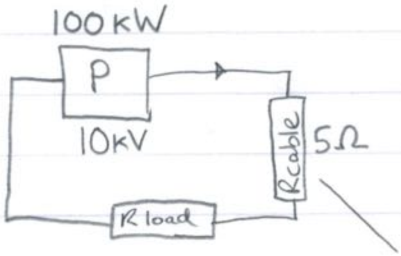
# Resistances : Issac Physics     SA answers.

① Power loss in cables

A



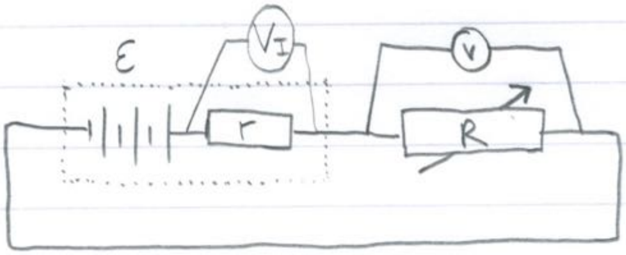

$P = IV$

$I = P/V = \frac{100 \times 10^3 W}{10 \times 10^3 V} = 10A$

$P = IV = I^2R = 10A^2 \times 5\Omega = 500W$

B $Eff = \frac{100 \times 10^3 - 500 \ W}{100 \times 10^3 W} \times 100 = 99.5\%$

② Finding internal resistance




$R = 2.0\Omega$, $V = 6.0V$   $I = V/R = \frac{6.0}{2.0} = 3.0A$

$R = 4.0\Omega$, $V = 8.0V$   $I = V/R = \frac{8.0}{4.0} = 2.0A$

$\mathcal{E} = V_I + V$ & $V_I = Ir$

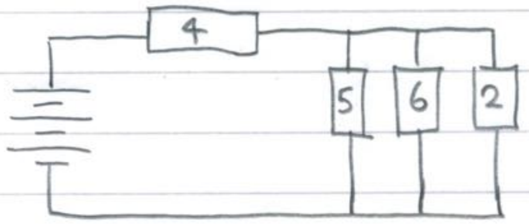
so $\mathcal{E} = V + Ir$

$\therefore \quad 8 + 2.0 \times r = 6 + 3.0 \times r$

$2 + 2r = 3r$

$2 = r$     $r = 2.0\,\Omega$

## ③ Current and resistance



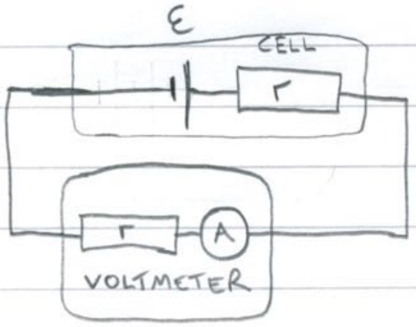

$\leftarrow \frac{1}{R_T} = \frac{1}{5} + \frac{1}{6} + \frac{1}{2} = \frac{13}{15}$

$\therefore R_T = \frac{15}{13} = 1.15\,\Omega$

so total R of circuit $= 4 + 1.15\,\Omega = 5.15\,\Omega$

$I = V/R = 10/5.15 = 1.9\,A$

## ④ Vital Voltmeters



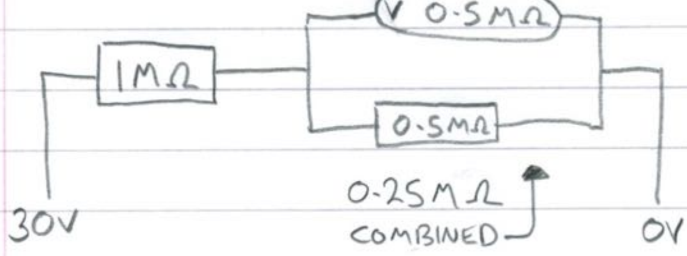

A Voltmeter P has resistance $r\,\Omega$ so $\varepsilon$ is shared equally across two resistances $\rightarrow \varepsilon/2$

Voltmeter Q has resistance $10r\,\Omega$ so most of $\varepsilon$ is across it $\rightarrow$ nearly $\varepsilon$

$\therefore$ 2nd option

B $V = V_{IN} \frac{R_2}{R_1 + R_2} = 30V \times \frac{0.5}{1 + 0.5} = 10V$

C




$V = V_{IN} \frac{R_2}{R_1 + R_2} = 30 \times \frac{0.25}{1 + 0.25}$

$= 6.0V$

## ⑤ Melting a Snowman

Ⓐ $P = IV = 0.23A \times 6.0V = 1.4W$

Ⓑ $V = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi \times 0.5^3 + \frac{4}{3}\pi \times 1.0^3$

