WEEKLY TEST RANKER'S BATCH TEST - 19 RAJPUR SOLUTION Date 09-02-2020

[PHYSICS]

1. B
2. C
3. $C = \frac{\varepsilon_0 A}{d}, C_1 = \frac{\varepsilon_0 A}{2d}$ and $C_2 = \frac{K\varepsilon_0 A}{2d}$

$$C_{\text{eff.}} = \frac{\varepsilon_0 A}{2d} + \frac{K\varepsilon_0 A}{2d} = \frac{\varepsilon_0 A}{2d}(K+1) = \frac{C}{2}(K+1)$$

4. The given combination is equivalent to two capacitors in parallel each with plate area $A/2$ and separation d.

Then, $C_1 = \frac{K_1\varepsilon_0(A/2)}{d} = \frac{K_1\varepsilon_0 A}{2d}$

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

5. 5 capacitors in parallel give $5 \times 2\,\mu\text{F} = 10\,\mu\text{F}$ capacitor. Further, two capacitors in series give a capacity 1 μF. When the two combinations are connected in series, they give a resultant capacitance

$$\frac{10 \times 1}{10 + 1} = \frac{10}{11}\,\mu\text{F}$$

6. $C = 10 = \frac{\varepsilon_0 A}{d}$

$$C' = K_1\frac{(\varepsilon_0 A/2)}{d} + K_2\frac{(\varepsilon_0 A/2)}{d}$$

$$= 2\left(\frac{\varepsilon_0 A}{2d}\right) + 4\left(\frac{\varepsilon_0 A}{2d}\right)$$

$$= 3\left(\frac{\varepsilon_0 A}{d}\right) = 3 \times 10 = 30\,\mu\text{F}$$

7. $V_A - V_0 = \frac{q}{C_1}$ or $q = (V_A - V_0)C_1$

$V_B - V_0 = \frac{q_1}{C_2}$ or $q_1 = (V_B - V_0)C_2$

8. Net electric flux emitted from a spherical surface of radius a is :

$\phi_{\text{net}} = \frac{q_{in}}{\epsilon_0}$ [According to Gauss's law]

or $ES = (Aa)(4\pi a^2) = \frac{q_{in}}{\epsilon_0}$, hence $q_{in} = 4\pi \epsilon_0 Aa^3$

9. B
10. Potential at the centre of square

$$V = \frac{1}{4\pi\varepsilon_0}\left[-\frac{Q}{R} - \frac{q}{R} + \frac{2q}{R} + \frac{2Q}{R}\right] = 0$$

Hence, $Q = -q$

11. B
12. When the two condensers are connected in series,

$$C = \frac{2 \times 1}{2 + 1} = \frac{2}{3}\,\mu\text{F} \quad \text{and} \quad Q = \frac{2E}{3}$$

The potential of condenser C_1 is given by:

$$V_1 = \frac{Q}{C_1} = \frac{2E}{3} < 6\text{ kV}$$

$$\therefore \quad E < 6 \times \frac{3}{2} < 9\text{ kV}$$

13. C_1, C_2 and C_3 are in series:

$$\frac{1}{C'} = \frac{1}{C} + \frac{1}{2C} + \frac{1}{3C}$$

or $$\frac{1}{C'} = \frac{6+3+2}{6C} = \frac{11}{6C}$$

$\therefore \quad C' = 6C/11$

Charge on each of the three capacitors in series is:

$$Q' = 6CV/11$$

Also charge on capacitor $C_4 = 4\,CV$

$$\therefore \quad \text{Ratio} = \frac{Q'}{Q} = \frac{6CV}{11 \times 4CV} = \frac{3}{22}$$

