revisely

Capacitance

Capacitance

A capacitor is any device used to store charge. The capacitance of an isolated conductor is the ratio of charge stored to the change in electric potential.

capacitance, $C = \dfrac{Q}{V}$ unit: Farad, F

For a **parallel plate** capacitor, $C = \dfrac{\varepsilon_0 \varepsilon_r A}{d}$

Energy stored

Charging a capacitor means transferring charge from the plate at lower potential to the plate at higher potential, which requires energy. Thus work done in charging = energy stored.

If a capacitor is charged to V by Q then the area under a V-Q graph gives the work done.

Work done, $W = \dfrac{1}{2}QV = \dfrac{1}{2}CV^2 = \dfrac{1}{2}\dfrac{Q^2}{C}$

Discharging

Charge left on a capacitor t s after it starts discharging, $Q = Q_0 e - \dfrac{t}{RC}$

For a discharging capacitor the graphs of charge, voltage and current against time all have the same shape, so this formula works for V and I too.

The **time constant** is t taken for Q to fall to $\frac{1}{e}$ of its previous value. $T = RC$

From this, we can calculate that the time for charge or voltage to half in value is 0.693RC.

Charging

The rate of charge leaving from or arriving on a capacitor depends on how much charge is already there. More work needs to be done to push electrons onto a partially charged capacitor than an empty one.

For a charging capacitor, $Q = Q_0(1 - e^{-\frac{t}{RC}})$

The graphs of Q and V against t show that charge & voltage increase rapidly at first, but the rate of change decreases as a maximum is approached. This means this equation works for V as well as Q, but not I (which looks the same for both a charging and discharging capacitor). Note that these don't work if current is kept constant.

Increasing R leads to a shallower charging or discharging curve which takes longer to reach its maximum or minimum. R decreases the current - decreasing the rate of flow of charge.

$$I = \frac{Q}{t}$$

Polarised molecules

Some molecules have one part more positive and another more negative - they are polarised.

If a polarised molecule is placed in an electric field, the two ends respond differently to the field, moving in opposite directions, rotating the molecule until it lines up with the field.