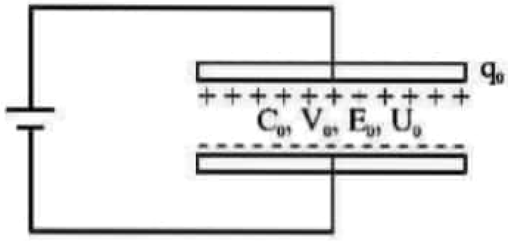
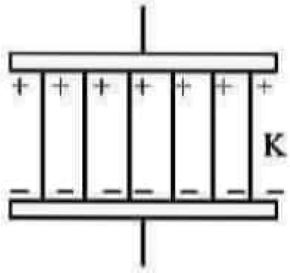
We have discussed that with the introduction of dielectric, capacity of capacitor increases. The effect of dielectric on other physical quantities such as charge, potential difference, field and the energy associated with a capacitor depends on the fact that whether the charged capacitor is isolated (i.e., charge held constant) or attached to a battery (i.e, potential is held constant).

(a) When the battery is disconnected





Let q_0, C_0, V_0, E_0 and U_0 represents the charge, capacity, potential difference, electric field and energy associated with charged air capacitor respectively. With the introduction of a dielectric slab of dielectric constant K between the plates and the battery disconnected.

(i) Charge remains constant, i.e., $q = q_0$, as in an isolated system charge is conserved.

(ii) Capacity increases, i.e., $C = KC_0$, as by the presence of a dielectric capacity becomes K times.

(iii) Potential difference between the plates decreases, i.e., $V = \left(\frac{V_0}{K}\right)$ as

$$V = \frac{q}{C} = \frac{q_0}{KC_0} = \frac{V_0}{K} \quad [\because\ q = q_0 \text{ and } C = KC_0]$$

(iv) Field between the plates decreases i.e, $E = \frac{E_0}{K}$, as

$$E = \frac{V}{d} = \frac{V_0}{Kd} = \frac{E_0}{K} \quad [\text{as } V = \frac{V_0}{K}] \text{ and } E_0 = \frac{V_0}{d}$$

(v) Energy stored in the capacitor decreases i.e., U = $\left(\frac{U_0}{K}\right)$, as

$$U = \frac{q^2}{2C} = \frac{q_0^2}{2KC_0} = \frac{V_0}{K}$$ (as q= q_0 and C = KC_0)

(b) When the battery remains connected (potential is held constant)

(i) Potential difference remains constant, i..e, V = V_0 as battery is a source of constant potential difference.

(ii) Capacity increases, i.e. C = KC_0 , as by presence of a dielectric capacity becomes K times

(iii) Charge on capacitor increases, i.e, q = Kq_0 , as

$$q = CV = (KC_0)V = Kq_0 \quad [\because \quad q_0 = C_0V]$$

(iv) Electric field remains unchanged i.e., E = E_0 , as

$$E = \frac{V}{d} = \frac{V_0}{d} = E_0 \quad \left[\text{as } V = V_0 \text{ and } \frac{V_0}{d} = E_0\right]$$

(v) Energy stored in the capacitor decreases i.e., $U = \left(\frac{U_0}{K}\right)$, as

$$U = \frac{q^2}{2C} = \frac{q_0^2}{2KC_0} = \frac{V_0}{K} \quad \text{(as } q = q_0 \text{ and } C = KC_0\text{)}$$

(b) When the battery remains connected (potential is held constant)

(i) Potential difference remains constant, i..e, $V = V_0$ as battery is a source of constant potential difference.

(ii) Capacity increases, i.e. $C = KC_0$, as by presence of a dielectric capacity becomes K times

(iii) Charge on capacitor increases, i.e, $q = Kq_0$, as

$$q = CV = (KC_0)V = Kq_0 \ [\because \ q_0 = C_0V]$$

(iv) Electric field remains unchanged i.e., $E = E_0$, as

$$E = \frac{V}{d} = \frac{V_0}{d} = E_0 \ \left[\text{as } V = V_0 \text{ and } \frac{V_0}{d} = E_0\right]$$

(v) Energy stored in the capacitor increases,

i.e., $U = KU_0$, as $U = \frac{1}{2}CV^2 = \frac{1}{2}(KC_0)(V_0)^2 = \frac{1}{2}CV^2 = \frac{1}{2}KU_0$

[as $C = KC_0$ and $U_0 = \frac{1}{2}CV^2 = \frac{1}{2}C_0V_0^2$]