14. When plates of capacitor are separated by a dielectric medium of dielectric constant K, its capacity,

$$C_m = \frac{K\varepsilon_0 A}{d} = KC_0$$

Here, $C_0 = C$

$\therefore \quad C_m = KC$

Now, two capacitor of capacities KC and C are in series, their effective capacitance,

$$\frac{1}{C'} = \frac{1}{KC} + \frac{1}{C}$$

15. Common potential = $\dfrac{\text{total charge}}{\text{total capacity}}$

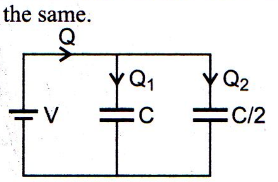
$\therefore \quad V = \dfrac{Q}{C_1 + C_2}$

charge on $C_1 = C_1V = \dfrac{C_1Q}{C_1 + C_2}$

charge on $C_2 = C_2V = \dfrac{C_2Q}{C_1 + C_2}$

$\therefore \quad \dfrac{\text{charge on } C_1}{\text{charge on } C_2} = \dfrac{C_1V}{C_2V} = \dfrac{C_1}{C_2}$

16. As the capacitors are connected in parallel, therefore, potential difference across both the condensers remains the same.



$\therefore \quad Q_1 = CV\ ;\ Q_2 = \dfrac{C}{2}V$

Also, $Q = Q_1 + Q_2$

$= CV + \dfrac{C}{2}V = \dfrac{3}{2}CV$

Work done in charging fully both the condensers is given by:

$$W = \frac{1}{2}QV = \frac{1}{2}\times\left(\frac{3}{2}CV\right)V = \frac{3}{4}CV^2$$

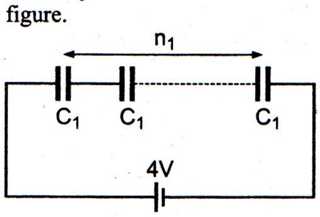
17. Three capacitors of capacitance C each are in series.

$\therefore$ Total capacitance, $C_{\text{total}} = \dfrac{C}{3}$

The charge is the same $(= Q)$, when capacitors are in series,

$$V_{\text{total}} = \frac{Q}{C_{\text{total}}} = \frac{Q}{C/3} = 3\,V$$

18. A series combination of n_1 capacitors each of capacitance C_1 are connected to 4V source as shown in the figure.



Total capacitance of the series combination of the capacitors is,

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_1} + \frac{1}{C_1} + \text{....... upto } n_1 \text{ terms} = \frac{n_1}{C_1}$$

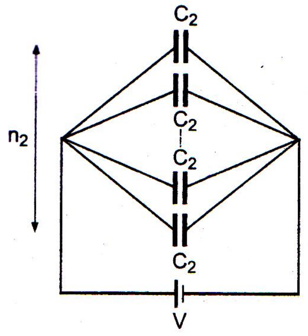
or $\quad C_s = \dfrac{C_1}{n_1} \quad$ ...(i)

Total energy stored in a series combination of the capacitors is,

$$U_s = \frac{1}{2}C_s(4V)^2$$

$$= \frac{1}{2}\left(\frac{C_1}{n_1}\right)(4V)^2 \quad \text{...(ii) [Using eqn. (i)]}$$

A parallel combination of n_2 capacitors each of capacitance C_2 are connected to V source as shown in the figure.



Total capacitance of the parallel combination of capacitors is,

$C_p = C_2 + C_2 + \text{.............} + \text{upto } n_2 \text{ terms} = n_2C_2$

or $C_p = n_2C_2 \quad$ ...(iii)

Total energy stored in a parallel combination of capacitors is,

$$U_p = \frac{1}{2}C_p(V)^2 = \frac{1}{2}(n_2C_2)(V)^2 \quad \text{...(iv)}$$

[Using eqn. (iii)]

According to the given problem, $U_s = U_p$

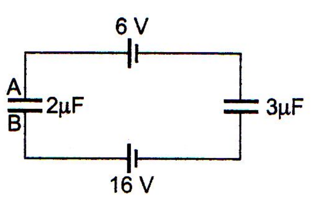
Substituting the values of U_s and U_p from equations (ii) and (iv), we get

$$\frac{1}{2}\cdot\frac{C_1}{n_1}(4V)^2 = \frac{1}{2}(n_2C_2)(V)^2$$

or $\quad \dfrac{C_1 \cdot 16}{n_1} = n_2C_2$

or $\quad C_2 = \dfrac{16C_1}{n_1n_2}$

19.

