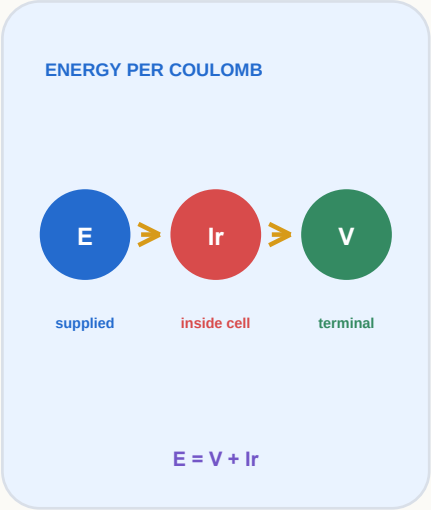
PEARSON EDEXCEL IAL PHYSICS | UNIT 2

LESSON 2.2.5

E.m.f., Internal Resistance and Circuit Measurements

A real cell supplies energy to the whole circuit. Some is transferred inside the cell, so terminal p.d. falls when current flows.



THREE IDEAS TO DISTINGUISH

E E.M.F.

$E = W_{source}/Q$

Energy supplied by the source per unit charge; measured in volts.

V TERMINAL P.D.

$V = W_{external}/Q$

Energy transferred in the external circuit per unit charge.

r INTERNAL R

lost volts = Ir

Resistance inside the cell; it transfers energy thermally inside the source.

RELATIONSHIPS FOR A CELL DELIVERING CURRENT

ENERGY BALANCE

$E = V + Ir$

supplied = useful + internal

TERMINAL P.D.

$V = E - Ir$

straight-line form

CIRCUIT CURRENT

$I = E/(R + r)$

external R plus internal r

OPEN-CIRCUIT LIMIT

When I = 0, lost volts Ir = 0, so the voltmeter reads V = E.

E.m.f. is not a force: both e.m.f. and potential difference are measured in volts.

1 A real cell under load

A 1.50 V cell with internal resistance 0.20 Ω is connected to a 2.80 Ω resistor. Find current, terminal p.d. and power transfers.

CURRENT AND VOLTAGE

1

TOTAL CIRCUIT RESISTANCE

$R + r = 2.80 + 0.20 = 3.00\ \Omega$

2

CURRENT

$I = E/(R + r) = 1.50/3.00 = 0.500\ A$

3

LOST VOLTS

$Ir = 0.500 \times 0.20 = 0.100\ V$

4

TERMINAL POTENTIAL DIFFERENCE

$V = E - Ir = 1.50 - 0.100 = 1.40\ V$

POWER BALANCE

SUPPLIED BY CELL

$EI = 0.750\ W$

1.50×0.500

EXTERNAL RESISTOR

$VI = 0.700\ W$

1.40×0.500

INSIDE CELL

$I^2r = 0.050\ W$

$0.500^2 \times 0.20$

$$0.750\ W = 0.700\ W + 0.050\ W$$

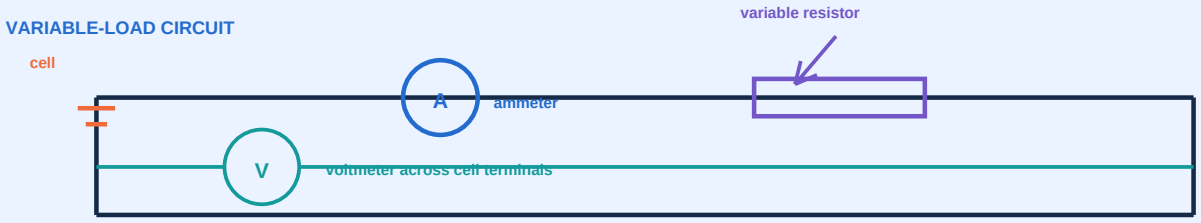
The cell's total power equals external power plus internal heating.

As current increases, Ir increases and terminal potential difference decreases.

2 Core Practical 8: determine E and r

Change the external load, measure terminal potential difference and current, then analyse a straight-line graph.

APPARATUS AND CONNECTIONS



METHOD

1 START WITH LARGE LOAD R

Keep current small initially; record terminal V and current I.

2 VARY THE LOAD

Adjust the variable resistor to obtain at least six pairs of V and I readings.

3 LIMIT HEATING

Open the switch between readings so cell temperature and internal resistance stay stable.

4 PLOT V AGAINST I

Fit one best straight line; do not join the points dot-to-dot.

EXTRACT THE CELL PROPERTIES



Because the line slopes downward, r is the magnitude of the negative gradient.