PROBLEMS FOR PRACTICE

1. Calculate the radius of a spherical conductor of capacitance 1 farad. **[9×10^6 km]**
2. Can a metal sphere of radius 1 cm hold a charge of 1C ? **[No]**
3. Calculate the capacitance of a conducting sphere of radius 10 cm situated in air. How much charge is required to raise it to a potential of 1000 V ? **[11 pF; 1.1×10^{-8} C]**
4. A capacitor consisting of two parallel plates 0.5 mm apart and each of effective area 500 cm^2 is connected to a 100 V battery. Calculate (*i*) capacitance of the capacitor and (*ii*) charge on each plate. **[(*i*) 885 μF, (*ii*) 0.0885 μC]**
5. Find the length of the paper used in a parallel plate capacitor of capacitance 2μF if the dielectric constant of the paper is 2.5 and its width and thickness are 50 mm and 0.05 mm respectively.

   [**Hint.** $C = \frac{\varepsilon_0 KA}{d}$. Here $d = 0.05$ mm. Now area, A = length × width]
6. The plates of a parallel plate capacitor are separated by a distance of 0.5 cm. What must be the plate area if the capacitance of the capacitor is to be 2F? **[1130 km^2]**
7. A parallel plate capacitor has circular plates of 8.2 cm radius and 1.3 mm separation. What is the capacitance of the capacitor. If a p.d. of 120 V is applied across the plates, what charge will appear on the plates? **[140 pF; 17 nC]**
8. A parallel plate capacitor has plates 0.15 mm apart, a plate area of 0.1m^2 and a dielectric of relative permittivity 3. If charge on capacitor plates is 0.5 μC, find (*i*) electric flux density, (*ii*) p.d. between plates, and (*iii*) electric field intensity. **[(*i*) 0.5×10^{-5} C/m^2 (*ii*) 28 V (iii) 186667 V/m]**
9. Two capacitors of capacitance 2 μF and 4 μF respectively are connected in series. A d.c. potential difference of 900V is applied to this series combination. Find p.d. across each capacitor. **[600V; 300V]**
10. How can three capacitors of capacitance 3μF, 6μF and 9μF respectively be connected to have a capacitance of 11μF? **[3μF and 6μF in series with 9μF in parallel with both]**
11. Three capacitors of 2μF, 3μF and 6μF respectively are connected in series across 500V d.c. supply. Find charge and p.d. on each capacitor. **[500 μC; 250V, 166.7V, 83.3V]**
12. Calculate the capacitance between points *A* and *B* in Fig. 5.23. **[3μF]**
13. In the circuit shown in Fig. 5.24, find the equivalent capacitance between points *A* and *B*. **[4μF]**

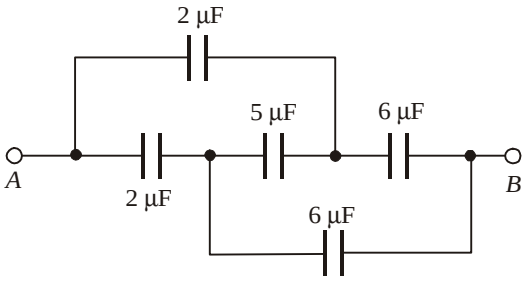

Fig. 5.23

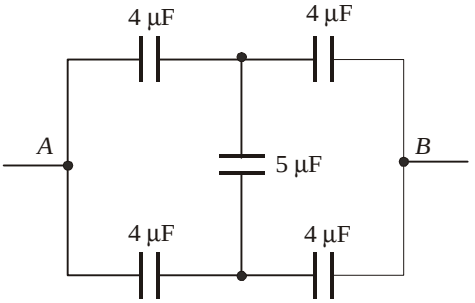

Fig. 5.24

14. In the circuit shown in Fig. 5.25, find the equivalent capacitance between points *A* and *B*. **[5μF]**
15. In the circuit shown in Fig. 5.26, find the equivalent capacitance between points *A* and *B*. **[1μF]**

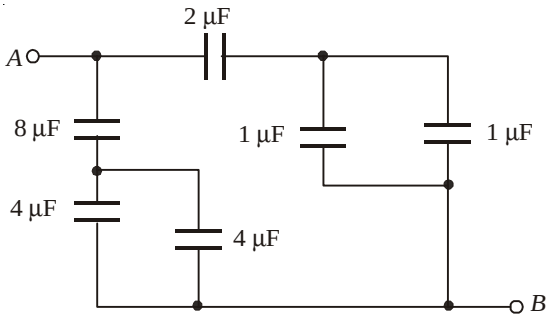

Fig. 5.25

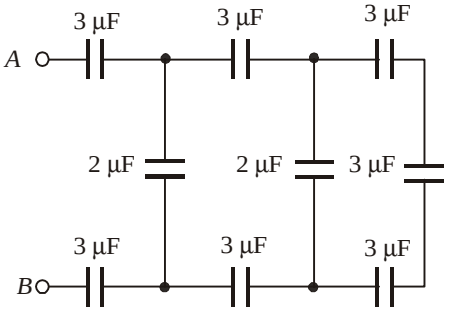

Fig. 5.26

16. How will you combine four capacitors, each of 1μF, to have a net capacitance of 0.75μF? **[Three in parallel and fourth in series with this parallel combination]**
17. A variable air capacitor has 11 movable plates and 12 stationary plates. The area of each plate is 0.0015 m^2 and separation between opposite plates is 0.001m. Determine the maximum capacitance of this variable capacitor. **[292 pF]**

18. Calculate the number of sheets of tin foil and mica for a capacitor of 0.33 μF capacitance if area of each sheet of tin foil is 82 cm^2, the mica sheets are 0.2 mm thick and have relative permittivity 5. **[183 sheets of tin foil; 182 sheets of mica]**

19. A 600 pF capacitor is charged by a 200Vsupply. It is then disconnected from the supply and is connected to another uncharged 600 pF capacitor. How much electrostatic energy is lost in the process?. **[6×10^{-6} J]**

20. An uncharged capacitor is connected to a battery. Show that half the energy supplied by the battery is lost as heat while charging the capacitor.

