A-level Physics
Summer Independent Learning
Y12-13

PART 1: COMPULSORY WORK

Task 1 Complete practice questions on circuits & thermal physics

Task 2 Complete longer exam questions on electrical circuits

Task 3 Multiple choice questions

PART 2: STRONGLY RECOMMENDED WORK

Task 4 Address progression exam focus areas

Task 5 AS papers from 2020 complete, correct & improve

Welcome to Y13 A-Level Physics, please complete the following tasks ready for your first day back at New College. You can either write on the document electronically, print the document out or write your notes and answers on paper to bring in for your first lesson in September.

You may have to **research** any knowledge or techniques you cannot immediately recall using common GCSE resources or other tutorials.

Please be aware that you will have an **assessment** on these topics shortly after beginning your A level Physics course and the knowledge covered is essential to understanding the subsequent content

Part 1: Compulsory work: Electricity & Thermal Physics

Task 1 **(2-3 hrs + corrections and improvements)**

Join Isaac Physics using either

1. Link
2. Share code: CMYM4E

Complete the questions set on Isaac Physics. The links are also included below
You must hand in workings for all answers.

ELECTRICITY	
	Click on QR code for link
C1	**Combinations of resistors Q1-9**
C4	**Kirchhoff's Laws Q1-5**
C5	**Potential Dividers Q1-8**
C6	**Internal Resistance Q1-5**

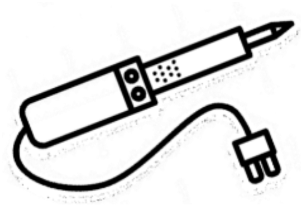
THERMAL PHYSICS	
	Click on QR code for link
G3	**Heat Capacity Q1-8**
G4	**Latent Heat & Heat Capacity Q1-5**

Task 2 **(1-2 hrs + corrections and improvements)**

Circuit questions

Tools at your disposal

For solving circuit problems



Internal resistance If you see the phrase, ‘neglect internal resistance’ then do so. Otherwise, assume that any cell / battery has an internal resistance.

Annotate Any information you extract from the question or calculate should go onto circuit diagrams.

Simplify cells / resistor networks This can produce simplified circuits which you are more familiar with e.g. simple potential divider circuits or where $\varepsilon = I(R + r)$ can easily be applied.

Potential divider formula A tool that can be applied in a variety of circuits

$$V_o = V_T \frac{R_1}{R_1 + R_2}$$

Current through cell Calculating the current through the cell can often lead to a solution.

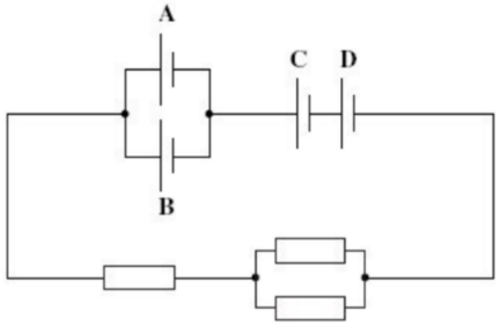
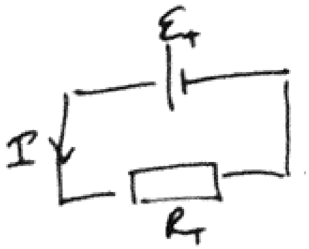
Kirchhoff’s laws The most important tool! If in doubt go back to these.
1. the JUNCTION rule 2. The LOOP rule.

$\boldsymbol{V = IR}$ If you know two of V, I & R then you can always find the third. Use in conjunction with Kirchhoff’s laws.
(Not for use on diodes and capacitors
– take care when using with bulbs as R depends upon V)

Complete the following exam questions by applying the above tools

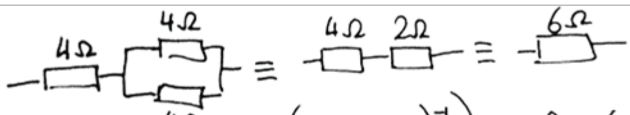
Worked example

Q1. The circuit in the diagram below contains four identical new cells, **A**, **B**, **C** and **D**, each of emf 1.5V and negligible internal resistance.

<table>
<tr>
<td>
</td>
<td>(NOTE: negligible r ∴ only need to combine ε for cell)
Equivalent circuit

</td>
</tr>
</table>

(a) The resistance of each resistor is 4.0 Ω.

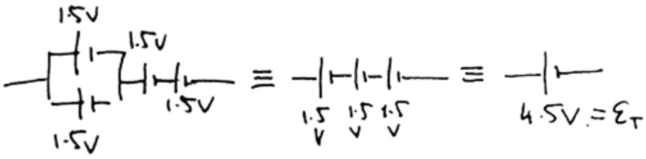
(i) Calculate the total resistance of the circuit.

<table>
<tr>
<td>(NOTE: two identical resistors in ∥ total to half of individual)</td>
<td>

$\left(R_T = (4^{-1} + 4^{-1})^{-1}\right)$ $= 2\Omega$.
$R_T = 6.0\Omega$</td>
</tr>
</table>

(1)

(ii) Calculate the total emf of the combination of cells.

<table>
<tr>
<td>(NOTE: negligible r)</td>
<td>
</td>
</tr>
</table>

(1)

(iii) Calculate the current passing through cell A.

(NOTE: cell A!)	$\varepsilon = I(R + r)$, $I_T = \varepsilon_T / R_T = 4.5/6 = \underline{0.75A}$, $I_A = \frac{1}{2} I_T = 0.75/2 = 0.375 = \underline{0.38A}$

(2)

(iv) Calculate the charge passing through cell A in five minutes, stating an appropriate unit.

(NOTE: cell A!)	$I = \Delta Q / \Delta t$, $\Delta Q = I\Delta t = 0.375 \times (5 \times 60) = 112.5 = \underline{110C}$

(2)

(b) Each of the cells can provide the same amount of electrical energy before going flat. State and explain which two cells in this circuit you would expect to go flat first.

<table>
<tr>
<td>According to Kirchhoff's 1st law the current through cell would obey $I_C = I_D = I_A + I_B$. As cells A & B are identical $I_A = I_B$ and $I_A = I_B = \frac{1}{2} I_C = \frac{1}{2} I_D$.
As $P = I\varepsilon$ if reduce the current for the same emf, less power is dissipated. Hence A & B will last longer and C & D will go flat first.</td>
<td>Mark scheme
cells C and D will go flat first or A and B last longer (1)

current/charge passing through cells C and D (per second) is double/more than that passing through A or B (1)

energy given to charge passing through cells per second is double or more than in cells C and D (1) or in terms of power</td>
</tr>
</table>

(3)

(Total 9 marks)

Circuit questions

Q20.(a) The cell in **Figure 1** has an emf of 3.0 V and negligible internal resistance.

Calculate the potential difference across the 8 Ω resistor.

(2)

Figure 1

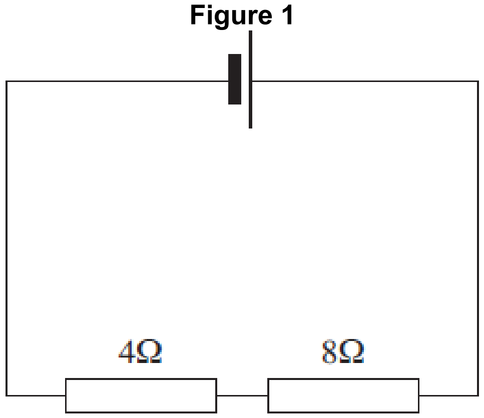
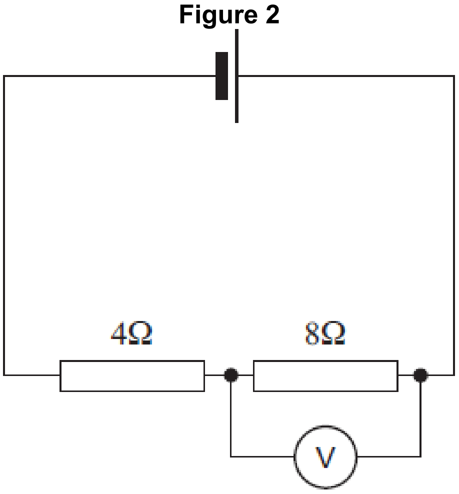


Figure 2



(b) **Figure 2** shows the same circuit with a voltmeter connected across the 8 Ω resistor.

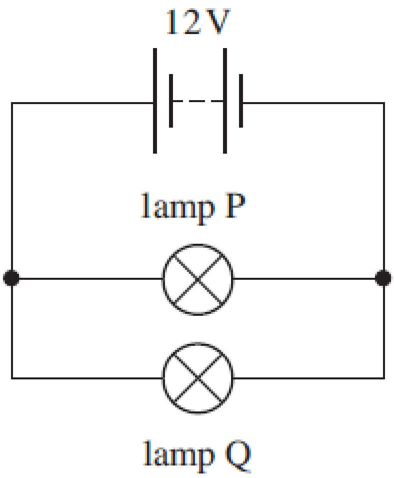
The voltmeter reads 1.8 V. Calculate the resistance of the voltmeter.

resistance ....Ω

(3)
(Total 5 marks)

Q26. A battery of negligible internal resistance is connected to lamp P in parallel with lamp Q as shown in **Figure 1**. The emf of the battery is 12 V.

Figure 1



(a) Lamp P is rated at 12 V 36 W and lamp Q is rated at 12 V 6 W.

(i) Calculate the current in the battery.

(2)

(ii) Calculate the resistance of P.

(1)

(iii) Calculate the resistance of Q.

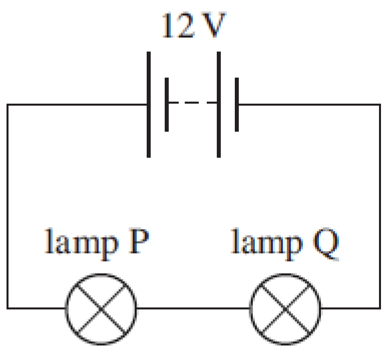
(1)

(b) State and explain the effect on the brightness of the lamps in the circuit shown in **Figure 1** if the battery has a significant internal resistance.

[6 lines available]

(3)

Figure 2



(c) The lamps are now reconnected to the 12 V battery in series as shown in **Figure 2.**

(i) Explain why the lamps will not be at their normal brightness in this circuit.

[5 lines available]

(2)

(ii) State and explain which of the lamps will be brighter assuming that the resistance of the lamps does not change significantly with temperature.

[4 lines available]

(3)
(Total 12 marks)

Circuit questions 2

Q31. **X** and **Y** are two lamps. **X** is rated at 12 V 36 W and **Y** at 4.5 V 2.0 W.

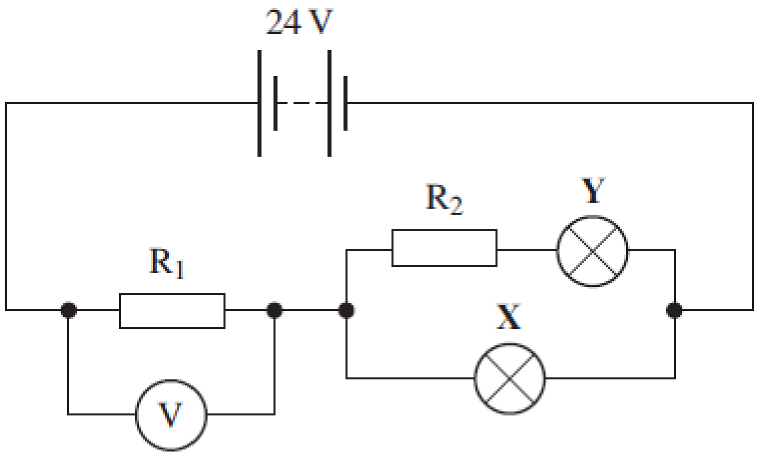
(a) Calculate the current in each lamp when it is operated at its correct working voltage.

