A2. (a) $11\,\text{m s}^{-2}$; *[1]*

(b) $\Delta v = 236$;

$a = \left(\frac{236}{8} = \right) 29.5\,(\text{m s}^{-2})$;

$(F = 1.1\times10^4 \times 29.5) = 3.2\times10^5\,\text{N}$; *[3]*

*Award **[2 max]** for omission of initial speed (answer is 390 kN).*

(c) phase 1 distance 88 m / phase 2 distance 1296 m;

total 1400 m; *[2]*

Watch for significant figure penalty in this question (1384 m).

*Award **[1 max]** for $\frac{1}{2}at^2$ substituted correctly for first phase, if no distances evaluated and answer incorrect.*

*Award **[1 max]** for correct addition of incorrect phase 1 and/or 2 distance(s).*

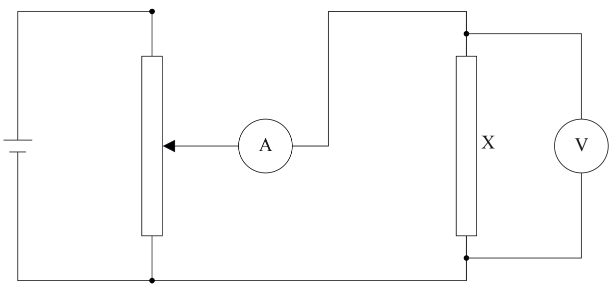
A3. (a) voltmeter in parallel across X;

ammeter in series with X;

correct circuit; *(allow ecf from 1st and 2nd marking points)* *[3]*

Accept voltmeter connections that include ammeter (in series with X)

Condone re-drawing of resistor X closer to variable resistor.



(b) $I = 2.4\,\text{A}$ at $2.0\,\text{V}$;

$\frac{2}{2.4}$;

$= 0.83\,\Omega$ *[2]*

*Award **[1 max]** for use of gradient of graph from (2,2.4) to origin.*

(c) total p.d. across $1\,\Omega$ resistor $= 1.3\,(\text{V})$;

p.d. across $\text{X} = 0.7\,(\text{V})$;

reading from graph $I = 1.3\,\text{A}$ at $0.7\,\text{V}$ / evidence that the graph has been read; *[3]*

*Award **[1 max]** if value of calculated p.d. is incorrect but there is clear graphical evidence of derivation of current (typically marks on graph).*

or

total p.d. across X + resistor $= 2.0\,(\text{V})$;

this occurs when $V_{\text{X}} = 0.7\,(\text{V})$ and $V_{1.0} = 1.3\,(\text{V})$;

at $I = 1.3\,\text{A}$;

Part 2 Electrical resistance and electric circuits

(a) *resistance*: the ratio of potential difference across a device/load/resistor to current in the device/load/resistor;

Ohm's law: the resistance of a conductor is constant provided its temperature is constant / the current is proportional to the voltage across; ***[2]***

(b) $\rho = \frac{RA}{l}$;

$= \left(\frac{1.5 \times \pi \times 1.2^2 \times 10^{-6}}{2.2 \times 10^{-2}} = \right) 3.1 \times 10^{-4}\,\Omega\,\mathrm{m}$; ***[2]***

(c) $I = \left(\sqrt{\frac{P}{R}} = \right) \sqrt{\frac{1}{1.35}}$;

$= 0.86\,\mathrm{A}$; ***[2]***

(d) (i) the power supplied per unit current / work done per unit charge in moving charge completely round the circuit / energy per unit charge made available by the source; ***[1]***

(ii) minimum resistance is $2.0\,\Omega$, maximum resistance is $2.5\,\Omega$;

so maximum power is $\left(\frac{2.0^2}{2.0} \right) = 2.0\,\mathrm{W}$;

and minimum power is $\left(\frac{2.0^2}{2.5} \right) = 1.6\,\mathrm{W}$; ***[3]***

B3. Part 1 Electrical heater

(a) (i) use of $R\left(=\frac{pl}{A}=\right)\frac{1.1\times10^{-6}\times4.5}{6.8\times10^{-8}}$; ***[1]***

72.8Ω (73Ω)

(ii) $\frac{240^{2}}{72.8}$ / shows appropriate alternative equation;

$790\,\text{W}$; ***[2]***

(iii) one-third length so E_2 has one-third resistance of E_1 / evaluates *R* (24Ω);

