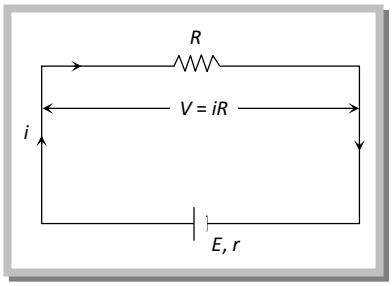
Cell in Various Position.

(1) Closed circuit (when the cell is discharging)



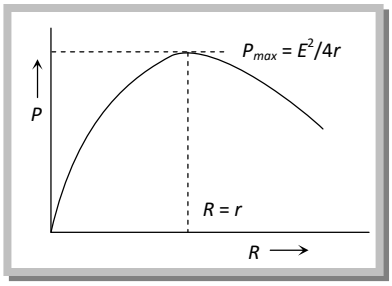
(i) Current given by the cell $i = \frac{E}{R + r}$

(ii) Potential difference across the resistance $V = iR$

(iii) Potential drop inside the cell = ir

(iv) Equation of cell $E = V + ir$ (E > V)

(v) Internal resistance of the cell $r = \left(\frac{E}{V} - 1\right) \cdot R$



(vi) Power dissipated in external resistance (load) $P = Vi = i^2 R = \frac{V^2}{R} = \left(\frac{E}{R + r}\right)^2 .R$

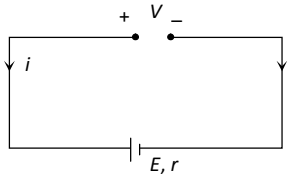
Power delivered will be maximum when $R = r$ so $P_{\max} = \frac{E^2}{4r}$.

This statement in generalized from is called "maximum power transfer theorem".

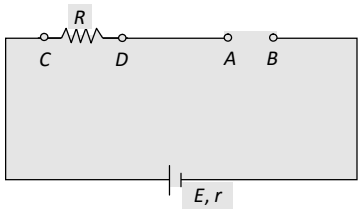
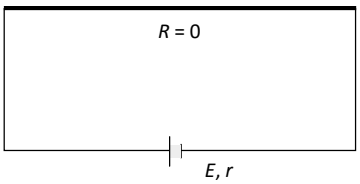
(vii) Short trick to calculate E and r: In the closed circuit of a cell having emf E and internal resistance r. If external resistance changes from R1 to R2 then current changes from i1 to i2 and potential difference changes from V1 to V2. By using following relations we can find the value of E and r.

$$\boldsymbol{E = \frac{i_1 i_2}{i_2 - i_1}(R_1 - R_2)} \quad \boldsymbol{r = \left(\frac{i_2 R_2 - i_1 R_1}{i_1 - i_2}\right) = \frac{V_2 - V_1}{i_1 - i_2}}$$

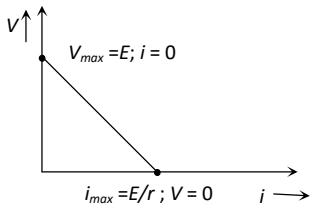
Note: When the cell is charging i.e. current is given to the cell then E = V – ir and E < V.



(2) Open circuit and short circuit

Open circuit	Short circuit
	
(i) Current through the circuit i = 0	(i) Maximum current (called short circuit current) flows momentarily $i_{sc} = \frac{E}{r}$
(ii) Potential difference between A and B, VAB = E	(ii) Potential difference V = 0
(iii) Potential difference between C and D, VCD = 0	

Note: Above information's can be summarized by the following graph



Concepts

It is a common misconception that "current in the circuit will be maximum when power consumed by the load is maximum."

Actually current $i = E/(R+r)$ is maximum (= E/r) when R = min = 0 with $P_L = (E/r)^2 \times 0 = 0 \min.$ while power consumed by the load E2R/(R + r)2 is maximum (= E2/4r) when R = r and $i = (E/2r) \neq \max(= E/r).$

Emf is independent of the resistance of the circuit and depends upon the nature of electrolyte of the cell while potential difference depends upon the resistance between the two points of the circuit and current flowing through the circuit.

Emf is a cause and potential difference is an effect.

Whenever a cell or battery is present in a branch there must be some resistance (internal or external or both) present in that branch. In practical situation it always happen because we can never have an ideal cell or battery with zero resistance.