X .... A

Y .... A

(2)

(b) The two lamps are connected in the circuit shown in the figure below. The battery has an emf of 24 V and negligible internal resistance. The resistors, R_1 and R_2 are chosen so that the lamps are operating at their correct working voltage.



(i) Calculate the pd across R_1.

answer V

(1)

(ii) Calculate the current in R_1.

answer .... A

(1)

(iii) Calculate the resistance of R_1.

answer .... Ω

(1)

(iv) Calculate the pd across R_2.

answer V

(1)

(v) Calculate the resistance of R_2.

answer .... Ω

(1)

(c) The filament of the lamp in **X** breaks and the lamp no longer conducts. It is observed that the voltmeter reading decreases and lamp **Y** glows more brightly.

(i) Explain without calculation why the voltmeter reading decreases.

[3 lines available]

(2)

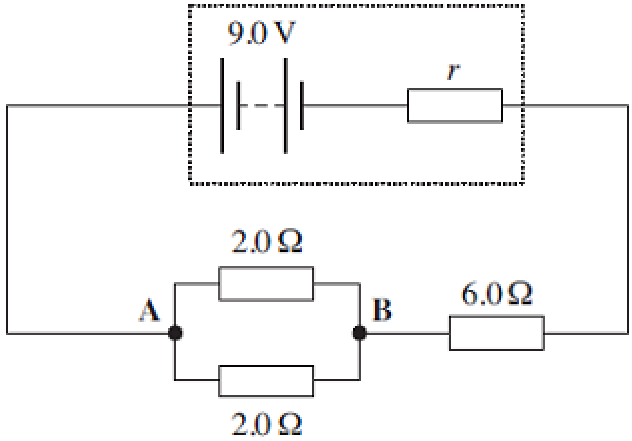
(ii) Explain without calculation why the lamp **Y** glows more brightly.

[3 lines available]

(2)

(Total 11 marks)

Q32. A battery of emf 9.0 V and internal resistance, *r*, is connected in the circuit shown in the figure below.



(a) The current in the battery is 1.0 A.

(i) Calculate the pd between points **A** and **B** in the circuit.

answer = ... V

(2)

(ii) Calculate the internal resistance, *r*.

answer = ... Ω

(2)

(iii) Calculate the **total** energy transformed by the battery in 5.0 minutes.

answer = ... J

(2)

(iv) Calculate the percentage of the energy calculated in part (iii) that is dissipated in the battery in 5.0 minutes.

answer = ... %

(2)

(b) State and explain **one** reason why it is an advantage for a rechargeable battery to have a low internal resistance.

[4 lines available]

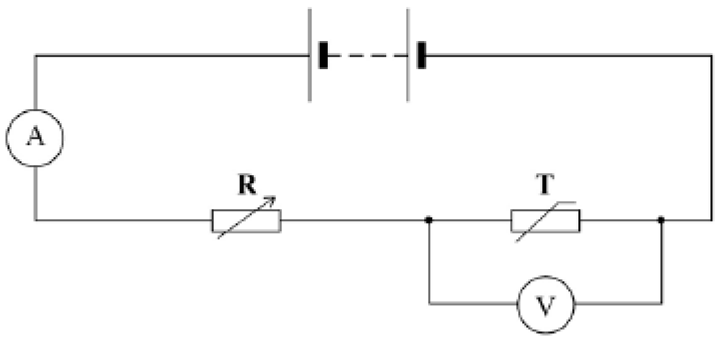
(2)

(Total 10 marks)

Circuit questions ChQ

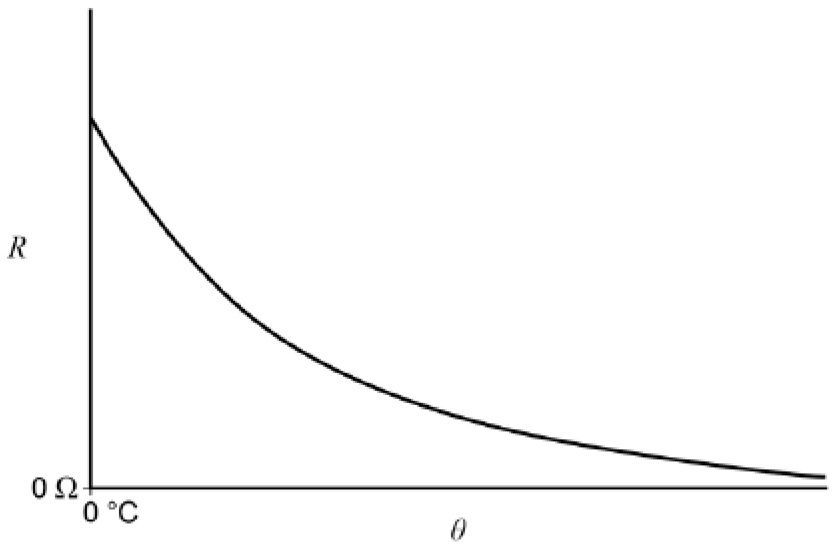
Q1.Figure 1 shows a circuit including a thermistor **T** in series with a variable resistor **R**. The battery has negligible internal resistance.

Figure 1



The resistance–temperature (R–θ) characteristic for **T** is shown in **Figure 2**.

Figure 2



(a) The resistor and thermistor in **Figure 1** make up a potential divider.

Explain what is meant by a potential divider.

[3 lines available]

(1)

(b) State and explain what happens to the voltmeter reading when the resistance of **R** is increased while the temperature is kept constant.

[6 lines available]

(3)

(c) State and explain what happens to the ammeter reading when the temperature of the thermistor increases.

[4 lines available]

(2)

(d) The battery has an emf of 12.0 V. At a temperature of 0 °C the resistance of the thermistor is 2.5×10^3 Ω.

The voltmeter is replaced by an alarm that sounds when the voltage across it exceeds 3.0 V.

Calculate the resistance of R that would cause the alarm to sound when the temperature of the thermistor is lowered to 0 °C.

resistance = ... Ω

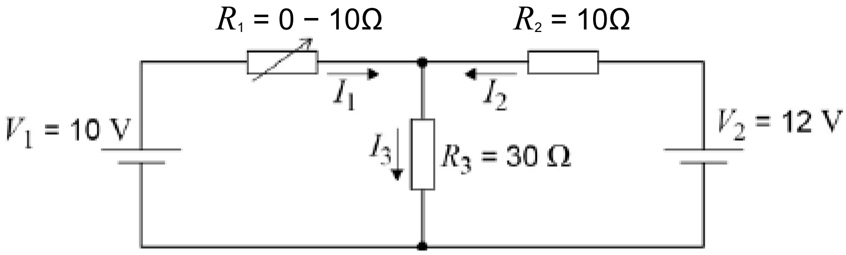
(2)

(e) State **one** change that you would make to the circuit so that instead of the alarm coming on when the temperature falls, it comes on when the temperature rises above a certain value.

[3 lines available]

(1)
(Total 9 marks)

Q9. The cells in the circuit shown in the figure below have zero internal resistance. Currents are in the directions shown by the arrows.



R_1 is a variable resistor with a resistance that varies between 0 and 10 Ω.

(a) Write down the relationship between currents I_1, I_2 and I_3.

....

(1)

(b) R_1 is adjusted until it has a value of 0 Ω.

State the potential difference across R_3.

potential difference = ... V

(1)

(c) Determine the current I_2.

current = ... A

(2)

(d) State and explain what happens to the potential difference across R_2 as the resistance of R_1 is gradually increased from zero.

[5 lines available]

(3)
(Total 7 marks)

Task 3 **(2.5 hrs + corrections and improvements)**

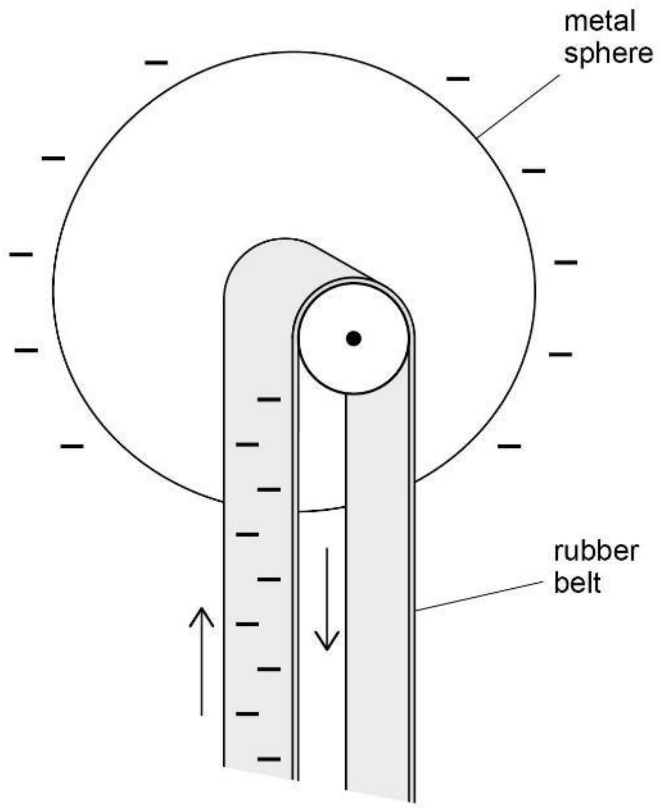
Attempt and mark the attached multiple-choice questions on electricity and circular motion (mark schemes at end of document). Once completed, **correct and improve** your work.

YOU MUST COMPLETE A MINIMUM OF 3 MULTIPLE CHOICE QUESTIONS FROM EACH TOPIC

10 Minutes on: 39 Circuit Basics

Q1. A rubber belt in an electrostatic machine has a width of 0.1 m and moves with speed 0.4 m s^{-1}.

Each square metre of the belt carries a charge Q coulomb. The charge is removed and transferred to a metal sphere.



What is the charge collected by the sphere each second?

A	$0.016Q$	○
B	$0.04Q$	○
C	$0.25Q$	○
D	$4Q$	○

(Total 1 mark)

Q2. In a cathode ray tube 7.5×10^{15} electrons strike the screen in 40 s. What current does this represent?

Charge of the electron is 1.6×10^{-19} C.

A 1.3×10^{-16} A ○

B 5.3×10^{-15} A ○

C 3.0×10^{-5} A ○

D 1.2×10^{-3} A ○

(Total 1 mark)

Q3. The current in a wire is 20 mA.

How many electrons pass a point in the wire in 2 minutes?

A 2.5×10^{17} ○

B 1.5×10^{19} ○

C 2.5×10^{20} ○

D 1.5×10^{22} ○

(Total 1 mark)

Q4. A gas containing doubly-charged ions flows to give an electric current of 0.64 A

How many ions pass a point in 1.0 minute?