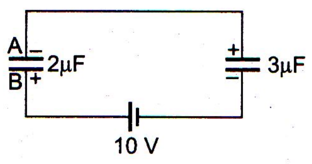


Here, 2μF and 3μF capacitors are connected in series. Their equivalent capacitance is,

$$\frac{1}{C_S} = \frac{1}{2} + \frac{1}{3} \quad \text{or} \quad C_S = \frac{6}{5}\,\mu\text{F}.$$

Net voltage, $V = 16\text{ V} - 6\text{V} = 10\text{ V}$

The equivalent circuit diagram as shown in below figure.



Charge on each capacitor,

$$q = C_S V = \frac{6}{5} \times 10 = 12\,\mu C$$

The potential difference between A and B is :

$$= -\frac{12\,\mu C}{2\,\mu F} = -6\ V$$

20. Electric field between the plates of a charged capacitor is given by

$$E = \frac{q}{K\varepsilon_0 A}$$

where q = Charge on the plates of capacitor
ε_0 = Permittivity of free space
A = Area of the plates
K = Dielectric constant of the medium between the plates.

It is clear from the expression that electric field inside a capacitor remains constant if medium remains same, *i.e.*, it does not vary with distance. If medium changes than K charges. As a result of this, E decreases with increase in K but decreased value again remain same in the charged medium. Hence, in the given problem, E remains constant at a higher value in the medium of air, but in the medium of slabs E decreases As $K_2 > K_1$, so decrease in value of E in medium of K_2 is more than that found in medium of K_1. So correct option is (c).

21.
$$U_i = \frac{1}{2}CV^2 = \frac{Q^2}{2C} \qquad (\because Q = CV)$$

and $$U_f = \frac{Q^2}{2C'} = \frac{Q^2}{2KC} = \frac{C^2V^2}{2KC} = \frac{U_i}{K}$$

$$\Delta U = U_f - U_i = \frac{1}{2}CV^2\left[\frac{1}{K} - 1\right]$$

As the capacitor is isolated, so charge will remain conserved. Further, pot. diff. $= \frac{Q}{C'} = \frac{Q}{KC} = \frac{V}{K}$.

22. Initial energy stored $= \frac{1}{2}(2\mu F) \times V^2$

Energy dissipated on connection across 8μF

$$= \frac{1}{2}\frac{C_1C_2}{C_1 + C_2}V^2 = \frac{1}{2} \times \frac{2\mu F \times 8\mu F}{10\mu F} \times V^2$$

$$= \frac{1}{2} \times (1.6\,\mu F)V^2$$

$\therefore$ % loss of energy $= \frac{1.6}{2} \times 100 = 80$ %

23. Energy, $E_1 = \frac{1}{2}C_1V_1^2 = \frac{1}{2} \times 1 \times 10^{-6} \times (30)^2$

$= 450 \times 10^{-6}$ J

Common potential,

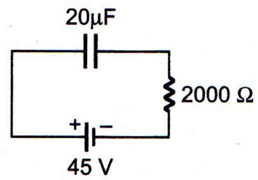
$$V = \frac{q_1 + q_2}{C_1 + C_2} = \frac{1 \times 30 + 0}{1 + 2} = 10 \text{ volt}$$

$$E_2 = \frac{1}{2}(C_1 + C_2)V^2 = \frac{1}{2}(1 + 2) \times 10^{-6} \times (10)^2$$

$= 1.5 \times 100 \times 10^{-6} = 150 \times 10^{-6}$ J

Loss of energy $= E_2 - E_1 = 300\,\mu J$

24. We know that in steady state the capacitor behaves like as open circuit, *i.e.*, capacitor will not pass the current.



So, the potential difference across the capacitor = 45 V

Hence, the final charge on the capacitor is,

$q = CV$ [Here, $C = 20\,\mu F$, $V = 45$ V]

or $q = 20 \times 10^{-6} \times 45$

or $q = 900 \times 10^{-6}$

or $q = 9 \times 10^{-4}$ C

25. Capacitance of a parallel plate capacitor is,

$$C = \frac{\varepsilon_0 A}{d} \qquad ...(i)$$

where A is the area of a plate and d is the distance between them.

