Topic 4 Electric Circuits
4B Complete electrical circuits

4B.1 Series and parallel circuits

1 All ammeter readings show the same current, so the same quantity of charge passes through them per second. As there is only one route the charge can take, it must be conserved.

2 12.0 V

3 0.25 A

4 0.24 × 50 = 12 V, and 0.12 × 100 = 12 V

5 1.53 mA

6 (a) 30 A

(b) 5.0 A

4B.2 Electrical circuit rules

1 0.9 A

2 0.9 A + 0.45 A = 1.35 A

3 pd = I_2R_3 = 0.9 × 5.0 = 4.5 V = cell emf

4 11.4 V

4B.3 Potential dividers

1 4.15 V

2 11.3 V

3 Drawing as per fig G, with lamp symbol replaced by a motor; LDR replaced by fixed resistor and the fixed resistor becomes a thermistor

4 The rotating contact is a variable resistance, which in series with the lamp forms a potential divider. As the contact rotates clockwise, its resistance increases, so its share of the voltage increases, and so the lamp voltage and brightness decrease.

4B.4 Emf and internal resistance

1 0.5 Ω

2 0.77 Ω

3 (a) The potential difference across the internal resistance will be proportional to its resistance value. If this is high, the potential difference across the starter motor may be too low to turn it.

(b) The car battery also powers the car headlights. As the starter draws a high current, the voltage lost across the internal resistance leaves a lower pd for the headlights, so they dim.

4 Plot V on y-axis and I on x-axis. Internal resistance from gradient is approximately 0.35 Ω; emf from y-intercept, $\mathcal{E}$ = 1.49 V.

4B.5 Power in electric circuits

1 20.4 J

2 1.85 W

3 (a) 1460 W

(b) 0.172 W

4 (a) 0.95 or 95%

(b) The input and output energies labelled go together, so for every 100 J supplied, 95 J are delivered as heat, so the efficiency will always be 95%.

4B Exam Practice

1 B

2 A

3 B

4 C

5 A

6 (a) The current in lamp A is equal to the current in lamp B.

The pd across lamp A is less than the pd across lamp B.

The resistance of lamp A is less than the resistance of lamp B.

(b) Bulb A brighter than bulb B; resistors in parallel have same pd

Identifies $P = \frac{V^2}{R}$ OR $P = VI$ and $I_A > I_B$

Uses this equation to state $P_A > P_B$

7 QWC (quality of written communication) – the answer must be clear and organised in a logical sequence, and include some of the following:

Different currents / current divides in parallel circuit

Same potential difference / voltage across each lamp

Use of $P = \frac{V^2}{R}$ OR $P = VI$ if identified $I_A < I_B$

Leading to high resistance, smaller power

Lamp B will be brighter / lamp A dimmer

Each electron loses the same energy

There are more electrons/sec in B

Hence, greater total energy loss / sec in B

8 (a) pd = $\frac{(40 \times 9.0)}{(40 + 80)}$

pd = 3.0 V

(b) QWC (quality of written communication) – work must be clear and organised in a logical sequence and including the following:

Resistance of parallel combination increases as temperature decreases

Total resistance of circuit increases

emf / pd remains constant therefore current decreases

9 (a) $R = \frac{V^2}{P}$

$R = \frac{220 \times 220}{1000}$

$R = 48.4\ \Omega$

(b) Use of $E = Pt$ OR $E = VIt$ OR $E = \frac{V^2 t}{R}$ with 3 OR 3 × 60 as the time

$E = 180\ 000$ J

(c) (i) Attempts to calculate power

Power = 250 W

Time to boil = 12 mins / 720 s

OR

Calculates new current 2.27 A

Use of $E = VIt$ with their current

Time = 12 mins / 720 s

OR

$P \alpha V^2 \alpha \frac{1}{4}$

$t \alpha 1 / P \alpha 4$

Time = 12 mins

(ii) Use of equation, $V = IR$ OR $P = \frac{V^2}{R}$ OR $P = VI$

This will lead to increased current or power, so causing damage / fuse to melt / circuit breaker to trip / element to burn out / wire to melt

10 (a) $I = \frac{P}{V} = \frac{4.8}{230} = 0.021$ A

(b) (i) $P = VI$, so W = V A

OR V = J C^{-1}, A = C s^{-1} so V A = J C^{-1} × C s^{-1} = J s^{-1} = W

OR 5 V × 0.1 A = 0.5 W

(ii) Efficiency = $\frac{0.5}{4.8} \times 100$

Efficiency = 10.42%

(iii) Energy / power wasted / transferred / lost to thermal or heat energy

11 (a) (i) 4.0 Ω

(ii) $I = \frac{3\text{ V}}{4\,\Omega}$

$I = 0.75$ A

(iii) $P = (0.75\text{ A})^2 \times 3.6\,\Omega$

$P = 2.0$ W

(b) Total resistance (of circuit) will increase so current will decrease

12 Award 1 mark for the (QWC) quality of written communication.

Award a maximum of 5 marks from the following expected answer points:

Current conservation rule is that the vector sum of the currents at any point in a circuit is zero.

This means that the total amount of current entering equals the total leaving that point.

In any given time, this will mean the same quantity of charge entering as leaving that point.

Hence, charge is conserved.

Voltages circuit rule is that the sum of the emfs around any closed circuit loop equals the sum of the pds in the same loop.

This means that the energy gained by any given quantity of charge in that loop will be given up again by the time it has travelled around the complete loop.

This will mean the same quantity of energy entering as leaving that circuit loop.

Hence, energy is conserved.