A 2.0×10^{18} ○

B 4.0×10^{18} ○

C 1.2×10^{20} ○

D 2.4×10^{20} ○

(Total 1 mark)

Q5. Which is equivalent to the ohm?

A $\text{J C}^{-2}\text{ s}^{-1}$ ○

B $\text{J C}^{-2}\text{ s}$ ○

C J s ○

D J s^{-1} ○

(Total 1 mark)

Q6. What is a unit for potential difference?

A A Ω^{-1} ○

B C J^{-1} ○

C J A^{-1} s^{-1} ○

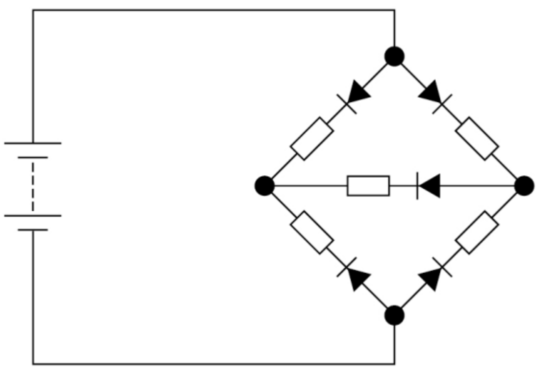
D W A ○

(Total 1 mark)

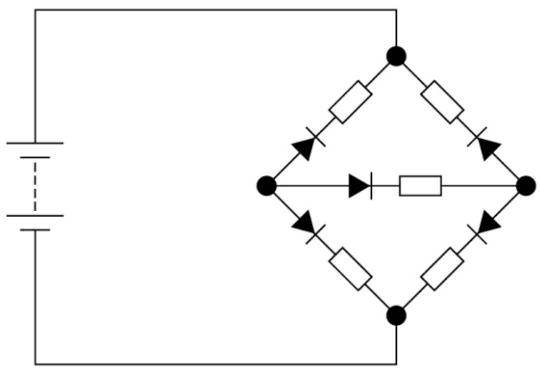
Q7. The diagrams show a battery connected to networks of ideal diodes and resistors.

In which circuit will a charge flow in the battery?

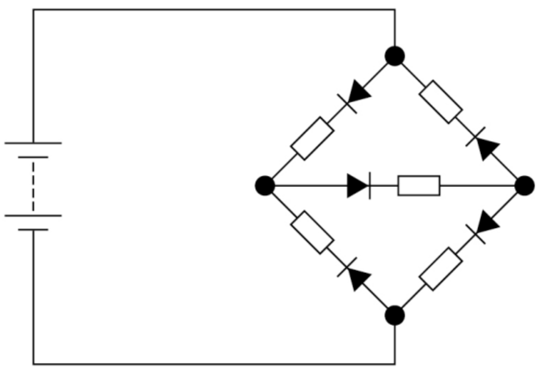
A



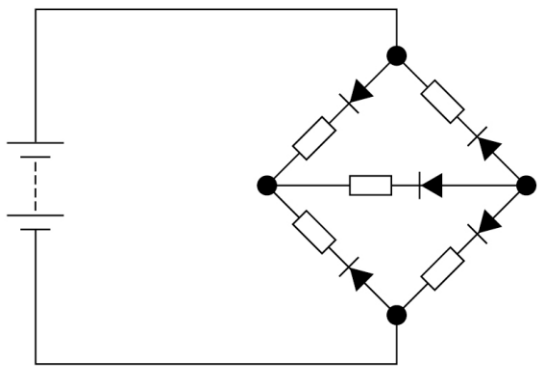
B



C



D



A ○

B ○

C ○

D ○

(Total 1 mark)

10 Minutes on: 40 I-V Graphs

Q1. Which row shows the resistances of an ideal ammeter and an ideal voltmeter?

	Ideal ammeter	Ideal voltmeter	
A	infinite	infinite	○
B	infinite	zero	○
C	zero	infinite	○
D	zero	zero	○

(Total 1 mark)

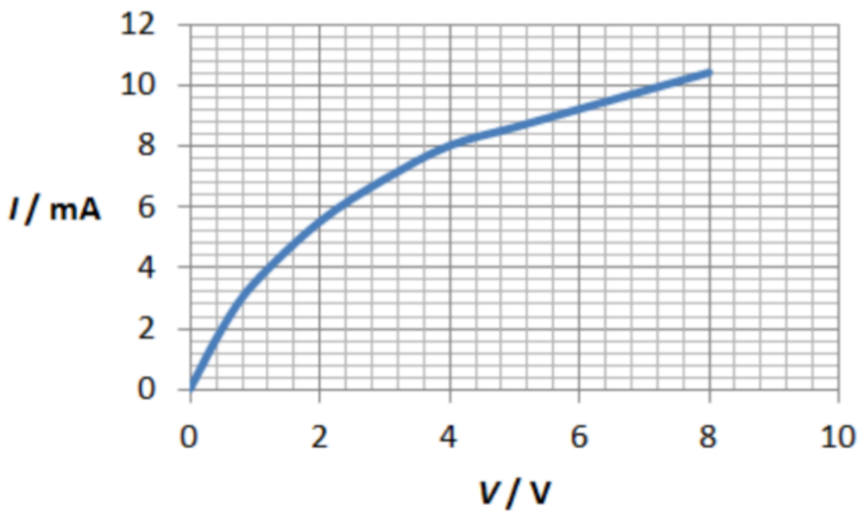
Q2. A voltmeter is used to measure potential difference for a component **X**.

Which row gives the position and ideal resistance for the voltmeter?

	Position	Ideal resistance	
A	in series with X	infinite	○
B	in series with X	zero	○
C	in parallel with X	infinite	○
D	in parallel with X	zero	○

(Total 1 mark)

Q3. The graph shows the current–voltage (*I*–*V*) characteristics of a filament lamp.

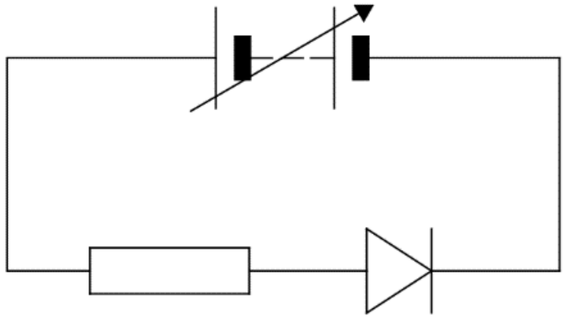


What is the resistance of the filament when the potential difference (pd) across it is 4.0 V?

A	500 Ω	○
B	1700 Ω	○
C	2000 Ω	○
D	6000 Ω	○

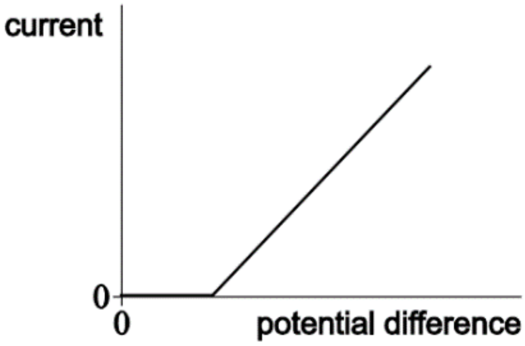
(Total 1 mark)

Q4. A resistor and diode are connected in series with a variable power supply as shown in the diagram.

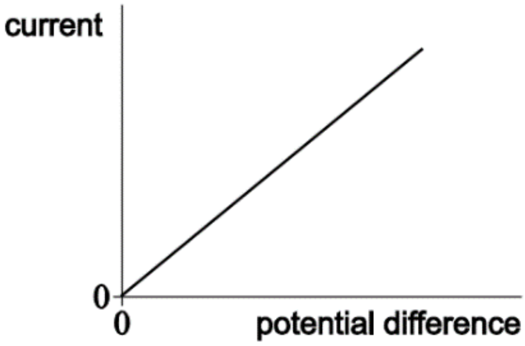


Which best shows the characteristic for the combination of the resistor and diode?

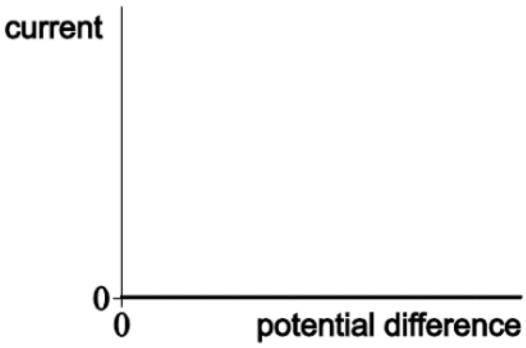
A



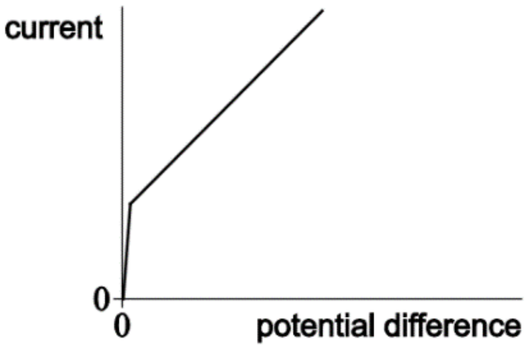
B



C



D



A ○

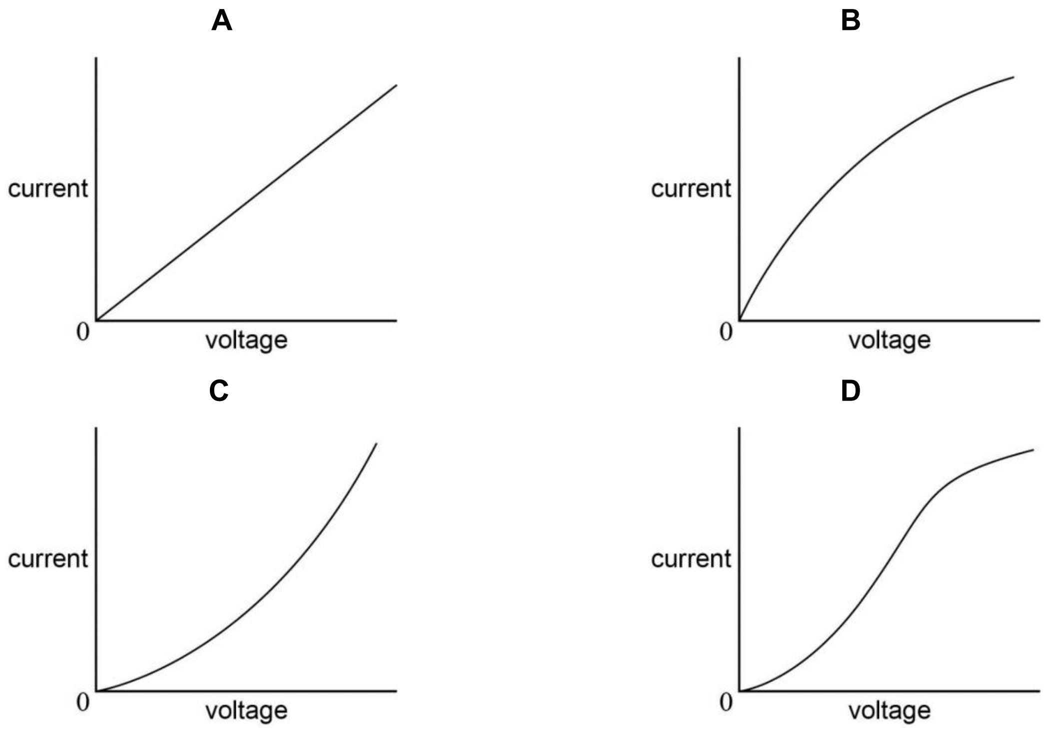
B ○

C ○

D ○

(Total 1 mark)

Q5. Which is the current–voltage characteristic graph for a filament lamp up to its working voltage?