Energy stored in a capacitor is,

$$U = \frac{1}{2}CV^2$$

Energy stored per unit volume of a capacitor is,

$$u_E = \frac{U}{\text{Volume}} = \frac{\frac{1}{2}CV^2}{Ad}$$

$$= \frac{1}{2}\left[\frac{\varepsilon_0 A}{d}\right]\frac{V^2}{Ad} \qquad \text{[Using eqn. (i)]}$$

$$= \frac{1}{2}\varepsilon_0\left(\frac{V}{d}\right)^2$$

26.
$$\text{Flux} = \frac{q_m}{\varepsilon_0}$$

The two plates of the capacitor has equal and opposite charges. Hence, net charge enclosed by the given surface = 0

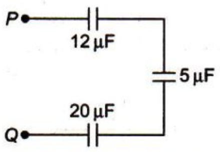
$\therefore$Flux is zero in both the cases. Hence, change in flux = 0

27. Let C be the capacitance of each capacitor.
Then, $6 = C/5$ or $C = 30\,\mu F$
If these are connected in parallel, then equivalent capacitance will be maximum.
$$C' = 30 \times 5 = 150\,\mu F$$

28. Given; Capacitance of big drop $(C_1) = 1\,\mu F$
Radius of small drop $= r$
Number of small drops $(n) = 8$
Since, volume of big drop remains the same after it is broken into eight small drops, therefore
$$\frac{4}{3}\pi R^3 = 8 \times \frac{4}{3}\pi r^3 \quad \text{or} \quad R = 2r,$$
where R = radius of big drop.
We also know that capacitance of the spherical drop $(C) = 4\pi\varepsilon_0 r$
i.e., $C \propto r$
Therefore, $\frac{C_1}{C_2} = \frac{R}{r} = \frac{2r}{r} = 2$
or $C_2 = \frac{C_1}{2} = \frac{1}{2}\,\mu F$
Where C_2 = capacitance of each small drop.

29. Both the capacitors are in series. Therefore, charge stored on them will be same.
Net capacity $= \frac{C(2C)}{C + 2C} = \frac{2}{3}C$
$$= \frac{2}{3} \times 6\,\mu F = 4\,\mu F$$
Potential difference= 10 V
$\therefore \quad q = CV = 40\,\mu C$

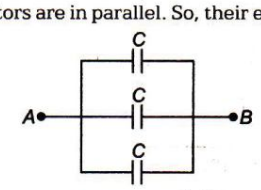
30. In circuit, condenser of capacity $2\,\mu F$ and $3\,\mu F$ are in parallel. Their resultant capacity is $5\,\mu F$.



Now, capacitor $12\,\mu F$, $5\,\mu F$ and $20\,\mu F$ are in series. So, their resultant capacity
$$\frac{1}{C} = \frac{1}{5} + \frac{1}{20} + \frac{1}{12} = \frac{1}{3}$$
$\therefore \quad C = 3\,\mu F$

31.

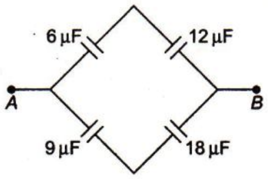
Three capacitors are in parallel. So, their equivalent capacity



$$C_p = C + C + C = 3C$$

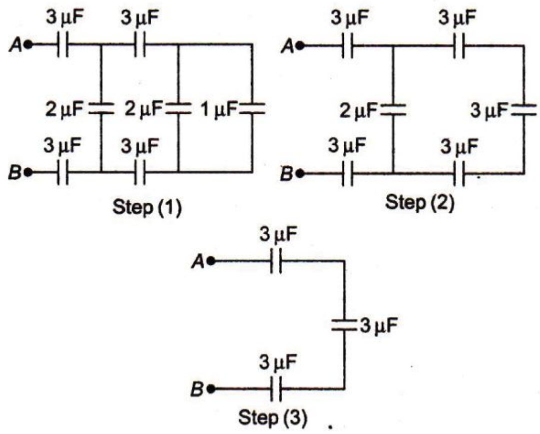
32. Given plates are equivalent to 3 identical capacitors in parallel combination. Hence, equivalent capacitance
$$C_p = C + C + C$$
$$= 3C$$
$$= 3\frac{\varepsilon_0 A}{d}$$

