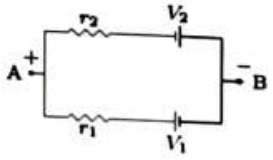
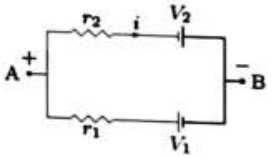
Q 11

... Find the *emf* (V) and the internal resistance (r) of a single battery which is equivalent to a parallel combination of two batteries of *emfs* V_1 and V_2 and internal resistances r_1 and r_2 respectively, with polarities as shown in the figure. (1997)



Sol. The *emf* of the equivalent battery is $V = V_A - V_B$ and its internal resistance r is the resistance between A and B, when A and B are not connected to external resistance. Let i be the current in the loop when A and B are open.



Kirchhoff's loop law

$$V_1 - ir_1 - ir_2 + V_2 = 0,$$

gives the current $i = \frac{V_1+V_2}{r_1+r_2}$. Traversing from B to A along the lower branch relates the potential at A and B by

$$V_A = V_B + V_1 - ir_1 = V_B + V_1 - \frac{(V_1 + V_2)r_1}{r_1 + r_2}.$$

which gives the *emf* of the equivalent battery as

$$V = V_A - V_B = \frac{V_1 r_2 - V_2 r_1}{r_1 + r_2}.$$

The internal resistance of the battery is $r = r_1 \parallel r_2 = \frac{r_1 r_2}{r_1+r_2}$.

Ans. $V = \frac{V_1 r_2 - V_2 r_1}{r_1+r_2}$, $r = \frac{r_1 r_2}{r_1+r_2}$ ⊡