A ○ **C** ○

B ○ **D** ○

(Total 1 mark)

Q6. The table shows corresponding values of potential difference V and current I for four electrical components **A**, **B**, **C** and **D**.

	A	**B**	**C**	**D**
V / V	I / A	I / A	I / A	I / A
0	0.0	0.0	0.0	0.0
2	0.0	0.3	0.4	0.3
4	0.1	0.6	0.8	0.6
6	0.7	0.9	1.2	0.9
8	1.4	1.2	1.6	1.1
10	2.1	1.5	2.0	1.3

Which component is an ohmic conductor with the greatest resistance?

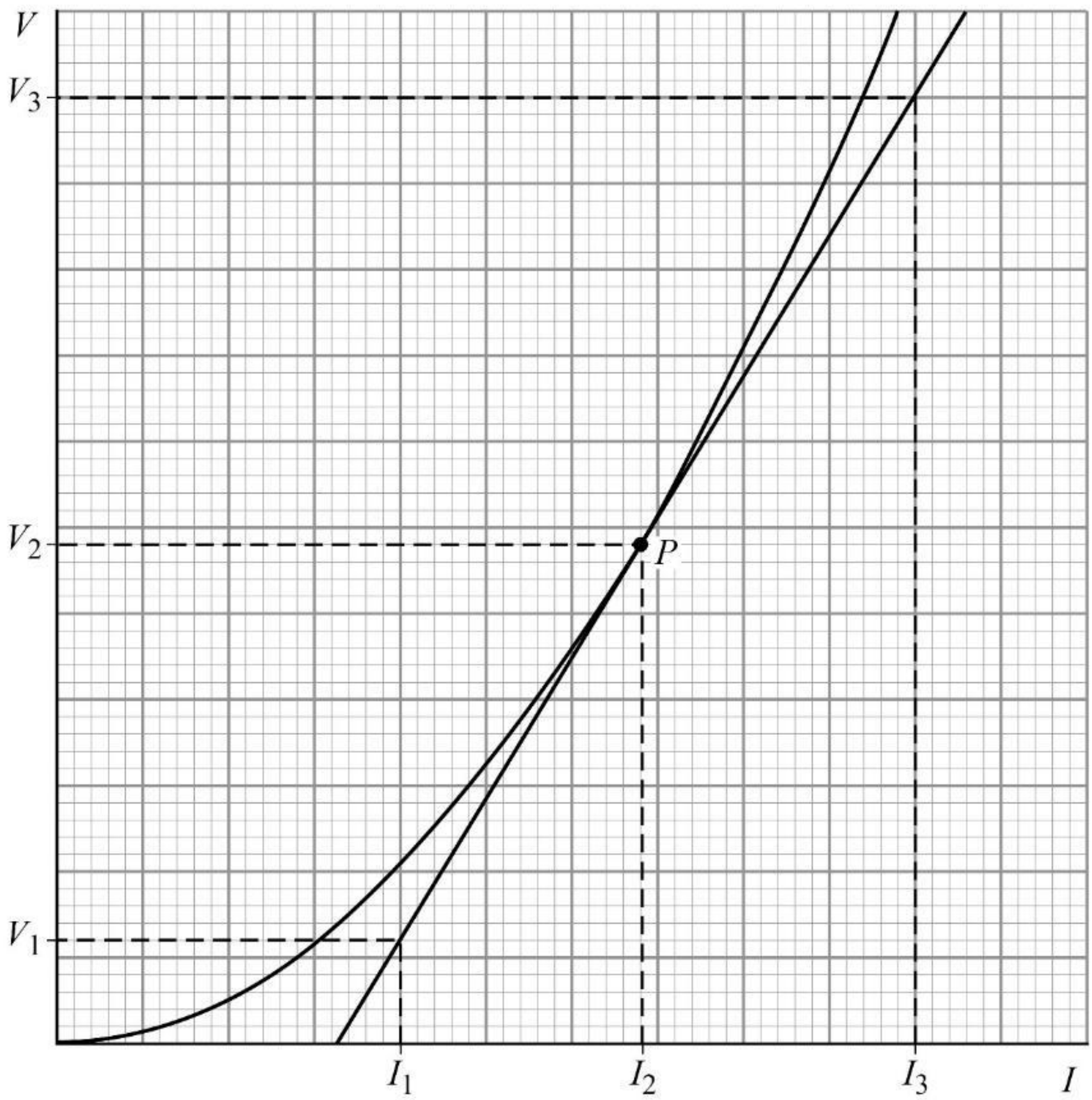
A ○ **C** ○

B ○ **D** ○

(Total 1 mark)

Q7. The graph shows how the potential difference V across an electrical component varies with current I in the component.

A tangent has been drawn on the curve at point P for a current of I_2.



What is the resistance of the electrical component when the current in the component is I_2?

A $\dfrac{V_3 - V_1}{2I_2}$ ○

B $\dfrac{V_3 - V_1}{I_3 - I_1}$ ○

C $\dfrac{V_2}{I_2}$ ○

D $\dfrac{2V_2}{I_2 - I_1}$ ○

10 Minutes on: 41 Resistivity

Q1. A resistor with resistance R is made from metal wire of resistivity ρ. The length of the wire is L.

What is the diameter of the wire?

A $\sqrt{\frac{2\rho R}{\pi L}}$ ○

B $\sqrt{\frac{2\rho L}{\pi R}}$ ○

C $2\sqrt{\frac{\rho L}{\pi R}}$ ○

D $2\sqrt{\frac{\rho R}{\pi L}}$ ○

(Total 1 mark)

Q2. A metal wire has a length l and a cross-sectional area A. When a potential difference V is applied to the wire, there is a current I in the wire.

What is the resistivity of the wire?

A $\frac{IA}{Vl}$ ○

B $\frac{VA}{Il}$ ○

C $\frac{Il}{VA}$ ○

D $\frac{Vl}{IA}$ ○

(Total 1 mark)

Q3. A wire has a resistance R.

What is the resistance when both the length and radius of the wire are doubled?

A $\frac{R}{4}$ ○

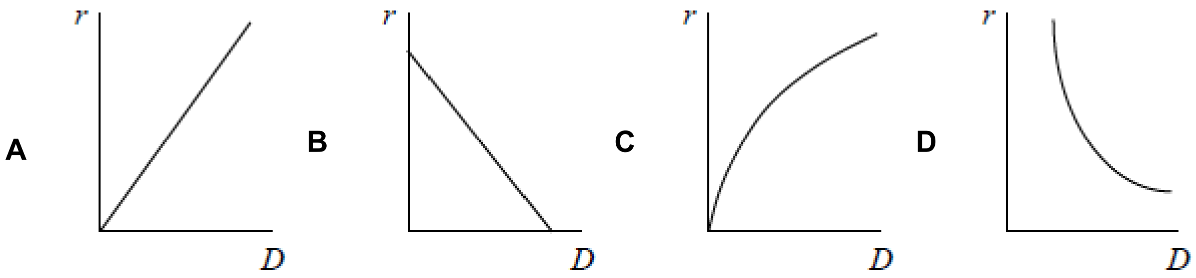
B $\frac{R}{2}$ ○

C $2R$ ○

D $4R$ ○

(Total 1 mark)

Q4. Which graph shows how the resistance per unit length *r* of a wire varies with diameter *D* of the wire?



A	⬭	**C**	⬭
B	⬭	**D**	⬭

(Total 1 mark)

Q5. When a constant potential difference (pd) is applied across the ends of a uniform wire there is a current I in the wire.

The wire is replaced by one made from the same material, but of double the length and double the diameter. The same pd is applied across the ends.

What is the new current?

A	$4I$	⬭
B	$2I$	⬭
C	$\frac{I}{2}$	⬭
D	$\frac{I}{4}$	⬭

(Total 1 mark)

Q6. A solid copper cylinder has a volume 1.3×10^{-4} m^3 and length 15 cm. Copper has a resistivity of 1.7×10^{-8} Ωm.

What is the resistance between the two ends of the copper cylinder??

A	2.9×10^{-6} Ω	⬭
B	2.0×10^{-5} Ω	⬭
C	2.0×10^{-3} Ω	⬭
D	2.9×10^{-2} Ω	⬭

(Total 1 mark)

Q7. A copper wire of length 1.3 m has a resistance of 0.70 Ω.

The wire has a diameter of 0.50 mm

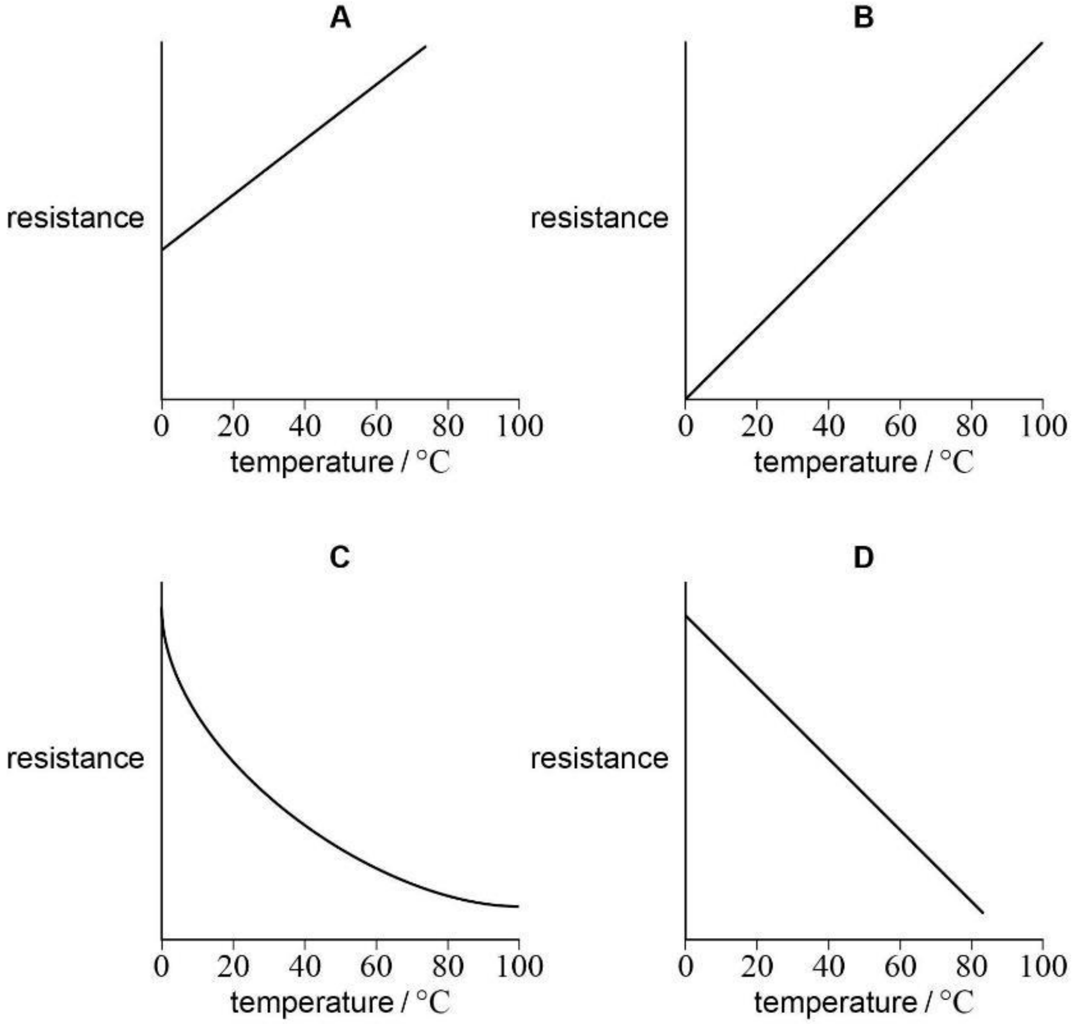
Calculate the resistivity of the copper in the wire.

