5: Electrical circuits – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
6	2017	June	21
6	2017	March	22
7	2017	June	22

The mark scheme for each question is provided at the end of the document.

6 **(a)** Define the *ohm*.

.....

.....[1]

(b) A cell X of electromotive force (e.m.f.) 1.5 V and negligible internal resistance is connected in series to three resistors A, B and C, as shown in Fig. 6.1.

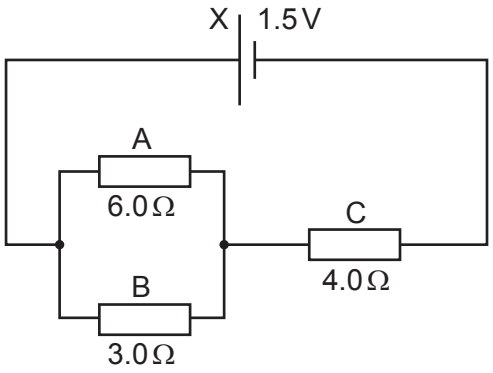

Fig. 6.1

Resistors A and B have resistances 6.0 Ω and 3.0 Ω respectively and are connected in parallel. Resistor C has resistance 4.0 Ω and is connected in series with the parallel combination.

Calculate

(i) the current in the circuit,

current = ...A [3]

(ii) the current in resistor B,

current = ...A [1]

(iii) the ratio

$$\frac{\text{power dissipated in resistor B}}{\text{power dissipated in resistor C}}.$$

ratio = ...[2]

(c) The resistors A, B and C in **(b)** are wires of the same material and have the same length.

(i) Explain how the resistors may be made with different resistance values.

.....[1]

(ii) Calculate the ratio

$$\frac{\text{average drift speed of the charge carriers in resistor B}}{\text{average drift speed of the charge carriers in resistor C}}.$$

ratio = ...[2]

(d) A cell of e.m.f. 1.5 V and negligible internal resistance is connected in parallel with cell X in Fig. 6.1 with their positive terminals together.

State the change, if any, to the current in

(i) cell X,

.....[1]

(ii) resistor C.

.....[1]

[Total: 12]

6 **(a)** Three resistors of resistances R_1, R_2 and R_3 are connected as shown in Fig. 6.1.

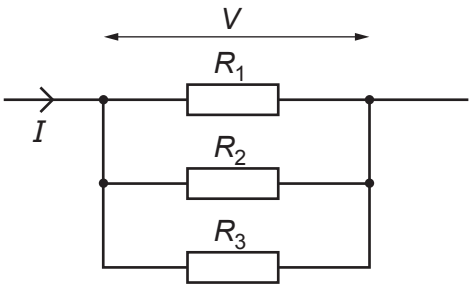

Fig. 6.1

The total current in the combination of resistors is I and the potential difference across the combination is V.

Show that the total resistance R of the combination is given by the equation

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}.$$

[2]

(b) A battery of electromotive force (e.m.f.) 6.0 V and internal resistance r is connected to a resistor of resistance 12 Ω and a variable resistor X, as shown in Fig. 6.2.

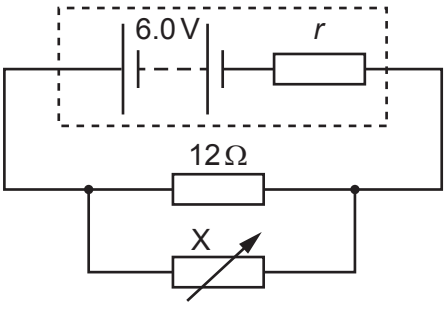

Fig. 6.2

(i) By considering energy, explain why the potential difference across the battery's terminals is less than the e.m.f. of the battery.

.....

.....

.....

.....[2]

(ii) A charge of 2.5 kC passes through the battery.

Calculate

1. the total energy transformed by the battery,

energy = ...J [2]

2. the number of electrons that pass through the battery.

number = ...[1]

(iii) The combined resistance of the two resistors connected in parallel is 4.8 Ω.

Calculate the resistance of X.

resistance of X = ...Ω [1]

(iv) Use your answer in **(b)(iii)** to determine the ratio

$$\frac{\text{power dissipated in X}}{\text{power dissipated in 12}\,\Omega\text{ resistor}}.$$

ratio = ...[2]

(v) The resistance of X is now decreased. Explain why the power produced by the battery is increased.

.....

.....

.....[1]

[Total: 11]

7 **(a)** Define *electromotive force* (e.m.f.) of a cell.

.....

.....[1]

(b) A cell C of e.m.f. 1.50 V and internal resistance 0.200 Ω is connected in series with resistors X and Y, as shown in Fig. 7.1.