33. Given circuit is balanced Wheatstone bridge circuit.



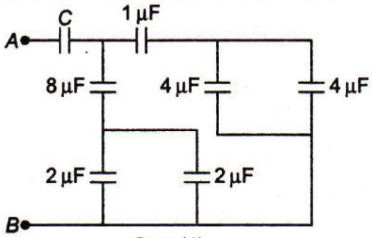
Now capacitor of capacity $6\,\mu F$, $12\,\mu F$ are in series and $9\,\mu F$, $18\,\mu F$ are also in series.
$\therefore$ Equivalent capacitance between A and B is
$$C_{AB} = 4 + 6 = 10\,\mu F$$

34. . The given circuit can be reduced in following manner

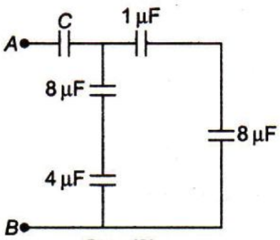


$\therefore$ Resultant capacity between A and B
i.e., $C_{AB} = 1\,\mu F$

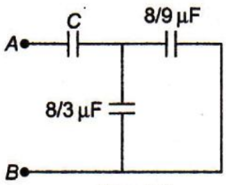
35. Given circuit can be reduced in following manner :



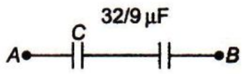
Step (1)



Step (2)



Step (3)

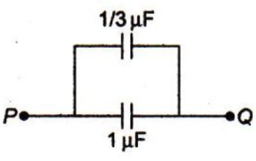


Step (4)

So, equivalent capacitance between A and B

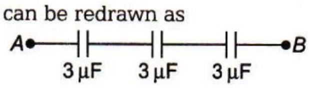
$$C_{eq.} = 1 = \frac{\frac{32}{9} \times C}{\frac{32}{9} + C} \quad \therefore \quad C = \frac{32}{23}\ \mu F$$

36. Given circuit can be simplified as shown



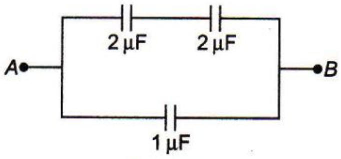
$\therefore$ $$C_{PQ} = \frac{1}{3} + 1 = \frac{4}{3}\ \mu F$$

37. The circuit can be redrawn as

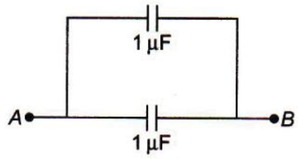


So, $$C_{AB} = \frac{3}{3} = 1\ \mu F$$

38. Given circuit can be redrawn as follows.



Step (1)

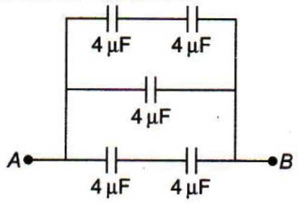


Step (2)

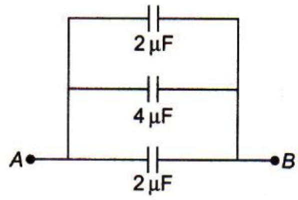
So, equivalent capacitance between A and B

$$C_{AB} = 1 + 1 = 2\ \mu F$$

39. Given circuit can be redrawn as



Step (1)



Step (2)

So, equivalent capacitance between A and B,

$$C_{AB} = 2 + 4 + 2 = 8\ \mu F$$

40. Capacitors C_1 and C_2 are in series with C_3 in parallel with them.

Now, $$C_1 = \frac{K_1 \varepsilon_0 (A/2)}{(d/2)} = \frac{K_1 \varepsilon_0 A}{d}$$

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

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

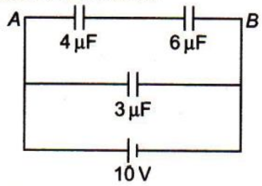
$$C_{\text{equivalent}} = C_3 + \frac{C_1 C_2}{C_1 + C_2}$$

$$= \frac{K_3 \varepsilon_0 A}{2d} + \frac{\left(\frac{K_1 \varepsilon_0 A}{d}\right)\left(\frac{K_2 \varepsilon_0 A}{d}\right)}{\frac{K_1 \varepsilon_0 A}{d} + \frac{K_2 \varepsilon_0 A}{d}}$$

$$= \frac{\varepsilon_0 A}{d}\left(\frac{K_3}{2} + \frac{K_1 K_2}{K_1 + K_2}\right)$$

So, none option is correct.