A	1.1×10^{-5} Ω m	⬭
B	1.1×10^{-7} Ω m	⬭
C	2.1×10^{-7} Ω m	⬭
D	4.2×10^{-7} Ω m	⬭

(Total 1 mark)

10 Minutes on: 42 Resistance and Temperature

Q1. Which graph shows the variation of the resistance with temperature for an ntc thermistor?



A	⬭	**C**	⬭
B	⬭	**D**	⬭

(Total 1 mark)

Q2. When the temperature of a copper wire increases, its ability to conduct electricity

A remains the same.

B increases.

C decreases.

D remains the same at first and then increases.

(Total 1 mark)

Q3 Which statement about superconductors is correct?

A When a material becomes a superconductor, its resistivity is almost zero.

B The temperature at which a material becomes a superconductor is called the critical temperature.

C When current passes through a superconductor the pd across it becomes a maximum.

D Copper is a superconductor at room temperature.

(Total 1 mark)

Q4. Superconductors are used to

A increase the strength of electricity cables.

B make light dependent resistors.

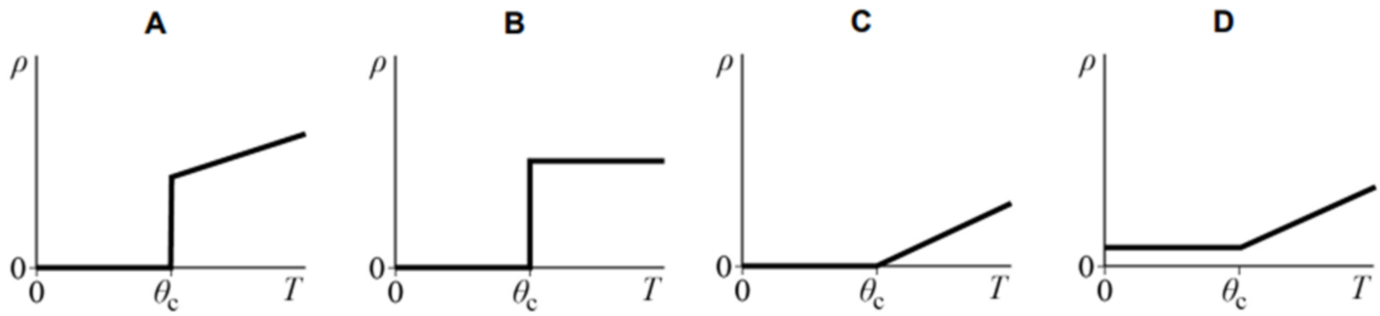
C produce strong magnetic fields.

D increase the rate of heat energy transfer.

(Total 1 mark)

Q5. A **s**uperconductors has a critical temperature.

Which graph shows the variation of resistivity ρ with temperature T for this superconductor?



A

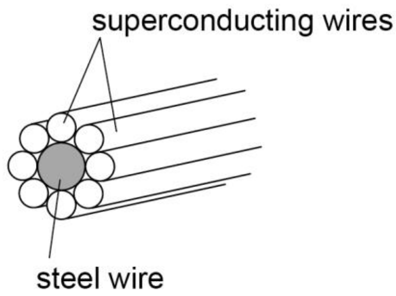
B

C

D

(Total 1 mark)

Q6 A cable consists of superconducting wires attached in parallel to a steel wire.



What is the purpose of the steel wire in the cable?

A to increase the critical temperature of the superconductor ⬭

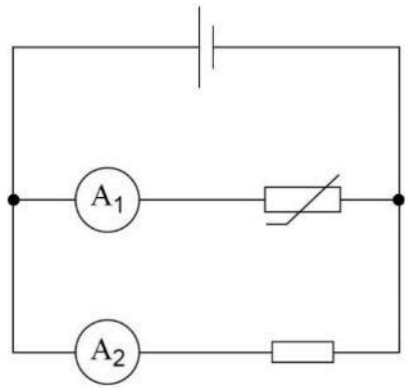
B to increase the strength of the cable ⬭

C to reduce the resistance of the cable when it is superconducting ⬭

D to reduce the current in the cable ⬭

(Total 1 mark)

Q7. A circuit consists of a cell, a thermistor, a fixed resistor and two ammeters.



The cell has a constant electromotive force and negligible internal resistance. Readings from the two ammeters are taken.

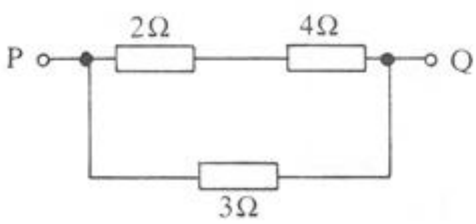
Which row describes what happens to the current in each ammeter when the temperature of the thermistor decreases?

	Current in ammeter A_1	Current in ammeter A_2	
A	Decreases	Unchanged	⬭
B	Decreases	Increases	⬭
C	Increases	Decreases	⬭
D	Increases	Unchanged	⬭

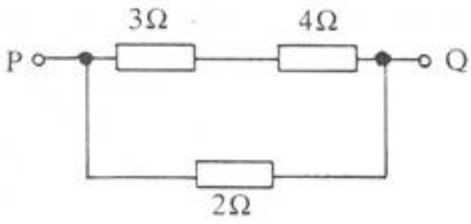
(Total 1 mark)

10 minutes on: 43 Resistors in Series and Parallel

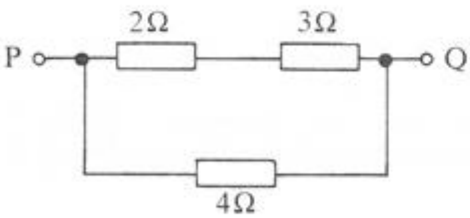
Q1. Which resistor arrangement has the greatest value of resistance?



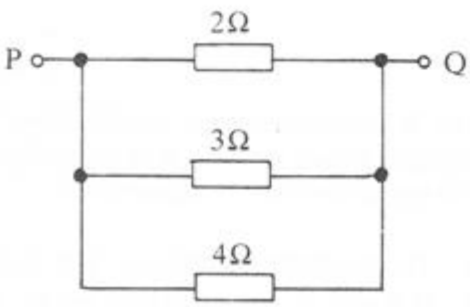
A



B



C



D

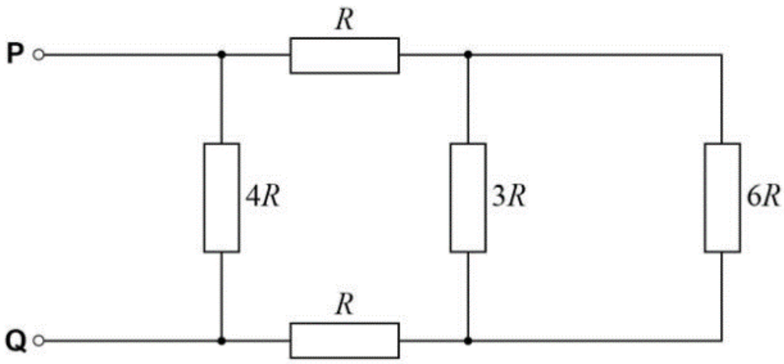
A ⬭ **C** ⬭

B ⬭ **D** ⬭

(Total 1 mark)

Q2. The diagram shows a network of resistors connected between the terminals **P** and **Q**.

The resistance of each resistor is shown.

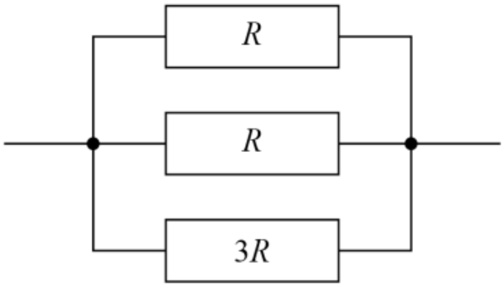


What is the effective resistance between **P** and **Q**?

A	R	⬭
B	$2R$	⬭
C	$3R$	⬭
D	$4R$	⬭

(Total 1 mark)

Q3. Resistors of resistance R, R and $3R$ are connected as shown.



What is the resistance of the arrangement?

A $\frac{3R}{7}$ ○

B $\frac{7R}{3}$ ○

C $\frac{5R}{6}$ ○

D $\frac{6R}{5}$ ○

(Total 1 mark)

Q4. The table shows the resistivity, length and cross-sectional area of wires P and Q.

	resistivity	**length**	**cross-sectional area**
wire P	ρ	L	A
wire Q	$\frac{\rho}{4}$	L	$\frac{A}{2}$

The resistance of wire P is R.

What is the total resistance of the wires when they are connected in parallel?

A $\frac{R}{9}$ ○

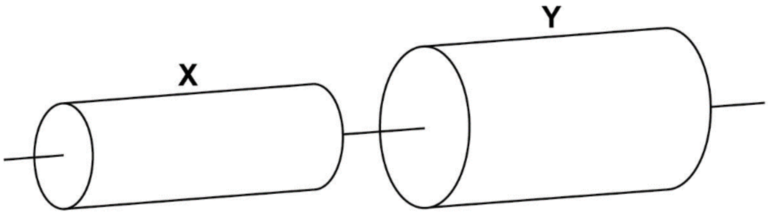
B $\frac{R}{3}$ ○

C $\frac{2R}{3}$ ○

D $\frac{3R}{2}$ ○

(Total 1 mark)

Q5. The two resistors shown are both uniform cylinders of equal length made from the same conducting putty.



The diameter of **Y** is twice that of **X**. The resistance of **Y** is R.

What is the total resistance of the combination?

A $\frac{4R}{5}$ ○

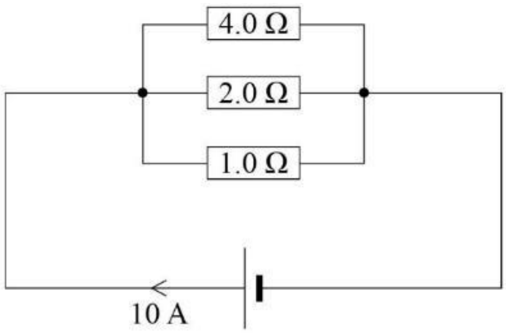
B $3R$ ○

C $4R$ ○

D $5R$ ○

(Total 1 mark)

Q6. The current in the cell is 10 A as shown.



What is the current in the 2.0 Ω resistor?

A 0.35 A ○

B 2.86 A ○

C 3.50 A ○

D 7.14 A ○

(Total 1 mark)

Q7. The combined resistance of n identical resistors connected in parallel is R_n.

