DPP - Daily Practice Problems

Name : ____________________ Date : __________

Start Time : __________ End Time : __________

PHYSICS 35

SYLLABUS : ELECTROSTATICS-4 (Capacitors, dielectrics)

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.15) : There are 15 multiple choice questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** choice is correct.

Q.1 A parallel plate capacitor is charged to a potential difference of 50V. It is discharged through a resistance. After 1 second, the potential difference between plates becomes 40V. Then

(a) Fraction of stored energy after 1 second is 16/25

(b) Potential difference between the plates after 2 seconds will be 30V

(c) Potential difference between the plates after 2 seconds will be 20V

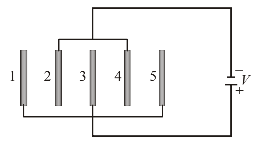
(d) Fraction of stored energy after 1 second is 4/5

Q.2 Five identical plates each of area A are joined as shown in the figure. The distance between the plates is d. The plates are connected to a potential difference of V volts. The charge on plates 1 and 4 will be respectively

(a) $\dfrac{\varepsilon_0 AV}{2d}, \dfrac{2\varepsilon_0 AV}{2d}$ (b) $\dfrac{\varepsilon_0 AV}{2d}, \dfrac{2\varepsilon_0 AV}{2d}$

(c) $\dfrac{\varepsilon_0 AV}{d}, \dfrac{-2\varepsilon_0 AV}{d}$

(d) $\dfrac{-\varepsilon_0 AV}{d}, \dfrac{-2\varepsilon_0 AV}{d}$



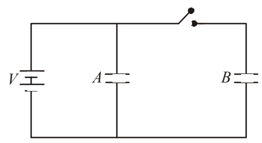
Q.3 Figure given below shows two identical parallel plate capacitors connected to a battery with switch S closed. The switch is now opened and the free space between the plates of capacitors is filled with a dielectric of dielectric constant 3. What will be the ratio of total electrostatic energy stored in both capacitors before and after the introduction of the dielectric?

(a) 3 : 1

(b) 5 : 1

(c) 3 : 5

(d) 5 : 3



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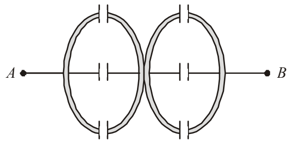
Space for Rough Work

Q.4 All six capacitors shown are identical, Each can withstand maximum 200 volts between its terminals. The maximum voltage that can be safely applied between A and B is

(a) 1200 V
(b) 400 V
(c) 800 V
(d) 200 V



Q.5 A capacitor of capacity C_1 is charged upto V volt and then connected to an uncharged capacitor of capacity C_2. Then final potential difference across each will be

(a) $\frac{C_2V}{C_1+C_2}$ (b) $\left(1+\frac{C_2}{C_1}\right)V$ (c) $\frac{C_1V}{C_1+C_2}$ (d) $\left(1-\frac{C_2}{C_1}\right)V$

Q.6 Two capacitors of capacitances 3μF and 6μF are charged to a potential of 12V each. They are now connected to each other, with the positive plate of each joined to the negative plate of the other. The potential difference across each will be

(a) 6 volt (b) 4 volt
(c) 3 volt (d) zero

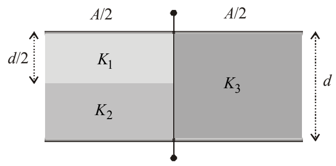
Q.7 In the figure a capacitor is filled with dielectrics K_1, K_2 and K_3. The resultant capacitance is

(a) $\frac{2\varepsilon_0 A}{d}\left[\frac{1}{K_1}+\frac{1}{K_2}+\frac{1}{K_3}\right]$

(b) $\frac{\varepsilon_0 A}{d}\left[\frac{1}{K_1}+\frac{1}{K_2}+\frac{1}{K_3}\right]$

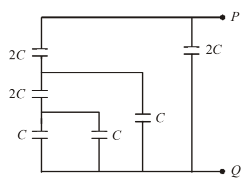
(c) $\frac{2\varepsilon_0 A}{d}[K_1+K_2+K_3]$

