $(1, 1, 1)$. $|E| = \sqrt{(4 + 100 + 36)} = \sqrt{140} = 2\sqrt{35}$ V/m, so $F = qE = 4\sqrt{35}$ N.

13. Answer: (C) $(1/2)\epsilon_0 E^2 Ad$

Energy density between the plates is $\frac{1}{2}\epsilon_0 E^2$ and the field occupies volume Ad , so $U = \frac{1}{2}\epsilon_0 E^2 Ad$. The expression $\frac{1}{2}\epsilon_0 E^2$ alone is energy per unit volume, not total energy.

14. Answer: (B) 3×10^{-2} C

Total charge = $-1 \times 10^{-2} + 5 \times 10^{-2} = 4 \times 10^{-2}$ C. When connected the spheres reach the same potential, so charge divides in the ratio of radii 1 : 3, giving the bigger sphere $\frac{3}{4} \times 4 \times 10^{-2} = 3 \times 10^{-2}$ C.

15. Answer: (B) $pE \sin \theta$, $-pE \cos \theta$

Torque on a dipole is $\tau = pE \sin \theta$, and with U taken as zero at $\theta = 90^\circ$, the potential energy is $U = -pE \cos \theta$. The forms with $2pE \cos \theta$ wrongly double the energy, and $pE \cos \theta$ is not the torque.

16. Answer: (B) $Q = -q$

All four charges are at the same distance from the centre, so the potential is proportional to the sum of charges: $-Q - q + 2q + 2Q = Q + q$. For zero potential, $Q = -q$. $Q = q$ would make the sum $2q$, not zero.

17. Answer: (B) 8 along negative X-axis

$E = -dV/dx = -8x$, which at $x = 1$ m is -8 V/m, i.e. 8 V/m along the negative x-axis. The value 16 V/m comes from wrong differentiation, and the positive direction ignores the minus sign in $E = -\nabla V$.

18. Answer: (A) $(1/2)\epsilon_0 E^2 Ad$

The energy density in the field is $(1/2)\epsilon_0 E^2$ and the field fills a volume Ad , so $U = (1/2)\epsilon_0 E^2 Ad$. The expression $(1/2)\epsilon_0 E^2$ alone is just the energy per unit volume, not the total energy.

19. Answer: (C) Decrease

With fixed charges $\pm Q$ the field between the plates is $\sigma/(K\epsilon_0)$ in a dielectric instead of σ/ϵ_0 in air.

Kerosene has $K > 1$, so the field decreases. The charge on isolated plates does not change, so the field cannot remain the same.

20. Answer: (A) $16C_1/(n_1 n_2)$

Series: $C_{eq} = C_1/n_1$, energy = $\frac{1}{2}(C_1/n_1)(4V)^2 = 8C_1V^2/n_1$. Parallel: $C_{eq} = n_2C_2$, energy = $\frac{1}{2}n_2C_2V^2$.

Equating gives $C_2 = 16C_1/(n_1 n_2)$.

21. Answer: (D) $VC = VA \neq VB$

$VA = (\sigma/\epsilon_0)(a - b + c) = 2a\sigma/\epsilon_0$ for $c = a + b$. $VC = (\sigma/\epsilon_0)(a^2 - b^2 + c^2)/c = (\sigma/\epsilon_0)(2a^2 + 2ab)/(a + b) = 2a\sigma/\epsilon_0$. $VB = (\sigma/\epsilon_0)(a^2/b - b + c) = (\sigma/\epsilon_0)(a^2/b + a)$, which differs from $2a\sigma/\epsilon_0$ unless $a = b$, so $VC = VA \neq VB$.

22. Answer: (B) $C/3$, $3V$

Capacitors in series: $1/C_{eq} = 3/C$, so $C_{eq} = C/3$. The same charge sits on each, so the applied voltage divides equally and each can take V before breakdown: total $3V$.

23. Answer: (D) $E = \hat{i}(2xy + z^3) + \hat{j}x^2 + \hat{k}3xz^2$

$E = -\nabla V$. $-\partial V/\partial x = 2xy + z^3$, $-\partial V/\partial y = x^2$, $-\partial V/\partial z = 3xz^2$. So $E = \hat{i}(2xy + z^3) + \hat{j}x^2 + \hat{k}3xz^2$. A sign slip on the z^3 term gives the $(2xy - z^3)$ form.

24. Answer: (A) $(1/2)\epsilon_0 E^2 Ad$

Energy = $(1/2)CV^2$ with $C = \epsilon_0 A/d$ and $V = Ed$, giving $(1/2)(\epsilon_0 A/d)(Ed)^2 = (1/2)\epsilon_0 E^2 Ad$, i.e. energy density $(1/2)\epsilon_0 E^2$ times the volume Ad . $\epsilon_0 E^2 Ad$ misses the factor $1/2$, and the forms divided by Ad have the wrong dimensions.

25. Answer: (B) $4\pi\epsilon_0 Q \times 10^{22}$ volt/m

$V = Q/(4\pi\epsilon_0 r) = Q \times 10^{11}$ gives $r = 1/(4\pi\epsilon_0 \times 10^{11})$. Then $E = V/r = Q \times 10^{11} \times 4\pi\epsilon_0 \times 10^{11} = 4\pi\epsilon_0 Q \times 10^{22}$ V/m. The 10^{20} forms come from mishandling the power of ten.

26. Answer: (D) increases

With the battery disconnected, the charge Q stays constant. Increasing the plate separation lowers $C = \epsilon_0 A/d$, so $V = Q/C$ increases. The p.d. would stay constant only if the battery remained connected.

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