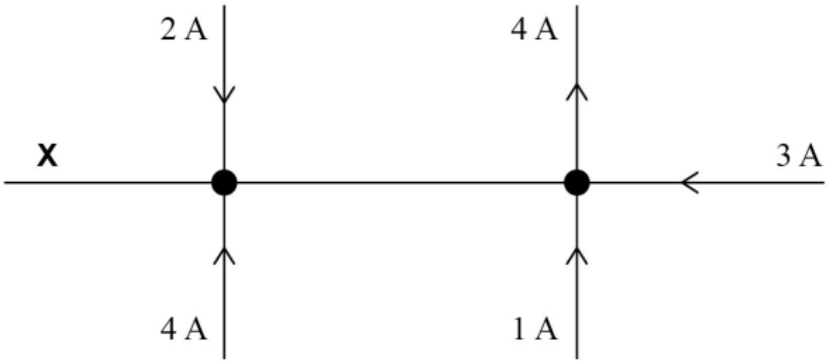
Which statement correctly describes the variation of R_n as n increases?

A	R_n decreases linearly as n increases	⬭
B	R_n decreases non-linearly as n increases	⬭
C	R_n increases linearly as n increases	⬭
D	R_n increases non-linearly as n increases	⬭

(Total 1 mark)

10 minutes on: 44 Series and Parallel Circuits

Q1. The diagram shows the currents in a set of wires.

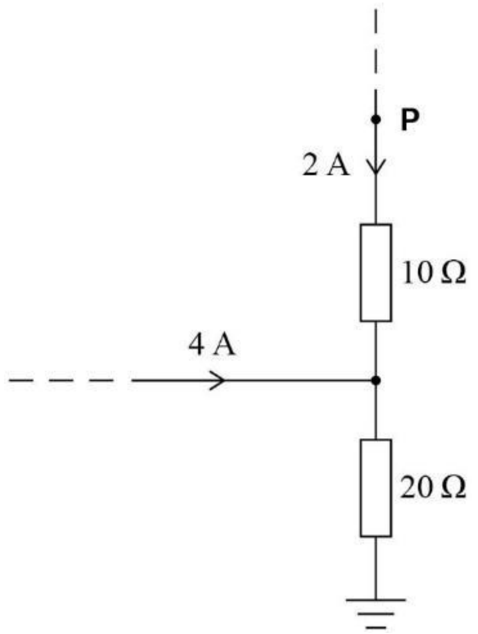


What is the magnitude of the current at **X**?

A	zero	⬭
B	2 A	⬭
C	3 A	⬭
D	6 A	⬭

(Total 1 mark)

Q2. The diagram shows part of a circuit and the currents in the circuit.



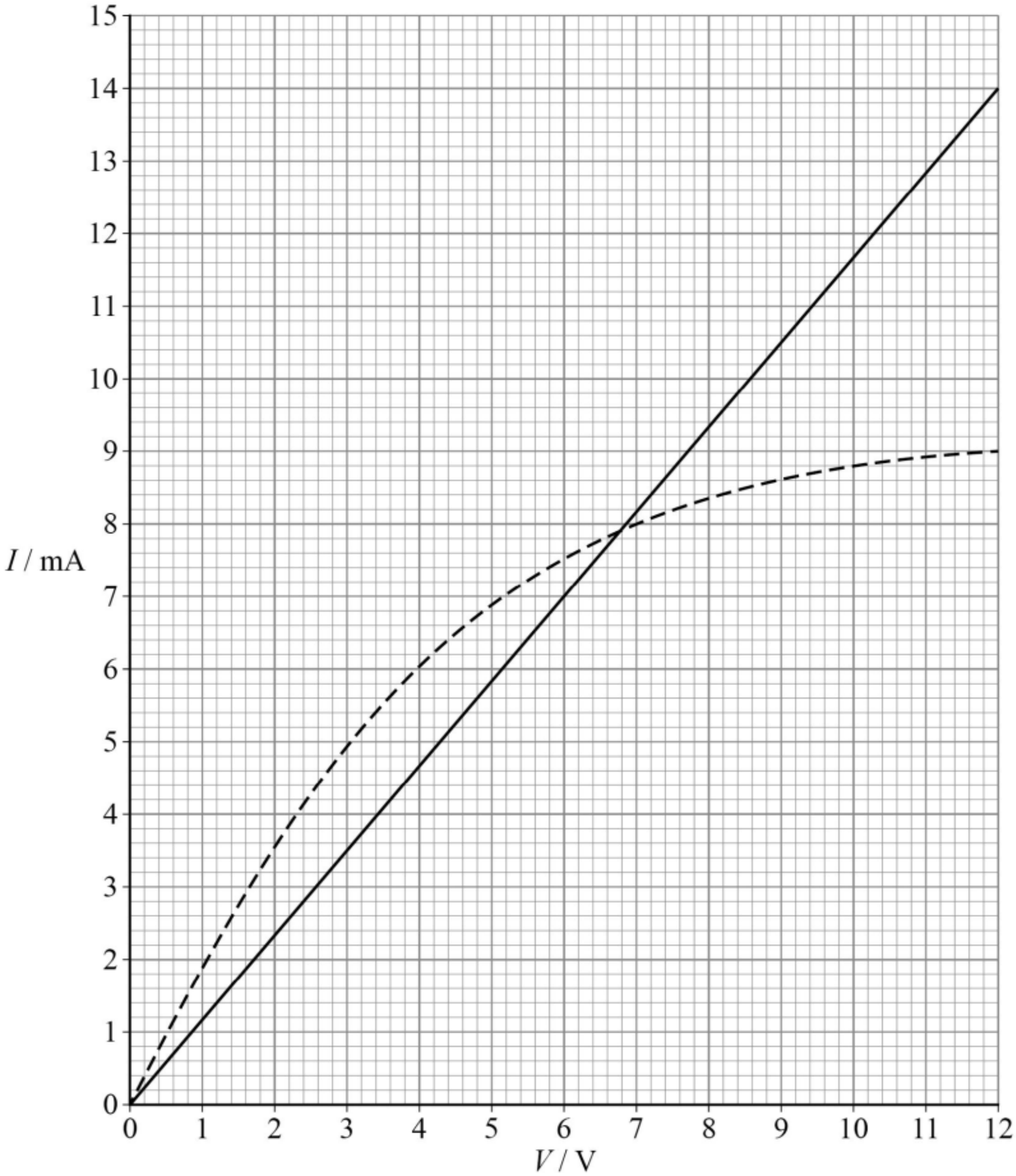
What is the potential difference between point P and earth?

A	60 V	○
B	100 V	○
C	120 V	○
D	140 V	○

(Total 1 mark)

PTO

Q3. The graph shows the current–voltage (I–V) characteristics for two components.



The two components are connected in parallel with a 12 V battery that has negligible internal resistance.

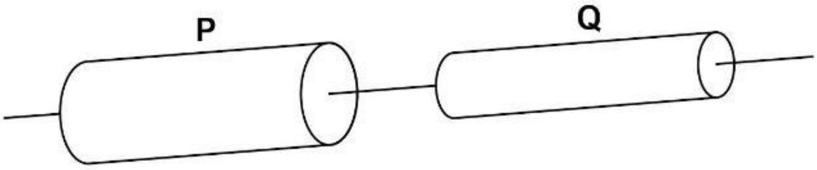
What is the current in the battery?

A	7.9 mA	○
B	14.5 mA	○
C	15.8 mA	○
D	23.0 mA	○

Q4. Two cylindrical wires **P** and **Q** are of equal length and made of the same material.

The diameter of **P** is greater than that of **Q**.

P and **Q** are connected in series and the ends of this arrangement are connected to a power supply.

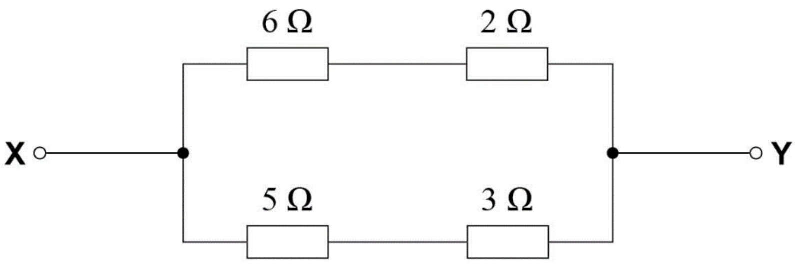


Which two quantities are the same for **P** and **Q**?

A	potential difference across wire	resistivity	⬭
B	resistivity	current	⬭
C	current	resistance	⬭
D	resistance	potential difference across wire	⬭

(Total 1 mark)

Q5. In the circuit shown, a potential difference of 3.0 V is applied across **XY**.

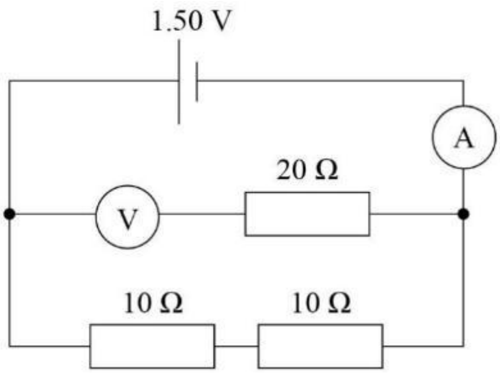


What is the current in the 5 Ω resistor?

A	0.38 A	⬭
B	0.60 A	⬭
C	0.75 A	⬭
D	2.7 A	⬭

(Total 1 mark)

Q6. The circuit shows a cell with negligible internal resistance connected in a circuit with three resistors, an ammeter and a voltmeter.

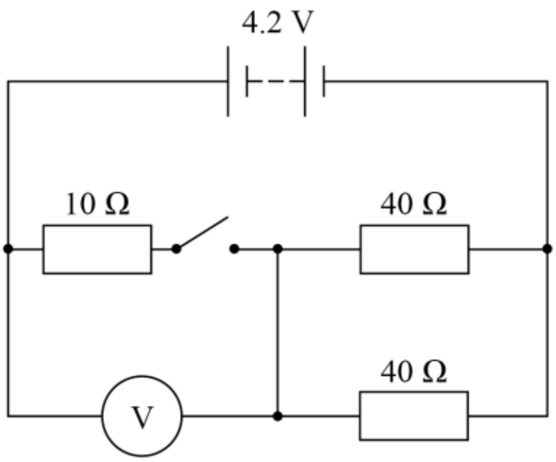


Which row shows the readings on the ammeter and voltmeter?

	Current / A	Voltage / V	
A	0.075	0.75	○
B	0.075	1.50	○
C	0.150	0.75	○
D	0.150	1.50	○

(Total 1 mark)

Q7. The battery in this circuit has an emf of 4.2 V and negligible internal resistance.



