UNIT 2 CELLS AND BATTERY

2.1 General Features of batteries

2.1.1 The relationship between cell and batteries

Generally, a cell delivers a certain voltage that is a function of what chemical reactions are taking place to generate the voltage. The purpose of an electric cell is to convert chemical energy into electrical energy. To get increased voltage one must add cells in series. The primary difference between a battery and a cell is a battery can be composed of a number of cells. A cell can be a battery. For example, the 9-volt batteries have 6 individual cells inside them.

2.1.2 The basic operation of battery

A **simple cell** comprises two dissimilar conductors (electrodes) in an electrolyte. Such a cell is shown in Figure 1, comprising copper and zinc electrodes. An electric current is found to flow between the electrodes. Other possible electrode pairs exist, including zinc-lead and zinc-iron. The electrode potential (i.e. the p.d. measured between the electrodes) varies for each pair of metals. By knowing the e.m.f. of each metal with respect to some standard electrode the e.m.f. of any pair of metals may be determined.

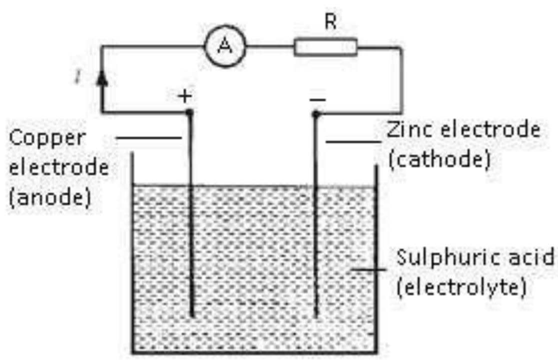


Figure 1

2.1.3 Comparison between primary and secondary cell

Primary cell	Secondary cell
1. Cannot be recharged	1. Can be recharged after use
2. Irreversible	2. Reversible
3. Can be used once	3. Can be used many times.

Table 1

2.1.4 Types of cells and batteries

a. Carbon-zinc cell
b. Alkaline cell
c. Nickel-cadmium cell
d. Edison cell
e. Mercury cell

2.2 Cell connections

2.2.1 Series connection

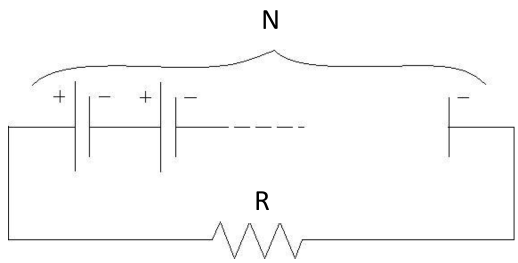


Figure 2

Assume that;
n = number of cells connected in series E = e.m.f cell
R = external resistance
r = internal resistance of cell

So that:

a) Total emf, E_T = nE Volts(V)
b) Total internal resistance, r_T = nr Ohm(Ω)
c) Total resistance in the circuit, R_T = nr + R
d) $Current = \frac{total\ emf}{resistance\ in\ the\ circuit} = \frac{nE(V)}{nr+R(\Omega)} = \frac{E_T}{R_T}$

2.2.2 Parallel connection

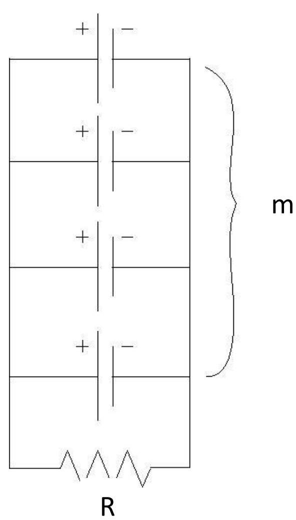


Figure 3

Assume that;
m = number of cells connected in parallel E = e.m.f cell
R = external resistance
r = internal resistance of cell

So that:

e) Total emf, E_T = E Volts(V)
f) Total internal resistance , r_T=r/mΩ
g) Total resistance in the circuit, R_T=(r/m)+R
h)

$$Current = \frac{total\ emf}{resistance\ in\ the\ circuit} = \frac{E(V)}{r/m + R(\Omega)} = \frac{E_T}{R_T}$$

2.2.3 Series-parallel combination

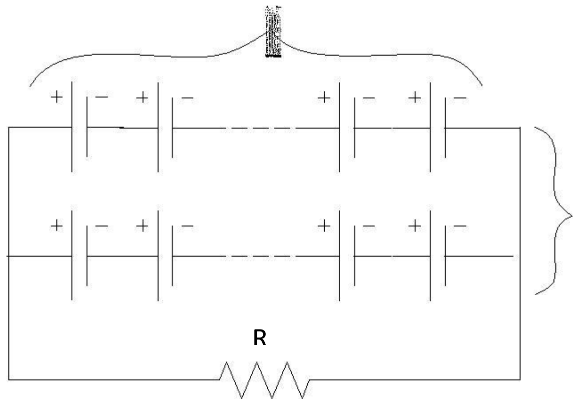


Figure 4

Assume that;
n = number of cell in series
m = number of cells in parallel
E = e.m.f cell
R = external resistance
r = internal resistance of cell

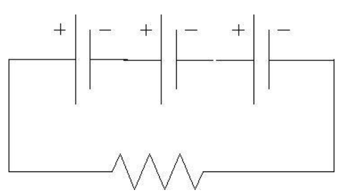
So that:

h) Total emf, E_T = nE Volts(V)
i) Total internal resistance, r_T = nr
j) Total resistance in the circuit, R_T=(nr/m)+R
k) $Current = \frac{total\ emf}{resistance\ in\ the\ circuit} = \frac{nE(V)}{nr/m + R(\Omega)} = \frac{E_T}{R_T}$

Example 1

One battery consists of three cells in series. External resistance is 5Ω. E.m.f each cell is 1.5V and internal resistance is 0.2Ω. Calculate the current flow and draw the circuit.