(same V so) $3\times$ power of E_1;

so total power $=4\times E_1=3.2\,\text{kW}$; ***[3]***

***or** numerical method*

current in $R_1=\frac{728}{240}=3\,\text{A}$;

current in $R_2=9\,\text{A}$;

total current $=12\,\text{A}$ and total power $=3.2\,\text{kW}$;

*Award **[3]** for correct alternative working.*

(iv) the power output will be less;

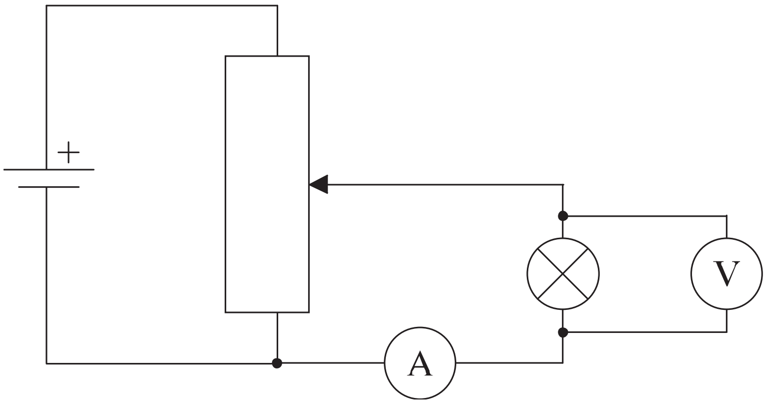
because the total resistance is greater in the series case;

hence the current is less and power depends on I^2;

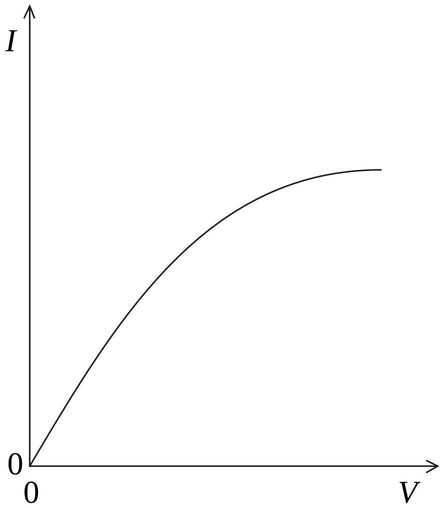
$P=\frac{V^2}{R}$; ***[3 max]***

Part 2 Electric circuits

(a) any circuit in which the current will flow through the lamp;
variable resistor connected as a potential divider;
voltmeter across lamp;
ammeter in series with lamp; ***[4]***



(b) correct shape;
through origin; ***[2]***



(c) 0.24 A ; ***[1]***

(d) resistance calculated = 5.2 (Ω) ;

$A = \left(\frac{\rho l}{R}\right) = 6.2 \times 10^{-8}\ \text{m}^2$;

$\text{radius} = \sqrt{\frac{A}{\pi}}$ seen/used;

$= 1.4 \times 10^{-4}$ m ; ***[4]***

(e) calculates resistance of lamps in parallel (2.6 Ω);
$V = \varepsilon - Ir$ used to give $V = 1.0\text{ V}$;
1.0 V is lower than 1.25 V / power available to each lamp is 192 mW lower than 300 mW;
(terminal pd/power lower) hence not operating normally; *Award **[0]** for only stating this bald answer.* ***[4]***
Watch for ECF from (d).
*Award **[4 max]** for any correct numerical argument involving energy or power calculations.*

A2. (a) (i) ratio of potential difference to current / $\frac{V}{I}$ with terms defined; ***[1]***

(ii) resistance $= \frac{230^2}{980}$;

$= 54\,\Omega$; ***[2]***

Award ***[2]*** *for bald correct answer.*

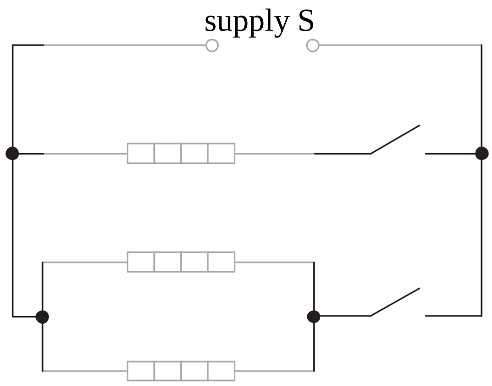
(iii) $L = \frac{RA}{\rho}$;

$= \frac{54 \times \pi \times \left[1.75 \times 10^{-4}\right]^2}{1.3 \times 10^{-6}}$;

$(L \approx 4\,\text{m})$ ***[2]***

Must see re-arrangement of data booklet equation or completely correct substitution as shown in second line for first mark.