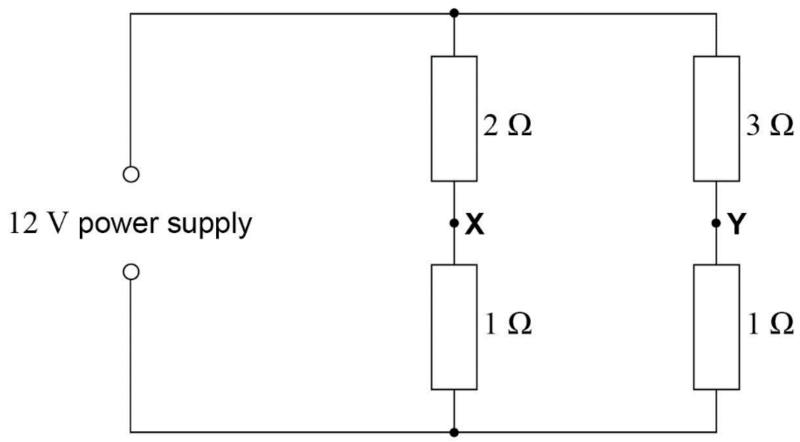
What are the readings on the voltmeter when the switch is open (off) and when the switch is closed (on)?

	Open	Closed	
A	0 V	2.1 V	○
B	4.2 V	2.1 V	○
C	0 V	1.4 V	○
D	4.2 V	1.4 V	○

(Total 1 mark)

10 minutes on: 45 Potential Dividers Basics

Q1. In this resistor network, the emf of the supply is 12 V and it has negligible internal resistance.

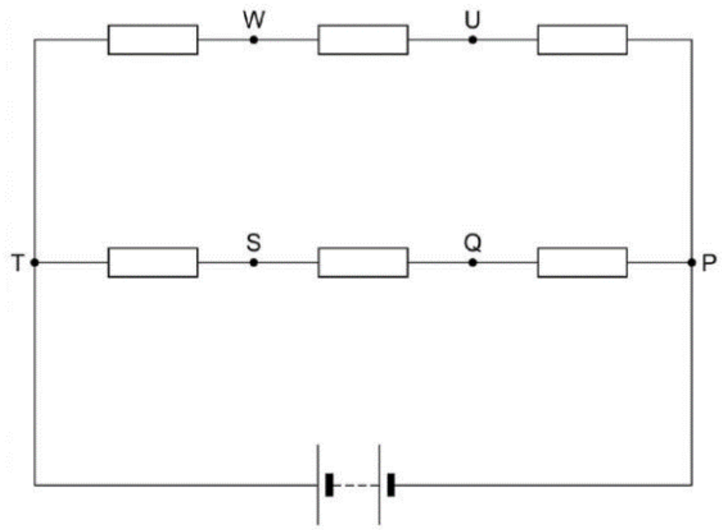


What is the reading on a voltmeter connected between points **X** and **Y**?

A	0 V	⬭
B	1 V	⬭
C	3 V	⬭
D	4 V	⬭

(Total 1 mark)

Q2. In the circuit shown below, each of the resistors has the same resistance.



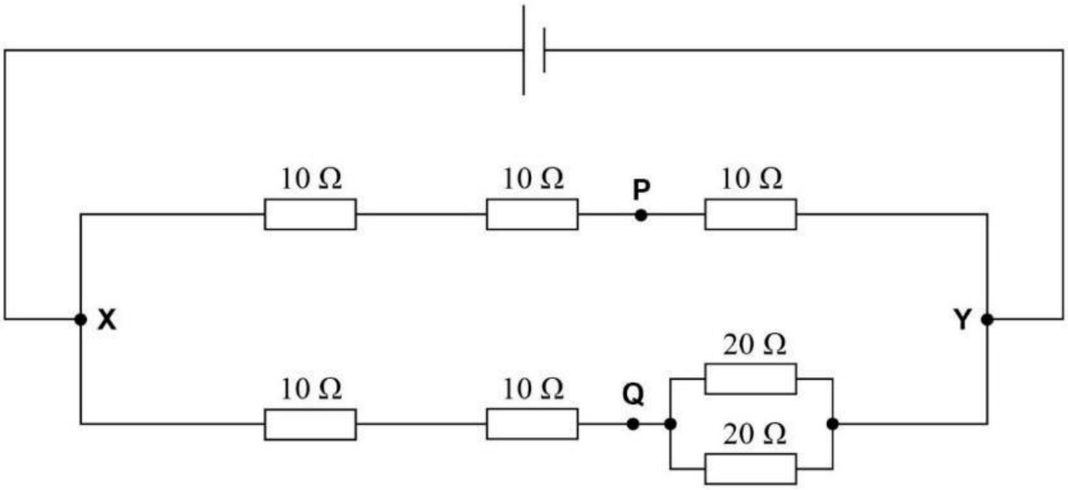
A voltmeter with very high resistance is connected between two points in the circuit.

Between which two points of connection would the voltmeter read zero?

A	Q and U	⬭
B	P and T	⬭
C	Q and W	⬭
D	S and U	⬭

(Total 1 mark)

Q3. The potential difference between points **X** and **Y** is V.



What is the potential difference between **P** and **Q**?

A zero ☐

B $\frac{V}{3}$ ☐

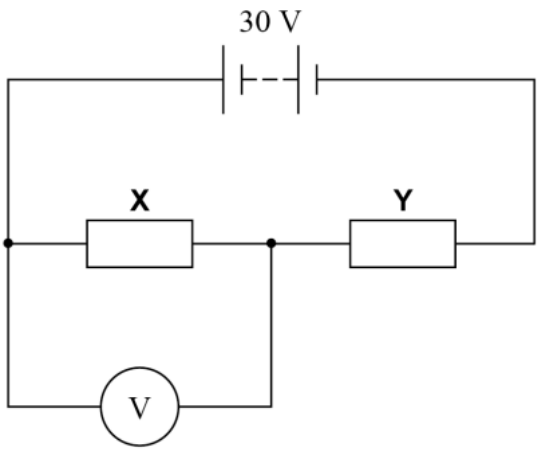
C $\frac{V}{2}$ ☐

D $\frac{2V}{3}$ ☐

(Total 1 mark)

Q4. Two resistors **X** and **Y** are connected in series with a power supply of emf 30 V and negligible internal resistance.

The resistors are made from wire of the same material. The wires have the same length. **X** uses wire of diameter d and **Y** uses wire of diameter $2d$.



What is the reading on the voltmeter?

A 10 V ☐

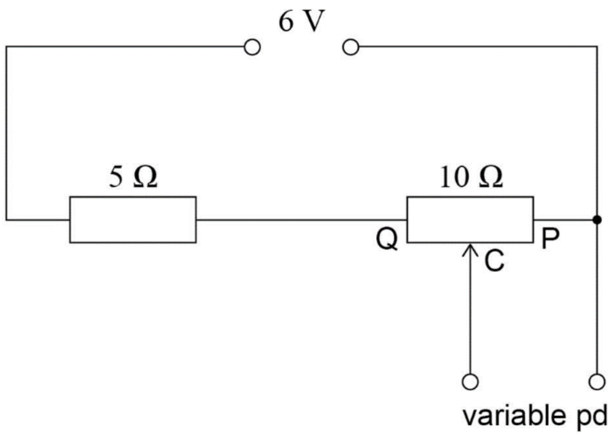
B 15 V ☐

C 20 V ☐

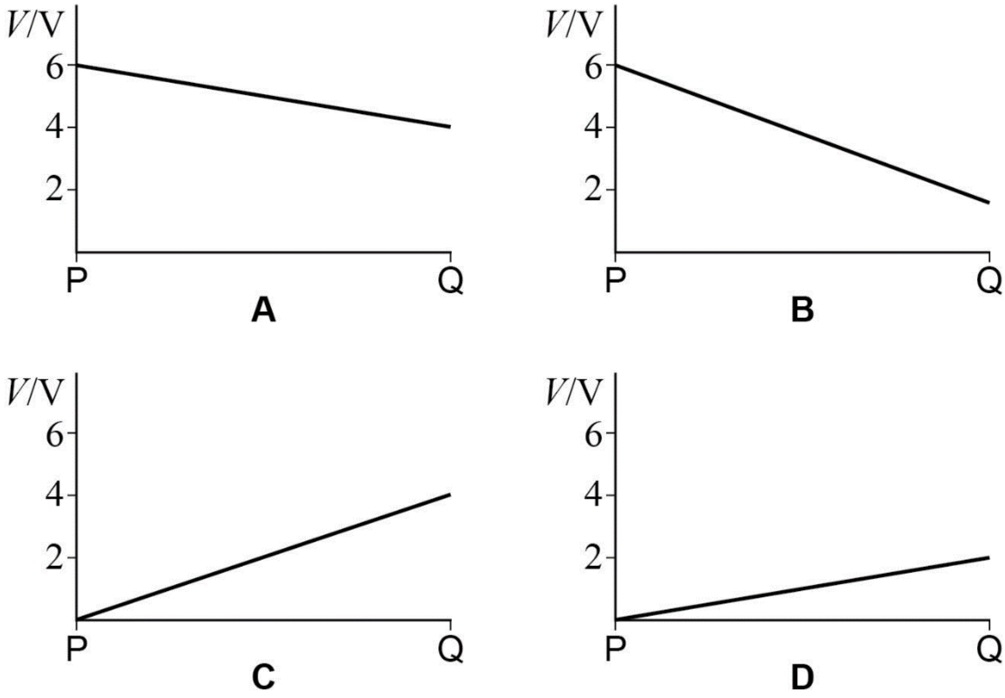
D 24 V ☐

(Total 1 mark)

Q5. The circuit shown is used to supply a variable potential difference (pd) to another circuit.



Which graph shows how the pd supplied V varies as the moving contact C is moved from position P to position Q?



A ○

B ○

C ○

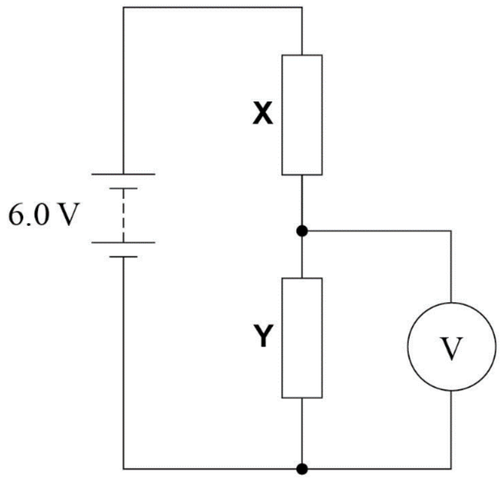
D ○

(Total 1 mark)

Q6. Resistors **X** and **Y** are connected in series with a 6.0 V battery of negligible internal resistance.

X has resistance R and **Y** has resistance $\frac{R}{2}$.

A voltmeter of resistance R is connected across **Y**.

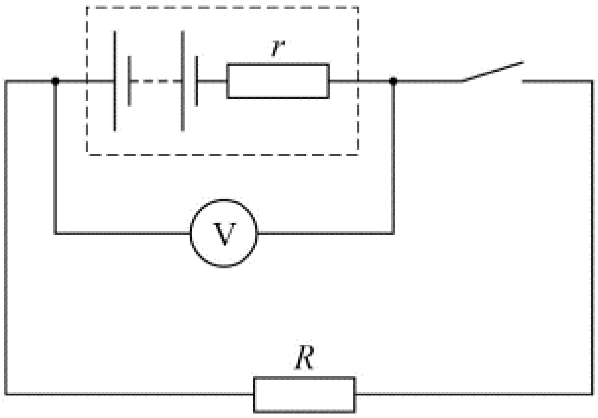


What is the reading on the voltmeter?

A	0.0 V	○	**C**	3.0 V	○
B	1.5 V	○	**D**	4.5 V	○

(Total 1 mark)

Q7. The diagram shows a 12 V battery connected to a resistor of resistance R. The voltmeter reads 10 V when the switch is closed.