(d) None of these



Q.8 The resultant capacitance of given circut is

(a) $3C$
(b) $2C$
(c) C
(d) $\frac{C}{3}$



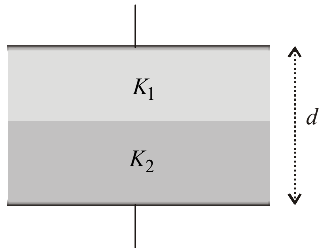
Q.9 Two dielectric slabs of constant K_1 and K_2 have been filled in between the plates of a capacitor as shown below. What will be the capacitance of the capacitor

(a) $\frac{2\varepsilon_0 A}{d}(K_1+K_2)$

(b) $\frac{2\varepsilon_0 A}{d}\left(\frac{K_1+K_2}{K_1\times K_2}\right)$

(c) $\frac{4\varepsilon_0 A}{d}\left(\frac{K_1\times K_2}{K_1+K_2}\right)$

(d) $\frac{2\varepsilon_0 A}{d}\left(\frac{K_1\times K_2}{K_1+K_2}\right)$



Q.10 Eight drops of mercury of equal radii possessing equal charges combine to form a big drop. Then the capacitance of bigger drop compared to each individual small drop is

(a) 8 times (b) 4 times
(c) 2 times (d) 32 times

Q.11 Separation between the plates of a parallel plate capacitor is d and the area of each plate is A. When a slab of material of dielectric constant k and thickness $t (t < d)$ is introduced between the plates, its capacitance becomes

(a) $\frac{\varepsilon_0 A}{d+t\left(1-\frac{1}{k}\right)}$ (b) $\frac{\varepsilon_0 A}{d+t\left(1+\frac{1}{k}\right)}$

(c) $\frac{\varepsilon_0 A}{d-t\left(1-\frac{1}{k}\right)}$ (d) $\frac{\varepsilon_0 A}{d-t\left(1+\frac{1}{k}\right)}$

Q.12 There is an air filled 1pF parallel plate capacitor. When the plate separation is doubled and the space is filled with wax, the capacitance increases to 2pF. The dielectric constant of wax is

(a) 2 (b) 4 (c) 6 (d) 8

Q.13 Between the plates of a parallel plate condenser, a plate of thickness t_1 and dielectric constant k_1 is placed. In the rest of the space, there is another plate of thickness t_2 and dielectric constant k_2. The potential difference across the condenser will be

(a) $\frac{Q}{A\varepsilon_0}\left(\frac{t_1}{K_1}+\frac{t_2}{K_2}\right)$ (b) $\frac{\varepsilon_0 Q}{A}\left(\frac{t_1}{K_1}+\frac{t_2}{K_2}\right)$

(c) $\frac{Q}{A\varepsilon_0}\left(\frac{K_1}{t_1}+\frac{K_2}{t_2}\right)$ (d) $\frac{\varepsilon_0 Q}{A}(K_1t_1+K_2t_2)$

RESPONSE GRID					
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	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ

Q.14 A parallel plate capacitor is charged and the charging battery is then disconnected. If the plates of the capacitor are moved further apart by means of insulating handles, then
(a) The charge on the capacitor increases
(b) The voltage across the plates decreases
(c) The capacitance increases
(d) The electrostatic energy stored in the capacitor increases

Q.15 A parallel plate capacitor of plate area A and plates separation distance d is charged by applying a potential V_0 between the plates. The dielectric constant of the medium between the plates is K. What is the uniform electric field E between the plates of the capacitor ?

(a) $E = \epsilon_0 \dfrac{CV_0}{KA}$ (b) $E = \dfrac{V_0}{Kd}$

(c) $E = \dfrac{V_0}{KA}$ (d) $E = \dfrac{Kv_0 d}{\epsilon_0 A}$

DIRECTIONS (Q.16-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

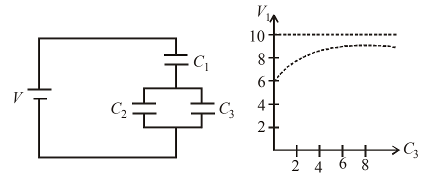
Q.16 A parallel plate air condenser is connected with a battery. Its charge, potenital difference, electric field and energy are Q_0, V_0, E_0, and U_0, respectively. In order to fill the complete space between the plates a dielectric slab is inserted, the battery is still connected. Now the corresponding values Q, V, E and U are in relation with the initially stated as
(1) $V > V_0$ (2) $Q > Q_0$ (3) $E > E_0$ (4) $U > U_0$