Solution:



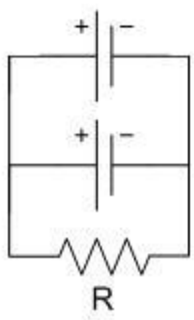
Total e.m.f , E = nE = 3 X 1.5V = 4.5V
Total internal resistance = nr = 3 X 0.2 = 0.6Ω
Total resistance, R_T = nr + R
= 0.6 + 5
= 5.6Ω

$I = \frac{total\ emf}{total\ resistance} = \frac{4.5}{5.6} = 0.8A$

Example 2

Two cells with e.m.f 1.5 V for each cell and internal resistance 0.2Ω are joined in parallel and connected to an external resistor of 4Ω. What is current will flow.

Solution:



Total e.m.f , E = 1.5V

Total internal resistance = r/m = 0.2/2 = 0.1Ω

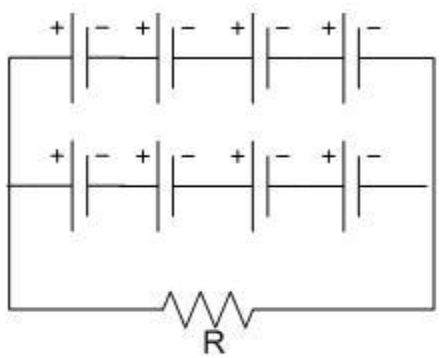
Total resistance, R_T = r/m + R = 0.1 + 4 = 4.1Ω

Example 3

Eight cells are divided in two groups. Four cells for each group and the group are joined in parallel. Emf for each cell is 1.5V and internal resistance is 0.6Ω. One external resistor 5Ω connected in parallel to the group. Calculate:

a) Current flow
b) Voltage drop for internal resistor
c) The potential difference at the battery terminals

Solution:



a) $I = \frac{nE\ (V)}{\frac{nr}{m} + R(\Omega)}\ (A) = \frac{4(1.5)}{\frac{4(0.6)}{2} + 5} = 0.968A$

b) $V_r = I \times \frac{nr}{m} = 0.968 \times \frac{4(0.6)}{2} = 1.16V$

c) Voltage source, V_S = nE - V_r

= 4(1.5) – 1.16V

= 4.84V

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$V_S = IR_L$ = 0.968 X 5 = 4.84V

TUTORIAL 1

1. An external resistance of 10Ω is connected to the terminal of a battery consisting 10 cells connected in series. Emf for each cells and internal resistance is 1.5V and 0.2Ω. Find the current flow.

2. 15 cells with emf for each cell are 1.5V and internal resistance 0.3Ω is connected in parallel. Calculate the value of current flow if the external resistance, 5Ω is joined to them.

3. A battery consist of 12 cells are divided in three group which each group consist of four cells in series. The three groups are joined in parallel. The emf of each cell is 1.5V and internal resistance cell is 0.2Ω. The group is connected to a load resistor of 4Ω. Calculate the current flow.

4. A battery consists of five cells in series. Each cell is 2.5V and internal resistance is 0.05Ω. A battery is connected to the load resistance of 15Ω. Determine:
   i. Total e.m.f
   ii. Total resistance
   iii. Total current

5. Ten 1.5V cells in series, each cells having an internal resistance of 0.3Ω, are connected series to a load of 25Ω. Determine :
   i. The current flowing the circuit
   ii. The potential difference at the battery terminals.

6. One battery consists of four cells, connected in series. Emf of each cell is 1.45V and internal resistance of 0.04Ω. if a load resistance of 5Ω is connected to the battery, draw the circuit and calculate:
   i. Total emf
   ii. Total internal resistance
   iii. Total resistance
   iv. Current flow

7. One battery consists of eight cells in parallel. Emf and internal resistance of each cells is 1.5V and 0.4Ω. Find the value of current if an external resistance of 5Ω is connected to the battery.

8. A battery consists of 5 cells with emf and internal resistance of each cell is 1.5V and 0.25Ω connected in series. If the current flow through load resistance is 1.5A, calculate the value of load resistance.

9. 15 cells with emf 1.5V and internal resistance of 0.5Ω are arranged five per row and three rows in parallel. Draw the circuit and calculate:
   i. Current flow if external load resistance is 15Ω
   ii. Terminal voltage

10. 20 cells with emf 1.45V and internal resistance 0.5Ω for each cells is connected 4 rows which every rows consists of 5 cells in series. Load resistance 15Ω is connected to the battery. Calculate the value of current flow.