41. The circuit can be redrawn as



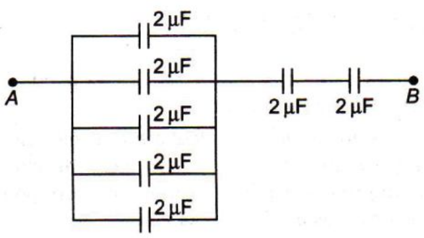
Here 4 μF and 6 μF are in series. So, charge is same on both.
Now equivalent capacity between A and B

$$C_{AB} = \frac{6 \times 4}{6+4} = 2.4\ \mu F$$

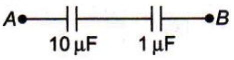
So, charge on 4 μF capacitor

$$Q = C_{AB} \times 10 = 2.4 \times 10 = 24\ \mu C$$

42. From concept of series and parallel combination, we can easily find that in option (a) the resultant capacity is $\frac{10}{11}\ \mu F$.



The circuit can be redrawn as



$$\therefore \quad C_{eq.} = \frac{10}{10+1} = \frac{10}{11}\ \mu F$$

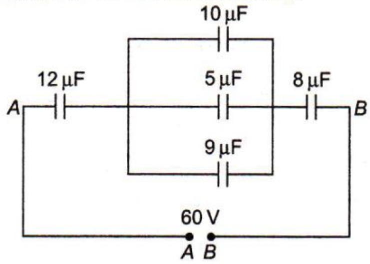
43. $q_{in} = 0$

$$\therefore \quad \frac{Kq'}{r} + \frac{Kq}{3r} = 0\ (q' \to \text{on inner shell})$$

or $$q' = -\frac{q}{3}$$

$\therefore + \frac{q}{3}$ charge will flow from inner shell to outer shell.

44. Given circuit can be redrawn a follows.



Equivalent capacitance of the circuit

$$C_{AB} = \frac{24}{2+1+3} = 4\ \mu F$$

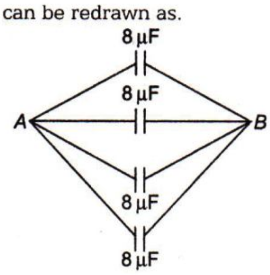
Total charge given by battery

$$q = C_{AB} \cdot V = 4 \times 60 = 240\ \mu C$$

Charge on 5 μF capacitor

$$q_2 = \left(\frac{5}{10+5+9}\right) \times 240 = 50\ \mu C$$

45. Here circuit can be redrawn as.



Equivalent capacitance of there capaciltors

$$C_{eq.} = 8+8+8+8 = 32\ \mu F$$

[CHEMISTRY]

53. **(a)** $n = 4 \ \therefore Fe^{2+}$

If BM = $\sqrt{24} = \sqrt{4(4+2)}$

number of unpaired e = 4

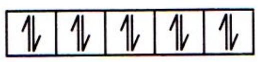
Then Fe must have +2 charge

57. **(d)** Ni^{2+} and Ti^{3+} ions are coloured in aqueous solution because they contain unpaired electrons.

58. **(b)** $_{30}Zn$ $[Ar]^{18}\ 3d^{10}$, so $n = 0$; Fe^{2+} $[Ar]^{18}\ 3d^6$, so $n = 4$; Ni^{2+} $[Ar]^{18}\ 3d^8$, so $n = 2$; Cu^{2+} [Ar]18 $3d^9$, so $n = 1$.

72. **(d)** Cuprous ion (Cu^+) $3d^{10}$ Completely filled d subshell

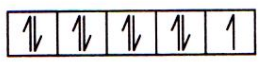
$3d^{10}$



No. unpaired $d - e^{-1}$

Cupric ion Cu^{+2}

$3d^9$



1. unpaired $d - e^{-1}$

73. **(c)** The ability of d-block element to form is due to the small and highly charged ions and vacant low energy orbital to accept lone pair electrons from ligands