Q.17 The false statement are, on increasing the distance between the plates of a parallel plate condenser,
(1) The electric field intensity between the plates will decrease
(2) The electric field intensity between the plates will increase
(3) The P. D. between the plates will decrease
(4) The electric field intensity between the plates will remain unchanged

Q.18 The capacitance of a parallel plate condenser depends on
(1) Area of the plates
(2) Medium between the plates
(3) Distance between the plates
(4) Metal of the plates

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

Capacitor C_3 in the circuit is variable capacitor (its capacitance can be varied). Graph is plotted between potential difference V_1 (across capacitor C_1) versus C_3.
Electric potential V_1 approaches on asymptote of 10 volts as $C_3 \to \infty$.



Q.19 The ratio of the capacitance $\dfrac{C_1}{C_2}$ will be
(a) 2 / 3 (b) 4 / 3 (c) 3 / 4 (d) 3 / 2

Q.20 The value of C_3 for which potential difference across C_1 will become 8V, is
(a) $1.5C_1$ (b) $2.5C_1$ (c) $3.5\,C_1$ (d) $4.5\,C_1$

Q.21 The ratio of energy stored in capacitor C_1 to that of total energy when $C_3 \to \infty$ is
(a) zero (b) 1/3
(c) 1 (d) Data insufficient

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.

RESPONSE GRID					
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	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ	21. ⓐⓑⓒⓓ		

Q.22 **Statement-1 :** The force with which one plate of a parallel plate capacitor is attracted towards the other plate is equal to square of surface density per $2\in_0$ per unit area.

Statement-2 : The electric field due to one charged plate of the capacitor at the location of the other is equal to surface density per $2\in_0$.

Q.23 **Statement-1 :** Circuit containing capacitors should be handled cautiously even when there is no current.

Statement-2 : The capacitors are very delicate and so quickly break down.

Q.24 **Statement-1 :** If the distance between parallel plates of a capacitor is halved and dielectric constant is made three times, then the capacitance becomes 6 times.

Statement-1 : Capacitance of the capacitor does not depend upon the nature of the material of plates.

RESPONSE GRID			
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DAILY PRACTICE PROBLEM SHEET 35 - PHYSICS			
Total Questions	24	Total Marks	96
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	22	Qualifying Score	40
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

Space for Rough Work

DAILY PRACTICE PROBLEMS

PHYSICS SOLUTIONS 35

1. **(a)** By using

$V = V_0 e^{-t/CR} \Rightarrow 40 = 50e^{-1/CR} \Rightarrow e^{-1/CR} = 4/5$

Potential difference after 2 sec

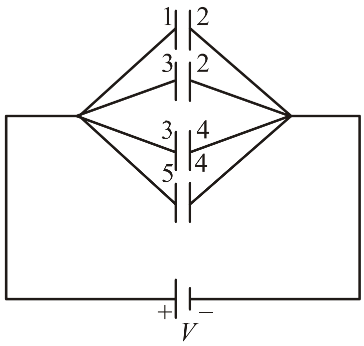
$$V' = V_0 e^{-2/CR} = 50(e^{-1/CR})^2 = 50\left(\frac{4}{5}\right)^2 = 32V$$

Fraction of energy after 1 sec

$$= \frac{\frac{1}{2}C(V_f)^2}{\frac{1}{2}C(V_i)^2} = \left(\frac{40}{50}\right)^2 = \frac{16}{25}$$

2. **(c)** The given circuit can be redrawn as follows. All capacitors are identical and each having capacitance

$$C = \frac{\varepsilon_0 A}{d}$$



| Charge on each capacitor | = | Charge on each plate |

$$= \frac{\varepsilon_0 A}{d} V$$

Plate 1 is connected with positive terminal of battery so charge on it will be $+\frac{\varepsilon_0 A}{d}.V$

Plate 4 comes twice and it is connected with negative terminal of battery, so charge on plate 4 will be

$$-\frac{2\varepsilon_0 A}{d} V$$

3. **(c)** Initially potential difference across both the capacitor is same hence energy of the system is

$$U_1 = \frac{1}{2}CV^2 + \frac{1}{2}CV^2 = CV^2 \quad .....(i)$$

In the second case when key K is opened and dielectric medium is filled between the plates, capacitance of both the capacitors becomes $3C$, while potential difference across A is V and potential difference across B is $\frac{V}{3}$ hence energy of the system now is

$$U_2 = \frac{1}{2}(3C)V^2 + \frac{1}{2}(3C)\left(\frac{V}{3}\right)^2 = \frac{10}{6}CV^2 \quad ......(ii)$$

So, $\frac{U_1}{U_2} = \frac{3}{5}$

4. **(c)** Plane conducting surfaces facing each other must have equal and opposite charge densities. Here as the plate areas are equal, $Q_2 = -Q_3$.