$= 4.712\ m^3$

$m = v \times d = 4.712 m^3 \times 930\ kg\,m^{-3}$

$= 4400\ kg$

Ⓒ At 30% efficiency → 70% Heat

so heating power $= 0.70 \times 1.4W = 0.98\ W$

Energy to melt $= 4400\ kg \times 1000 \times 335\ J/g$

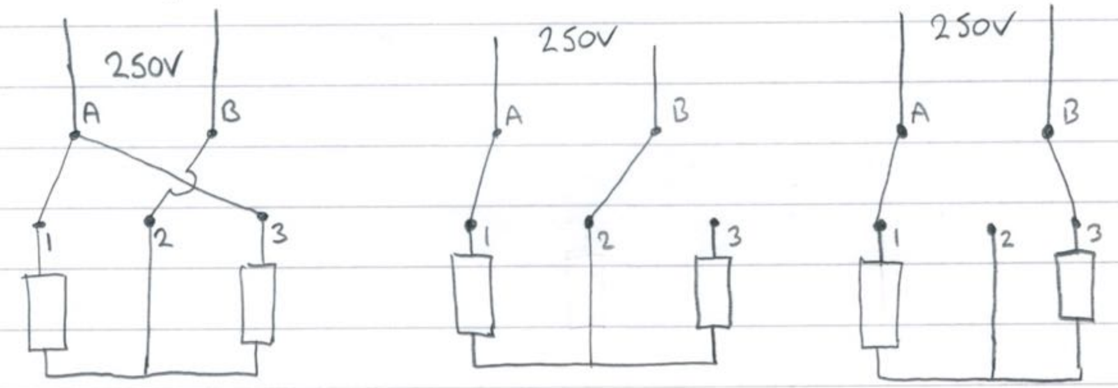
$= 1.47 \times 10^9\ J$

$E = Pt \quad \therefore t = E/P = \frac{1.47 \times 10^9}{0.98} = 1.5 \times 10^9 s$

In years $1.5 \times 10^9 / 60 \times 60 \times 24 \times 365.25$

$= 48$ years

⑥ Heating an Electric Fire




3·0 kW     1·5 kW     0·75 kW

$P = IV$

$I = V/R$

$\therefore$

$P = \frac{V^2}{R}$

$R = \frac{V^2}{P}$

$R = \frac{250^2}{3 \times 10^3} = 21\,\Omega$ , $R = \frac{250^2}{1.5 \times 10^3} = 42\,\Omega$ , $R = \frac{250^2}{0.75 \times 10^3} = 83\,\Omega$

must be in parallel
eg.
A = 1 & 3
+
B = 2

must be single
eg.
A = 1 B = 2

must be in series
eg.
A = 1 B = 3

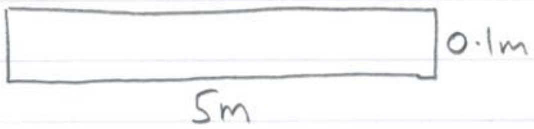
Ⓐ First Answer
Ⓑ Last Answer
Ⓒ Third Answer

Ⓓ 42 Ω

## ⑦ Conveying Current

Each second...

A




$A = 5m \times 0{\cdot}1m = 0{\cdot}5m^2$

e density $= 1 \times 10^4$ per $mm^2$ $= 1 \times 10^{10}$ per $m^2$

so No of electrons $= 0{\cdot}5m^2 \times 1 \times 10^{10} m^{-2} = 5 \times 10^9$

$e = 1{\cdot}6 \times 10^{-19} C \quad \therefore \quad Q = 1{\cdot}6 \times 10^{-19} \times 5 \times 10^9 = 8 \times 10^{-10} C$

$\therefore \quad I = 8{\cdot}0 \times 10^{-10} A$

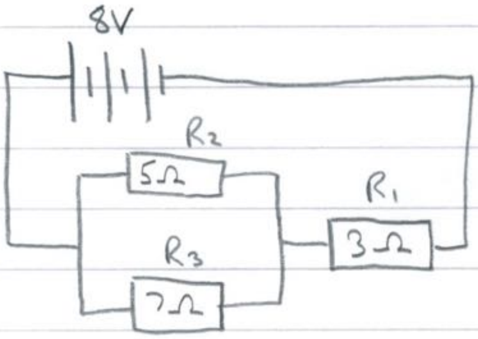
B 3000 protons cancel out 3000 electrons per $mm^2$

so effective number of electrons $= 0{\cdot}5 \times 0{\cdot}7 \times 10^{10}$

$= 3{\cdot}5 \times 10^9$ electrons

$I = 3{\cdot}5 \times 10^9 \times 1{\cdot}6 \times 10^{-19} = 5{\cdot}6 \times 10^{-10} A$

