2022 Sec 4 Physics Notes Answers
Chapter 14 Current of Electricity

14.1 Charge and Electric Current

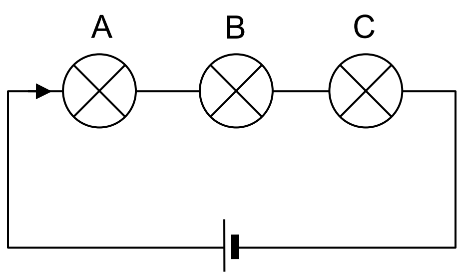
1 $1/(1.6 \times 10^{-19})$ = <u>6.25×10^{18} electrons</u>

2. *Q* = I *t* = *(0.40 A)(10 x 60 s)* = *<u>240 C</u> (2sf)*

3. I = Q/t = 6.3/0.015 = <u>420 A</u>

4 (a) t = Q/ I = 0.0036 / 0.012 = 0.30 s
(b) From the conducting body to earth.
(c) From earth to the conducting body.

5 (a) Arrow(s) through the circuit pointing from the positive terminal towards the negative terminal of the cell.

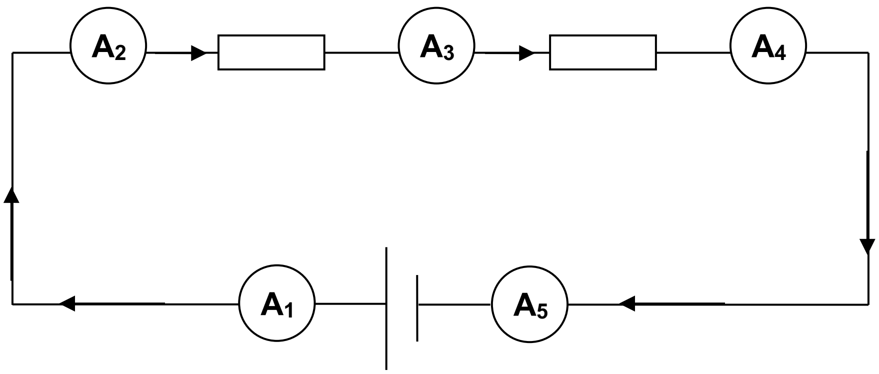


(b) All bulbs will light up at the same time. The battery applies a p.d. simultaneously across each of the bulbs in series (*and the electric field along the connecting wires and bulbs move the electrons at the same time*). Hence current flows through all bulbs at the same time.

Note: *Think of the flow of current like a metal chain. When you pull at one end of the chain the entire chain moves.) The electrons are linked in a similar way, if one begins to move through the circuit, it will push the electron in front of it and pull the electron behind it. Since all the electrons around the circuit move instantaneously at the same time by the "chain" principle, all the lights should light up at the same moment.*

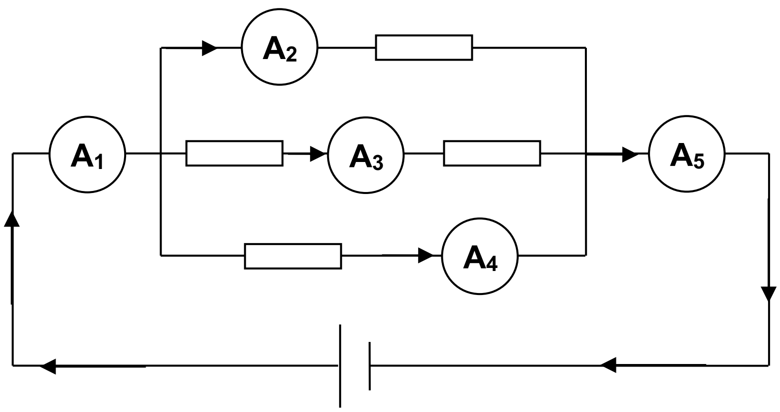
(c) Since they are identical bulbs in series, the same amount of current flows through each of them. Hence, they will all be equally bright.