The charge on a capacitor means the charge on the inner surface of the positive plate (here it is Q_2)

Potential difference between the plates

$$= \frac{\text{charge}}{\text{capacitance}} = \frac{Q_2}{C} = \frac{2Q_2}{2C}$$

$$= \frac{Q_2 - (-Q_2)}{2C} = \frac{Q_2 - Q_3}{2C}$$

5. **(b)** While drawing the dielectric plate outside, the capacitance decreases till the entire plate comes out and then becomes constant. So, V increases and then becomes constant.

6. **(b)** Given circuit can be reduced as follows

(C = capacitance of each capacitor)

The capacitor $3C, 3C$ shown in figure can with stand maximum 200 V.

$\therefore$ So maximum voltage that can be applied across A and B equally shared. Hence maximum voltage applied cross A and B be equally shared. Hence Maz. voltage applied across A and B will be (200 + 200) = 400 *volt.*

7. **(c)** Common potential

$$V' = \frac{C_1 V + C_2 \times 0}{C_1 + C_2} = \frac{C_1}{C_1 + C_2}.V$$

8. **(b)** $V = \frac{C_1 V_1 - C_2 V_2}{C_1 + C_2} = \frac{6 \times 12 - 3 \times 12}{3 + 6} = 4$ volt

9. **(d)** $C_1 = \frac{K_1 \varepsilon_0 \frac{A}{2}}{\left(\frac{d}{2}\right)} = \frac{K_1 \varepsilon_0 A}{d}$

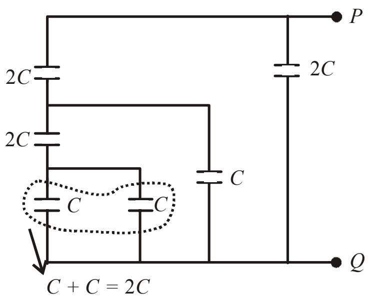
$$C_2 = \frac{K_2\varepsilon_0 \frac{A}{2}}{\left(\frac{d}{2}\right)} = \frac{K_2\varepsilon_0 A}{d}$$

and $C_3 = \frac{K_3\varepsilon_0 A}{2d} = \frac{K_3\varepsilon_0 A}{2d}$

Now, $C_{eq} = C_3 + \frac{C_1C_2}{C_1+C_2} = \left(\frac{K_3}{2} + \frac{K_1K_2}{K_1+K_2}\right).\frac{\varepsilon_0 A}{d}$

10. **(b)** Given circuit is a balanced Wheatstone bridge.

11. **(a)**



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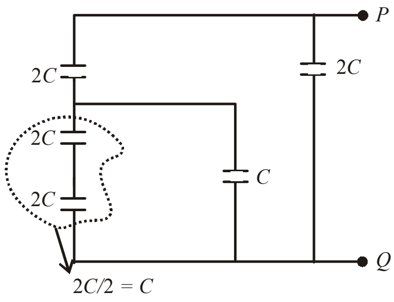

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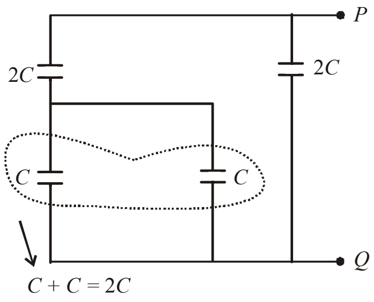