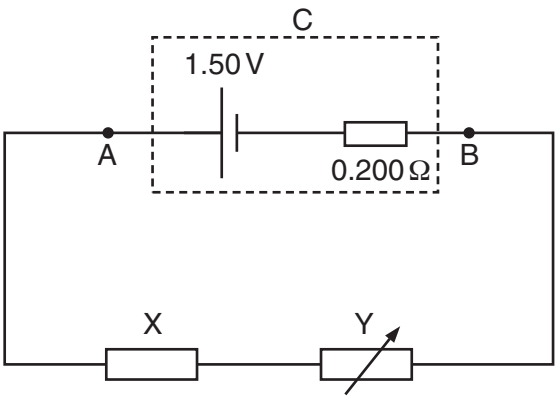

Fig. 7.1

The resistance of X is constant and the resistance of Y can be varied.

(i) The resistance of Y is varied from 0 to 8.00 Ω.

State and explain the variation in the potential difference (p.d.) between points A and B (terminal p.d. across C). Numerical values are not required.

.....

.....

.....

.....[3]

(ii) The resistance of Y is set at 6.00 Ω. The current in the circuit is 0.180 A.

Calculate

1. the resistance of X,

resistance = ... Ω [2]

2. the p.d. between points A and B,

p.d. = ... V [2]

3. the efficiency of the cell.

efficiency = ...[2]

[Total: 10]

Question	Answer	Marks
6 (a)	volt / ampere	**1**
6 (b) (i)	R_T = [1 / 3.0 + 1 / 6.0]$^{-1}$ + 4.0 (= 6.0 Ω)	**1**
	I = 1.5 / 6.0	**1**
	= 0.25 A	**1**
6 (b) (ii)	V_B = 0.5 V I = 0.5 / 3.0 = 0.17 (0.167) A	**1**
6 (b) (iii)	$P = I^2R$ **or** VI **or** V^2/R	**1**
	ratio = (0.167^2 × 3.0) / (0.25^2 × 4.0) = 0.33	**1**
6 (c) (i)	vary/change/different radius/diameter/cross-sectional area (of wire)	**1**
6 (c) (ii)	$v = I / Ane$ ratio = $\frac{(I_B/A_B)}{(I_C/A_C)}$ or $\frac{I_B}{I_C} \times \frac{A_C}{A_B}$	**1**
	(R ∝ 1/A so) ratio = $\frac{I_B}{I_C} \times \frac{A_C}{A_B} = \frac{0.167}{0.25} \times \frac{3.0}{4.0}$ = 0.50	**1**
6 (d) (i)	0.25 A to 0.13 (0.125) A **or** halved	**1**
6 (d) (ii)	no change	**1**
		Total: 12
6 (a)	$I = I_1 + I_2 + I_3$	**1**
	$(V/R) = (V/R_1) + (V/R_2) + (V/R_3)$ *or* $(I/V) = (I_1/V) + (I_2/V) + (I_3/V)$ and (so) $1/R = 1/R_1 + 1/R_2 + 1/R_3$	**1**
6 (b) (i)	e.m.f. is total energy available per unit charge	**1**
	energy is dissipated in the internal resistance / resistor / *r*	**1**
6 (b) (ii) 1	Energy = EQ	**1**
	= 6.0 × 2.5 × 10^3 = 1.5 × 10^{4}J	**1**
6 (b) (ii) 2	number = 2.5 × 10^3/ 1.6 × 10^{-19} = 1.6 × 10^{22} (1.56 × 10^{22})	**1**
6 (b) (iii)	1 / 4.8 = 1 / 12 + 1 / R_X R_X = 8.0 Ω	**1**
6 (b) (iv)	$P = V^2/R$ *or* $P = VI$ and $V = IR$	**1**
	ratio = (V^2/ 8) / (V^2/ 12) = 12 / 8 = 1.5	**1**
6 (b) (v)	(total) current, *or* I, increases and $P = EI$ *or* P = 6I *or* $P \propto I$ *or* total (circuit) resistance decreases and $P = E2/R$ *or* $P = 36/R$ or $P \propto 1/R$	**1**
		Total: 11

Question	Answer	Marks
7 (a)	energy transformed from chemical to electrical / unit charge (driven around a complete circuit)	**1**
7 (b) (i)	the current decreases (as resistance of Y increases)	**1**
	lost volts go down (as resistance of Y increases)	**1**
	p.d. AB increases (as resistance of Y increases)	**1**
7 (b) (i) 1	$1.50 = 0.180 \times (6.00 + 0.200 + R_X)$	**1**
	$R_X = 2.1(3)\ \Omega$	**1**
7 (b) (ii) 2	p.d. AB = 1.5 − (0.180 × 0.200) **or** 0.18 × (2.13 + 6.00)	**1**
	= 1.46(4) V	**1**
7 (b) (ii) 3	efficiency = (useful) power output / (total) power input **or** IV / IE	**1**
	(= 1.46 / 1.5) = 0.97 [0.98 if full figures used]	**1**
		Total: 10

Notes about the mark scheme are available separately.