6 (a)



(b) All the ammeters show the same reading.

7 (a)



(b) A_1 and A_5 both show the same high reading. A_3 shows the lowest reading.

8 (a) $I = Emf / R_T = 2.0 \div (8.0 + 4.0) = 0.17$ A
(b) $I = 0$ A (Short-circuit across 4.0 Ω resistor)

14.2 Electromotive Force & Potential Difference

1 (a) An emf of 12.0 V means that the battery will convert 12.0 J of chemical potential energy to electrical energy to move 1C of charge round the circuit. [emf = W / Q]
(b) $E = IVt = 3.5 \times 8.0 \times 6.0 = 168$ J (c) thermal energy

2 (a) 4(1.5) = 6.0 V (b) W = QV = 4.0 x 6.0 = 24 J

3 (a) 0 V (b) 6.0 V (c) 3.0 V (d) 1.5 V

4 Consider original circuit to have cell with emf V and lamp of resistance R and V = IR
(a) Vey bright. Effective emf = 2V, hence current = 2I
(b) Normal brightness. Effective emf = V + V – V = V, hence current = I
(c) Normal brightness. Effective emf = 2V, effective resistance = 2R, hence current = I
(d) Not lighted up. Polarity of cells are in opposite directions, Effective emf = 0 V

5 (a) 24 V (b) 240 ÷ 20 = 12 V

6 (a) (i) 0.70V (ii) 1.00 V
(b) (i) $V_{sq} = V_q – V_s$ = 1.00 – 0.70 = 0.30 V
(ii) $V_{sr} = V_s – V_r$ = 0.70 – 0.50 = 0.20 V
(c) Emf = $V_A + V_B$ = 0.80 + 0.70 = 1.50 V

Example 1

(a) R = ρl / A

Let resistance of R_B be R.

First consider Wire A' has resistivity twice that of Wire B. Thus, $R_{A'}$ = 2R

In addition, Wire A has thrice the cross sectional area of Wire B.

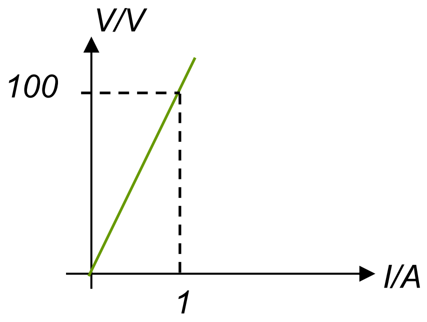
Therefore, in total,

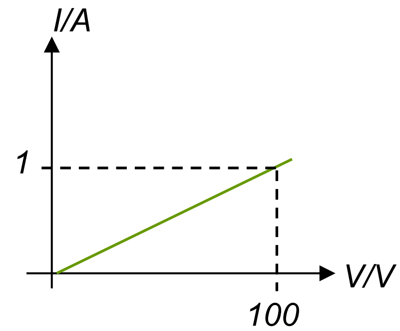
$R_A = 2R / 3 = 2/3\ R_B$

(b) Resistivity ρ = RA/L = 6(1.0 x 10^{-6}) / 1.5 = <u>4.0 x 10^{-6} Ωm</u>

Example 2

Draw the V against I graph and I against V graph for an ohmic conductor that has a 100 Ω resistance.

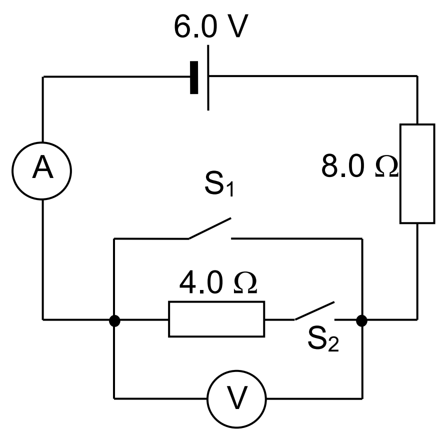




Note: Redraw & simplify circuit for each part!