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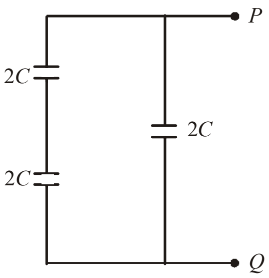
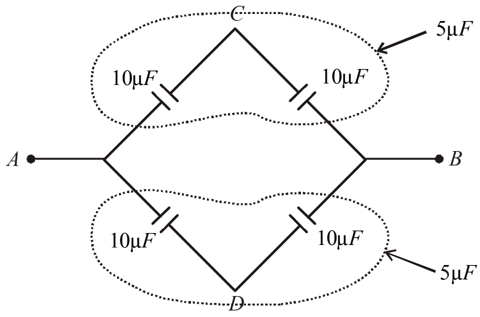


$\Rightarrow\ C_{PQ} = 3C$

12. **(d)** The two capacitors formed by the slabs may assumed to be in series combination.

13. **(d)** In the given system, no current will flow through the branch CD so it can be removed



Effective capacitance of the system $= 5 + 5 = 10\mu F$

14. **(c)** Volume of 8 small drops = Volume of big drop

$$8 \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3 \Rightarrow R = 2r$$

As capacity is proportional to r, hence capacity becomes 2 times.

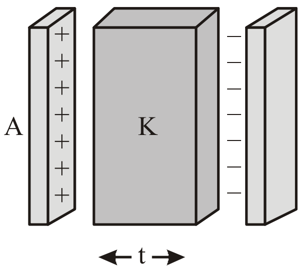
15. **(c)** Potential difference between the plates

$V = V_{air} + V_{medium}$

$= \frac{\sigma}{\varepsilon_0} \times (d-t) + \frac{\sigma}{K\varepsilon_0} \times t$

$\Rightarrow V = \frac{\sigma}{\varepsilon_0}(d - t + \frac{t}{K})$

$= \frac{Q}{A\varepsilon_0}(d - t + \frac{t}{K})$



Hence capacitance

$$C = \frac{Q}{V} = \frac{Q}{\frac{Q}{A\varepsilon_0}(d - t + \frac{t}{K})}$$

$$= \frac{\varepsilon_0 A}{(d - t + \frac{t}{K})} = \frac{\varepsilon_0 A}{d - t\left(1 - \frac{1}{K}\right)}$$

16. **(b)** $C = \frac{\varepsilon_0 A}{d} = 1pF$ and $C' = \frac{K\varepsilon_0 A}{2d} = 2pF \therefore K = 4$

17. **(a)** Potential difference across the condenser

$$V = V_1 + V_2 = E_1t_1 + E_2t_2 = \frac{\sigma}{K_1\varepsilon_0}t_1 + \frac{\sigma}{K_2\varepsilon_0}t_2$$

$$\Rightarrow V = \frac{\sigma}{\varepsilon_0}\left(\frac{t_1}{K_1} + \frac{t_2}{K_2}\right) = \frac{Q}{A\varepsilon_0}\left(\frac{t_1}{K_1} + \frac{t_2}{K_2}\right)$$

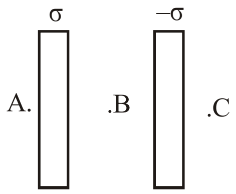
18. **(d)** When the battery is disconnected, the charge will remain same in any case.

Capacitance of a parallel plate capacitor is given by

$$C = \frac{\varepsilon_0 A}{d}$$

When d is increased, capacitance will decreases and because the charge remains the same, so according to $q = CV$, the voltage will increase. Hence the electrostatics energy stored in the capacitor will increase.

19. (c)



$E_A = \frac{\sigma}{2\varepsilon_0} - \frac{\sigma}{2\varepsilon_0} = 0$

$E_C = 0,$

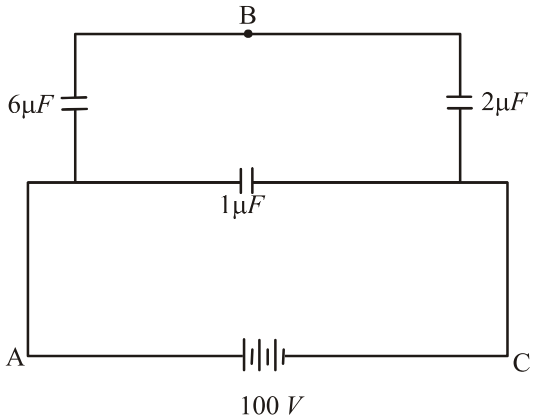
$E_B = \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0} = \frac{\sigma}{\varepsilon_0}.$