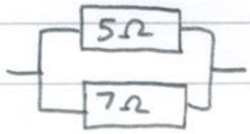
## (8) Power in Resistors




Overall resistance $= 3 + \frac{1}{\frac{1}{5} + \frac{1}{7}} = 5.92\ \Omega$

(A) $P = IR$ & $I = V/R$ $\therefore$ $P = V^2/R = 8^2/5.92 = 11W$

(B) Current $= V/R = 8/5.92 = 1.35A$

Combined resistance of  $= \frac{1}{1/5 + 1/7} = 2.9\ \Omega$

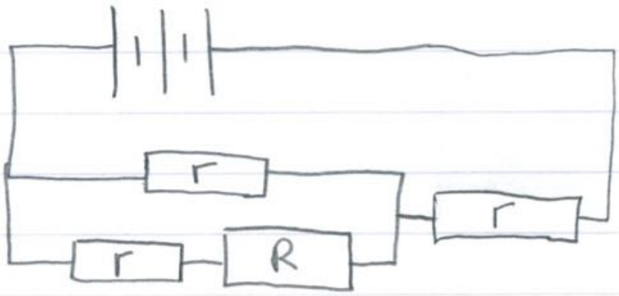

so voltage approx shared equally across them and the 3Ω

$\therefore$
5Ω $P \approx 4^2/5 \approx 3.2$ W
7Ω $P \approx 4^2/7 \approx 2.3$ W
3Ω $P \approx 4^2/3 \approx 5.3$ W

so $R_1$ dissipates most power

(C) $P = I^2 R = 1.35^2 \times 3.0 = 5.5$ W

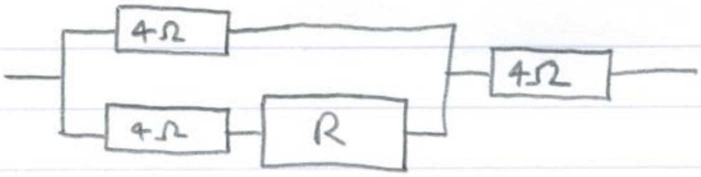
## (9) Resistors with tolerance




$r = 5.0\,\Omega \pm 20\% \quad = \quad 5.0\,\Omega \pm 1\,\Omega$

min $= 4.0\,\Omega$ max $= 6.0\,\Omega$

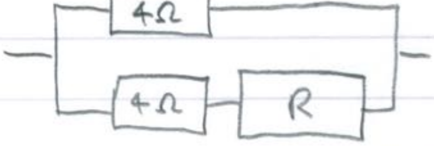
Need to ensure $I \leq 1.0\,A$ worst case senario is when all r s are $4.0\,\Omega$




If $I \leq 1.0\,A$ then $R_{TOTAL} \geq 7.0\,\Omega$ as $I = \frac{V}{R}$

and $\frac{7V}{7\Omega} = 1\,A.$

∴




must = or exceed $3\,\Omega$

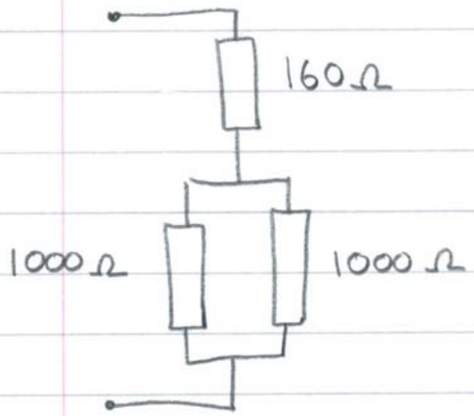
$$\therefore \frac{1}{3\Omega} = \frac{1}{4\Omega} + \frac{1}{4\Omega + R}$$

$$\therefore \frac{1}{4+R} = \frac{1}{3} - \frac{1}{4} = \frac{1}{12}$$

$\therefore 4 + R = 12 \quad \therefore \quad R = 8.0\,\Omega$ but R is $\pm 20\%$

$\therefore 8.0/0.8 = \underline{\underline{10\,\Omega}}$ ($\pm$ 20% has lowest value of $8\,\Omega$)

## (10) Power limited resistors




$P_{max} = 0.40W$

→ combined = 500Ω

so overall resistance 160 + 500 = 660Ω

(A) $V_{160\Omega} = V_T \times \frac{160}{660}$ $V_{1000\Omega} = V_T \times \frac{500}{660}$

$P = IV$ $= \frac{V_T\, 160\, I}{660}$ $= \frac{V_T\, 500\, I}{660 \times 2}$ ↖ half current

$= \frac{160}{660} V_T I$ $= \frac{250}{660} V_T I$

↑ higher power so 1000Ω will fail first

(B) $P = I^2 R$ ∴

$I_{1000} = \sqrt{P/R} = \sqrt{0.4/1000} = 0.02A$ each

$I_{1000}$ total $= 0.04A$

$V = IR = 0.04A \times 660\Omega = 26V$