21. Two capacitors are connected in parallel and the energy stored is 18J when a potential difference of 6000 V is applied across the combination. When the same capacitors are connected in series, the stored energy is 4J for the same potential difference. What are the individual capacitances ? **$\frac{2}{3}\mu F ; \frac{1}{3}\mu F$**

22. The capacitance of a parallel plate capacitor is 50 pF and the distance between the plates is 4mm. It is charged to 200V and then the charging battery is removed. Now a dielectric slab ($K = 4$) of thickness 2mm is placed between the plates. Calculate (*i*) final charge on each plate (*ii*) final potential difference between plates (*iii*) final energy in the capacitor. **[(*i*) 10^{-8} C (*ii*) 125 V (*iii*) 6.25×10^{-7} J]**

23. An ebonite plate ($K = 3$), 6 mm thick is introduced between the parallel plates of a capacitor of plate area 2×10^{-2} m^2 and plate separation 0.01m. Find the capacitance. **[29.5 pF]**

24. A parallel-plate capacitor having plate area 100 cm^2 and separation 1.0 mm holds a charge of 0.12 μ*C* when connected to a 120 V battery. Find the dielectric constant of the material filling the gap. **[11.3]**

25. A slab of material of dielectric constant *K* has the same area as the plates of a parallel-plate capacitor but has a thickness 3*d*/4 where *d* is the separation of the plates. How is the capacitance changed when the slab is inserted between the plates ? **$C = \frac{4K}{K+3} C_0$**

26. Two parallel-plate capacitors, each of capacitance 40 μF, are connected in series. The space between the plates of the capacitors is filled with a dielectric material of dielectric constant of 4. Find the equivalent capacitance of the system. **[32 μF]**

LONG/SHORT ANSWER QUESTIONS

1. Write a short note on conductors and insulators.
2. Discuss the behaviour of metallic conductors in electric field.
3. What is a capacitor? How does a capacitor store charge?
4. Define the SI unit of capacitance.
5. Derive an expression for the capacitance of an isolated spherical conductor.
6. Derive an expression for the capacitance of a spherical capacitor.
7. What is a parallel plate capacitor? Derive an expression for its capacitance.
8. What do you mean by dielectric constant of a dielectric?
9. Three capacitors are connected in (*i*) series (*ii*) parallel. Obtain an expression for their equivalent capacitance.
10. Write a short note on multiplate capacitor.
11. Derive an expression for the capacitance of a cylindrical capacitor.
12. Show that energy stored by a capacitor is $q^2/2C$ where *q* is the final charge on the capacitor and *C* is its capacitance.
13. What do you mean by energy density of electric field?
14. Two capacitors of capacitances C_1 and C_2 are charged to potentials V_1 and V_2 respectively. The capacitors are joined through a conducting wire. What is the value of common potential?
15. Write a short note on polar and non-polar dielectrics.
16. Discuss the behaviour of a dielectric in a uniform electric field.
17. What do you mean by dielectric strength of a dielectric?

18. Derive an expression for the capacitance of a parallel plate capacitor with conducting slab between the plates; assuming that thickness of slab is less than the plate separation.
19. A parallel plate air capacitor has plate separation d. If a dielectric slab of thickness t ($t < d$) is introduced between the plates, derive an expression for the capacitance of the resulting capacitor.
20. Write a short note on atmospheric electricity.
21. Give an account of thunderstorms and lightning.
22. Write a short note on the discharging effect of sharp points.
23. Write a short note on lightning conductor.
24. Describe the principle, construction and working of Van de Graaff generator.

VERY SHORT ANSWER QUESTIONS

1. Why is an insulator called a dielectric?
2. How will you prove that electric field inside a charged conductor is zero?
3. Show that farad is a too large unit of capacitance.
4. Show that SI unit of ε_0 is F/m.
5. Mention three advantages of dielectrics in capacitors.
6. Can you apply any value of electric field to a dielectric?
7. What do you mean by voltage rating of a capacitor?
8. Why are capacitors connected in series or parallel?
9. What is the need of a multiplate capacitor?
10. Name the practical example of a cylindrical capacitor.
11. Show that electrostatic energy of a capacitor is stored in its electric field.
12. What is the importance of energy density of electric field?
13. How will you discharge a charged capacitor?
14. What is the difference between polar and non-polar dielectrics?
15. A parallel plate air capacitor has a capacitance of 10 μF. If air is replaced by mica ($K = 6$), what is the capacitance of the capacitor?
16. What is the dielectric constant of a metal?
17. What is the importance of capacitance?
18. How does lightning conductor prevent the building from lightning?
19. Why does charge leak off rapidly from pointed ends of a charged conductor?
20. What is the breakdown voltage of air?