Example 3

1 The following diagram shows a 6.0 V cell of negligible internal resistance connected to two resistors with switches S_1 and S_2. The current taken by the voltmeter and the resistance of the ammeter can both be neglected.



Calculate and explain the readings of the ammeter and the voltmeter when:

(a) switch S_1 is opened and switch S_2 is closed.

V=IR

6=I.12

I=0.50 A

V=IR

V=0.50 x 4.0

V=2.0 V

(b) Both the switches S_1 and S_2 are closed.

Closing S_1 creates a short-circuit across 4.0 Ω resistor. V=0 V

V=IR

6=I.8

I=0.75 A

(c) Both the switches S_1 and S_2 are opened.

I=0 A (very small current due to infinite resistance of the voltmeter)

V=6.0 V

14.3 Resistance

1 (a) Each wire = 1.5 m x 3.0 Ω/m = 4.5 Ω

Effective resistance of 3 wires in parallel, $R_E = (3/4.5)^{-1}$ = <u>1.5 Ω</u>

(b) V = IR = 2.0 x 4.5 = <u>9.0 V</u>

OR V = $I_{main}R_E$ = (3x2.0) x (1.5) = 9.0 V

2 $L_1 = (L_2/R_2)xR_1$ = (3.5/20)X50 = 8.75 m = <u>8.8 m</u> (2sf)

3 R ∝ 1/A and R ∝ $1/d^2$ where d is the diameter of the wire.

Therefore $R_B = R_A \times (d_A)^2/(d_B)^2$

Since $d_A = 2d_B$, $R_B = R_A \times (2d_B)^2/(d_B)^2$ = 25.8 x 4 = 103.2 = <u>103 Ω</u> (3sf)

4 (ai) 4.0 V (aii) R = V / I = 4.0 V ÷ 0.035 A = 114.3 = <u>110 Ω</u> (2 sf)

(bi) R = V / I = 8.0 V ÷ 0.045 A = 177.7 = <u>180 Ω</u> (2 sf)

Note it is a common mistake to define resistance as the rate of change of V with respect to I.

(bii) Resistance of lamp increases as current increases.

**Not in the 2022 notes

5 Compare the resistance of an ideal ammeter and voltmeter to those used in the laboratories.

Resistance of	**Ideal**	**Those used in laboratories**
Ammeter	Zero	Approx 1 Ω
Voltmeter	Infinite	Approx 3000 Ω