20. (b) $E = \frac{V}{d} = \frac{V_0/k}{d} = \frac{V_0}{kd}$

21. (c) $C_{eq} = \frac{(3+3)\times(1+1)}{(3+3)+(1+1)} + 1 = \left(\frac{6\times 2}{6+2}\right) + 1 = \frac{5}{2}\mu F$

$\therefore \quad Q = C \times V = \frac{5}{2} \times 100 = 250\ \mu C$

Change in 6 μF branch – $VC = \left(\frac{6\times 2}{6+2}\right)100 = 150\ \mu C$



$V_{AB} = \frac{150}{6} = 25\ V$ and $V_{BC} = 100 - V_{AB} = 75\ V$

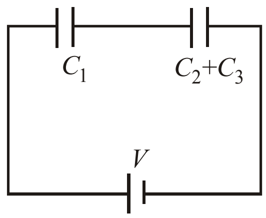
22. (c) Capacitance will be increased when a dielectric is introduced in the capacitor but potential difference will remain the same because battery is still connected. So according to q = CV, charge will increase i.e. $Q > Q_0$ and

$U = \frac{1}{2}QV_0, U_0 = \frac{1}{2}Q_0V_0 \Rightarrow Q > Q_0$ so $U > U_0$

23. (a) Electric field between the plates of a parallel plate capacitor $E = \frac{\sigma}{\varepsilon} = \frac{Q}{A\varepsilon_0}$ i.e $E \propto d^0$

24. (a) Capacitance of parallel plate condenser $= \frac{\varepsilon_0 A}{d}$

25. (a)



$V_{C_1} = \frac{V(C_2 + C_3)}{C_1 + (C_2 + C_3)}$

Initially $C_3 = 0$

So $V_{C_1} = \frac{VC_2}{C_1 + C_2} = 6$ .... (1)

Now, at $V_{C_1} = 10,\ C_3 = \infty$

$\Rightarrow 10 = \frac{V(C_2 + C_3)}{C_1 + (C_2 + C_3)}$

$\Rightarrow 10 = \frac{V}{\left(\frac{C_1}{C_2 + C_3} + 1\right)} \Rightarrow 10 = V$ .... (2)

Eq. (1) and (2),

$\frac{10}{\left(\frac{C_1}{C_2} + 1\right)} = 6 \Rightarrow 5 = 3\left(\frac{C_1}{C_2} + 1\right)$

$\Rightarrow \frac{C_1}{C_2} = \frac{5}{3} - 1 = \frac{2}{3}$

26. (b) Now, $V_{C_1} = \frac{10(C_2 + C_3)}{(C_1 + C_2 + C_3)} = 8$

$\Rightarrow \frac{10\left(\frac{C_2}{C_1} + \frac{C_3}{C_1}\right)}{\left(1 + \frac{C_2}{C_1} + \frac{C_3}{C_1}\right)} = 8 \Rightarrow C_3 = 2.5C_1$

27. (c) $\frac{1}{C_3 + C_2} + \frac{1}{C_1} \approx \frac{1}{C_1}$ (where $C_3 \to \infty$)

$\therefore$ Total energy = energy in C_1

$\therefore$ Required ratio = 1

28. **(b)** The electric field due to one charged plate at the location of the other is $E = \frac{\sigma}{2\varepsilon_0}$ and the force per unit area is $F = \sigma E = \frac{\sigma^2}{2\varepsilon_0}$.

29. **(d)** A charged capacitor, after removing the battery, does not discharge itself. If this capacitor is touched by someone, he may feel shock due to large charge still present on the capacitor. Hence it should be handled cautiously otherwise this may cause a severe shock.

30. **(b)** By the formula capacitance of a capacitor

$$C_1 = \varepsilon_0 \times \frac{KA}{d} \propto \frac{K}{d}$$

Hence, $\frac{C_1}{C_2} = \frac{K_1}{d_1} \times \frac{d_2}{K_2} = \frac{K_1}{K_2} \times \frac{d/2}{3K} = \frac{1}{6}$

or $\quad C_2 = 6C_1$

Again for capacity of a capacitor $C = \frac{Q}{V}$

Therefore, capacity of a capacitor does not depend upon the nature of the material of the capacitor.