(b) *e.g.*

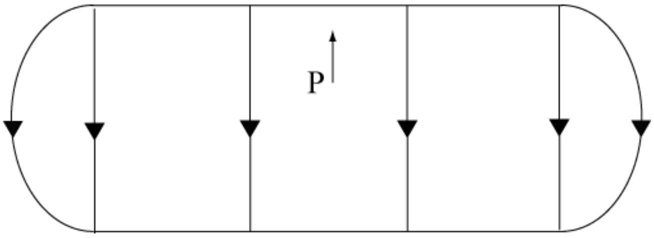


switch connected so that P can be achieved;
another switch connected so that $2P$ and $3P$ can be achieved; ***[2]***

Award ***[0]*** *if three or more switches used. Allow any correct alternative including case where single resistor is permanently connected to supply. There are many variants, this diagram is only one example.*

Part 2 Electric fields and electric circuits

(a) (i)



uniform field equal spacing of lines;
edge effect;
direction; ***[3]***

(ii) as shown; ***[1]***

(b) combine $F = qE$ and $F = ma$;

to get $E = \frac{ma}{q}$;

$E = 5.0 \times 10^3\ \text{N C}^{-1}\ /\ \text{V m}^{-1}$; ***[3]***

(c) $V = \frac{1.9 \times 10^{-17}}{1.6 \times 10^{-19}}$;

$= 120\ \text{V}$ ***[1]***

(d) (i) 3.0 W; ***[1]***

(ii) power dissipated in battery $= \left(0.25^2 \times 4.0\right) = 0.25\ \text{W}$;

power dissipated in circuit $= \left(3.0 - 0.25\right) = 2.8\ (2.75)\ \text{W}$; ***[2]***

(iii) power dissipated in lamp $= \left(3.0 \times 0.25\right) = 0.75\ \text{W}$;

power dissipated in resistor $= \left(2.75 - 0.75\right) = 2.0\ \text{W}$;

resistance $\left(= \frac{2.0}{0.25^2}\right) = 32\ \Omega$; ***[3]***

or

resistance of lamp $= 12\ \Omega$;
$12 = 0.25\,(R + 16)$;
$R = 32\ \Omega$;

or

V across $R = 8.0\ \text{V}$;

$R = \frac{8.0}{0.25}$;

$= 32\ \Omega$; ***[3]***

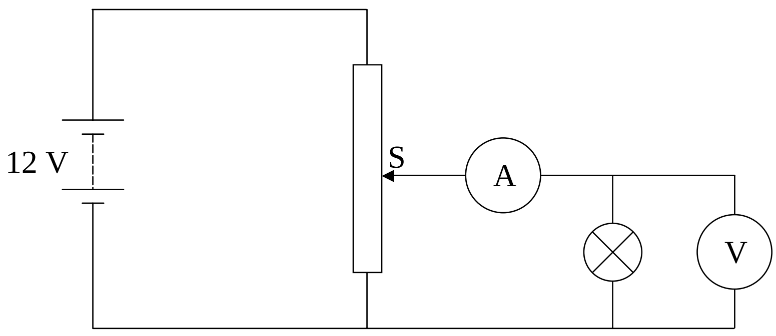
A2. (a) there are no positions;
the lamp is effectively in series with $100\,\text{k}\Omega$ no matter what the position of S;
this means that the pd across it will always be close to zero (very small) / never reach $6\,\text{V}$;

or

the resistance of the filament is much smaller than $100\,\text{k}\Omega$;
so (nearly) all the potential of the battery appears across the variable resistance; ***[3]***
*Award **[0]** for incorrect argument or just the answer without any explanation.*

(b) $I = \frac{V}{R}$;
$= \frac{12}{10^5} = 1.2 \times 10^{-4}\text{ A}$; ***[2]***

(c)



correct position of ammeter;
correct position of voltmeter (either to the right <u>or</u> left of the lamp); ***[2]***

~~**A3.** (a) the force exerted per unit mass;~~
~~on a point (small) mass;~~ ~~***[2]***~~

~~(b) (i) use of $g = \frac{F}{m}$ and $F = G\frac{Mm}{R^2}$;~~
~~combine to get $g = G\frac{M}{R^2}$;~~ ~~***[2]***~~

~~(ii) $M = \frac{gR^2}{G}$;~~
~~substitute to get $M = 1.9 \times 10^{27}$ kg;~~ ~~***[2]***~~