Discussion

1. No. A flow of positive or negative ions can constitute an electrical current.

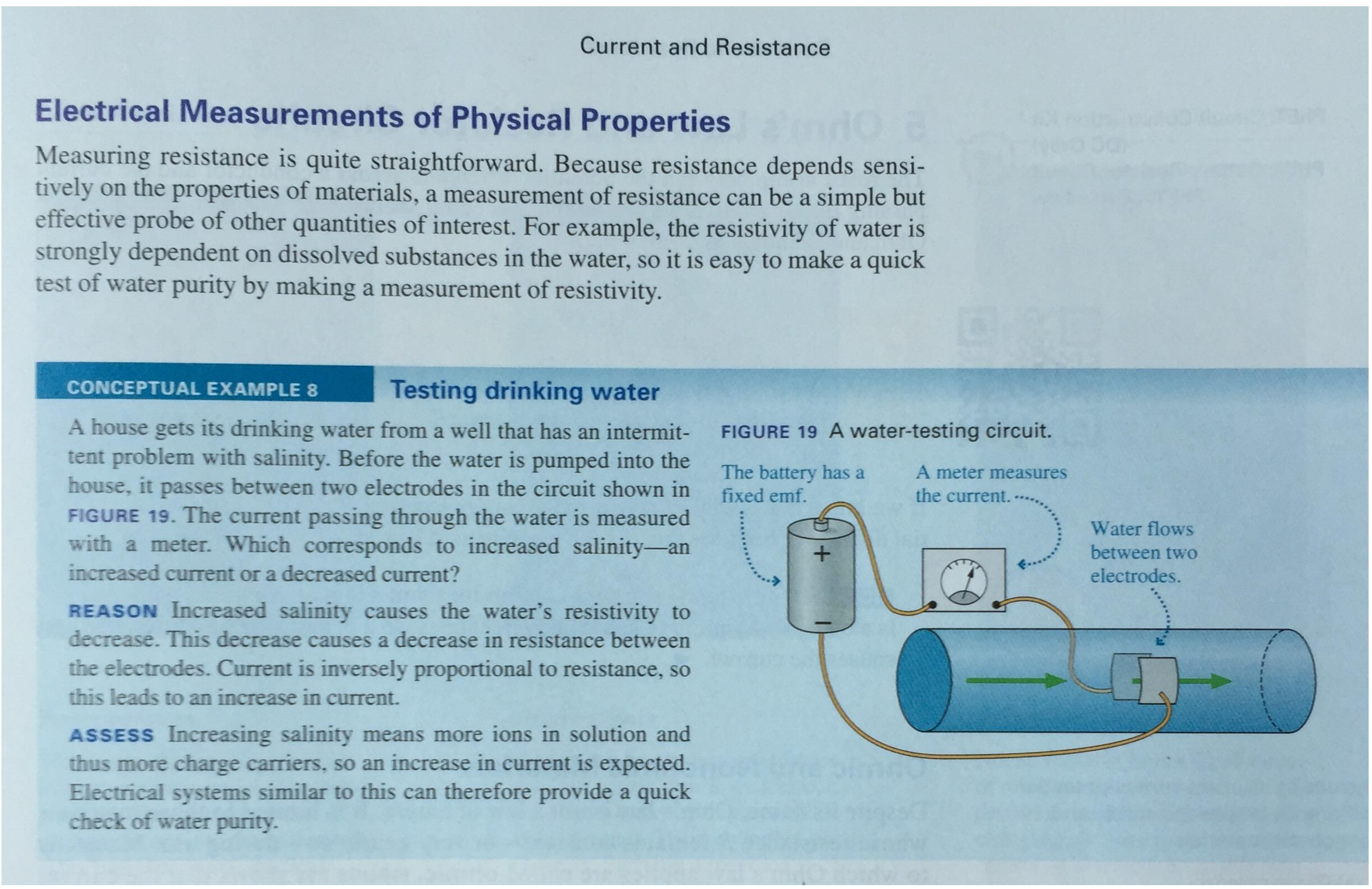
2. draw right-angled triangle, gradient ≈ 8 / (0.050 - 0.020) = 267 V/A = 267 Ω
   No. Resistance = V / I = 110 Ω

3. Bioimpedance Impedance Analysis (BIA):
   Two conductors are attached to a person's body and a small electrical current is sent through the body. The resistance between the conductors will provide a measure of body fat. The resistance to electricity varies between types of tissue.

Reference:

- https://en.wikipedia.org/wiki/Bioelectrical_impedance_analysis

4.



Current and Resistance

Electrical Measurements of Physical Properties

Measuring resistance is quite straightforward. Because resistance depends sensitively on the properties of materials, a measurement of resistance can be a simple but effective probe of other quantities of interest. For example, the resistivity of water is strongly dependent on dissolved substances in the water, so it is easy to make a quick test of water purity by making a measurement of resistivity.

CONCEPTUAL EXAMPLE 8 Testing drinking water

A house gets its drinking water from a well that has an intermittent problem with salinity. Before the water is pumped into the house, it passes between two electrodes in the circuit shown in FIGURE 19. The current passing through the water is measured with a meter. Which corresponds to increased salinity—an increased current or a decreased current?

REASON Increased salinity causes the water's resistivity to decrease. This decrease causes a decrease in resistance between the electrodes. Current is inversely proportional to resistance, so this leads to an increase in current.

ASSESS Increasing salinity means more ions in solution and thus more charge carriers, so an increase in current is expected. Electrical systems similar to this can therefore provide a quick check of water purity.

FIGURE 19 A water-testing circuit.

Reference: College Physics, Pearson New International Edition (2014), p.815