What is the internal resistance r of the battery?

A	$\frac{R}{6}$	○
B	$\frac{R}{5}$	○
C	$5R$	○
D	$6R$	○

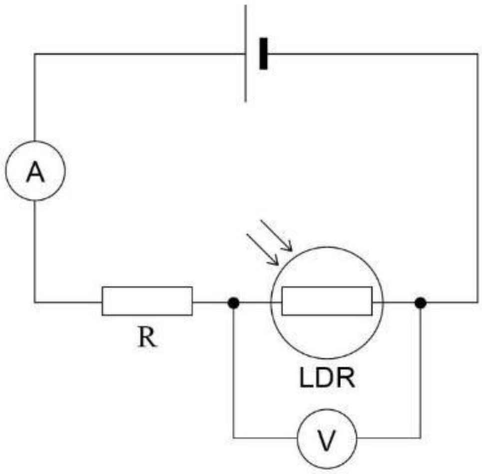
(Total 1 mark)

10 minutes on: 46 Sensing Circuits

Q1.

The figure shows a light dependent resistor (LDR) and fixed resistor R connected in series across a cell. The internal resistance of the cell is negligible.

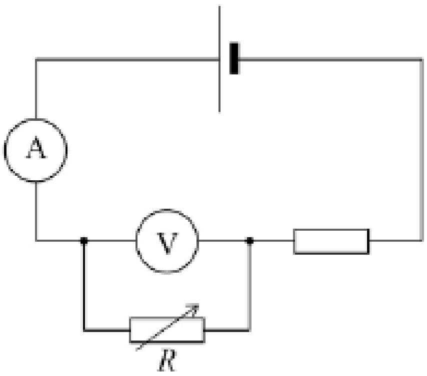
Which row shows how the readings on the ammeter and the voltmeter change when the light intensity incident on the LDR is increased?



	Ammeter reading	Voltmeter reading	
A	decreases	increases	⬭
B	decreases	decreases	⬭
C	increases	increases	⬭
D	increases	decreases	⬭

(Total 1 mark)

Q2. In the circuit shown in the diagram the cell has negligible internal resistance.

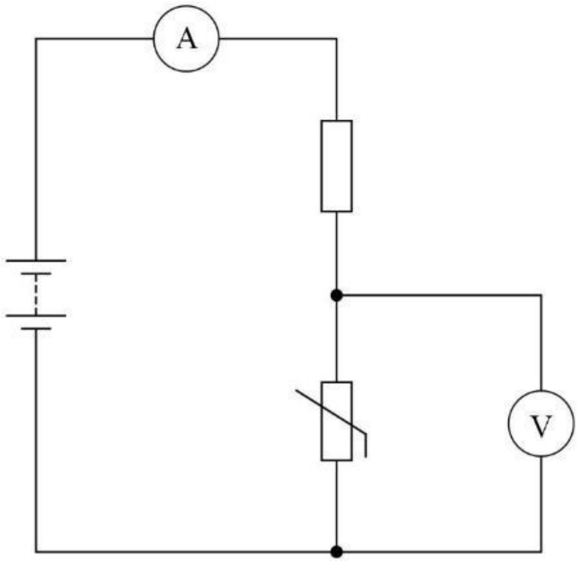


What happens to the reading of both meters when the resistance of R is decreased?

	Reading of ammeter	Reading of voltmeter	
A	increases	increases	⬭
B	increases	decreases	⬭
C	decreases	increases	⬭
D	unchanged	decreases	⬭

(Total 1 mark)

Q3. The diagram shows a temperature-sensing circuit.



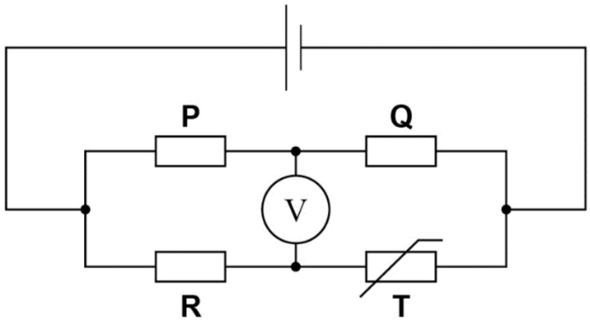
The temperature of the thermistor is decreased.

Which row shows the changes to the ammeter reading and the voltmeter reading?

	Ammeter reading	Voltmeter reading	
A	increases	increases	⬭
B	increases	decreases	⬭
C	decreases	decreases	⬭
D	decreases	increases	⬭

(Total 1 mark)

Q4. In the circuit below, the voltmeter reading is zero.



When the temperature of the thermistor **T** is increased, the voltmeter reading changes.

Which change to the circuit will restore the voltmeter to zero?

A a reduction in the emf of the cell ⬭

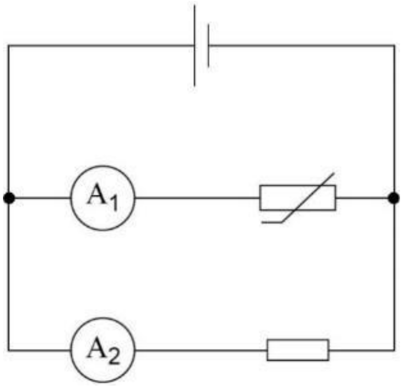
B a reduction in the resistance of **P** ⬭

C an increase in the resistance of **Q** ⬭

D a reduction in the resistance of **R** ⬭

(Total 1 mark)

Q5. A circuit consists of a cell, a thermistor, a fixed resistor and two ammeters.



The cell has a constant electromotive force and negligible internal resistance. Readings from the two ammeters are taken.

Which row describes what happens to the current in each ammeter when the temperature of the thermistor decreases?

	Current in ammeter A_1	Current in ammeter A_2	
A	Decreases	Unchanged	⬭
B	Decreases	Increases	⬭
C	Increases	Decreases	⬭
D	Increases	Unchanged	⬭

(Total 1 mark)

Q6. A voltmeter has a resistance of 4.0 kΩ and reads 1.0 V for every scale division on the meter.

A power supply of emf 20 V and negligible internal resistance is connected across this voltmeter and a thermistor in series. The voltmeter reads two divisions.

What is the value of the thermistor?

A 44 kΩ ⬭

B 36 kΩ ⬭

C 4.4 kΩ ⬭

D 3.6 kΩ ⬭

(Total 1 mark)

Q7. A potential divider circuit consists of a battery connected across a thermistor and variable resistor in series.

Which of the following causes the potential difference (pd) across the thermistor to increase?

A increasing the temperature of the thermistor ⬭

B increasing the resistance of the variable resistor ⬭

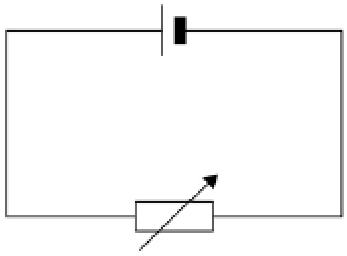
C reducing the emf of the battery ⬭

D adding a resistor across the variable resistor ⬭

(Total 1 mark)

10 minutes on: 47 EMF and Internal Resistance

Q1. The cell in the circuit has an emf of 2.0 V. When the variable resistor has a resistance of 4.0 Ω, the potential difference (pd) across the terminals of the cell is 1.0 V.

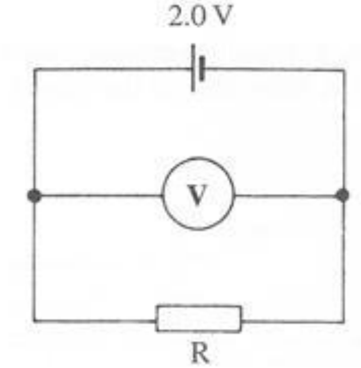


What is the pd across the terminals of the cell when the resistance of the variable resistor is 12 Ω?

A	0.25 V	⬭
B	0.75 V	⬭
C	1.33 V	⬭
D	1.50 V	⬭

(Total 1 mark)

Q2. The cell in the following circuit has an emf of 2.0 V and an internal resistance of 1.0 Ω.

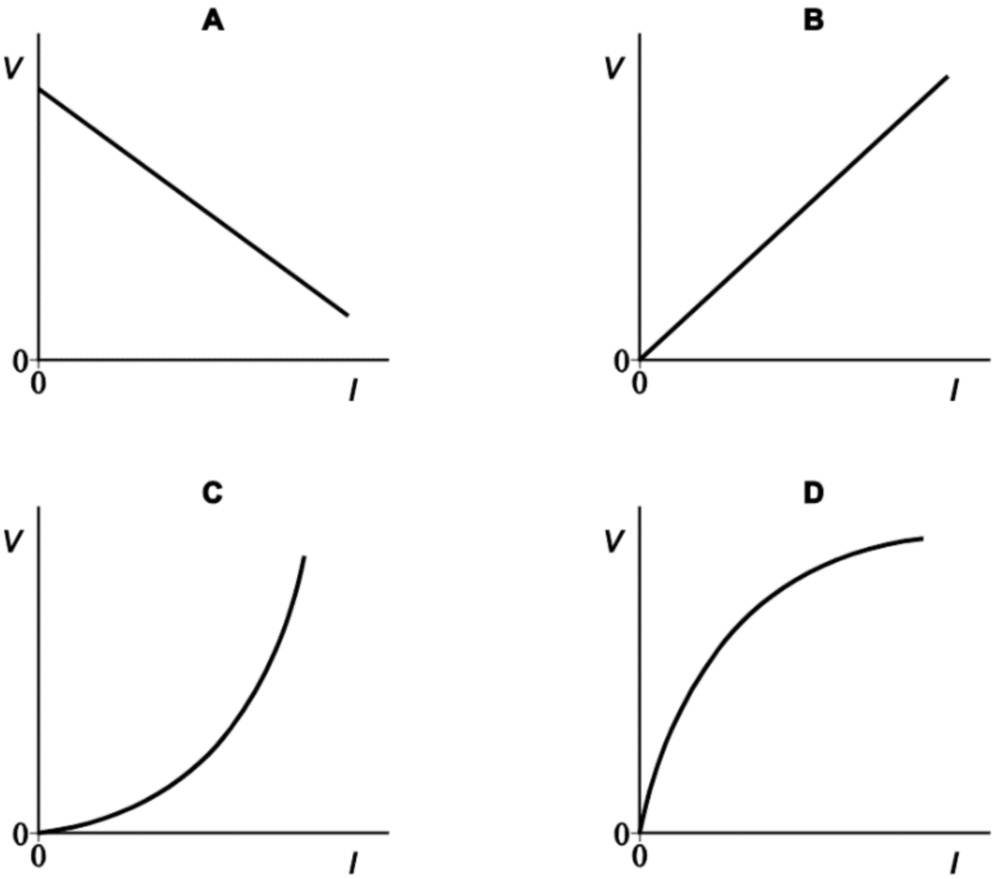


The digital voltmeter reads 1.6 V. What is the resistance of R?

A	0.4 Ω	⬭
B	1.0 Ω	⬭
C	2.0 Ω	⬭
D	4.0 Ω	⬭

(Total 1 mark)

Q3. A student investigates how the potential difference V across the terminals of a cell varies with the current I in the cell.



Which graph correctly shows how V varies with I?

A ◯

B ◯

C ◯

D ◯

(Total 1 mark)

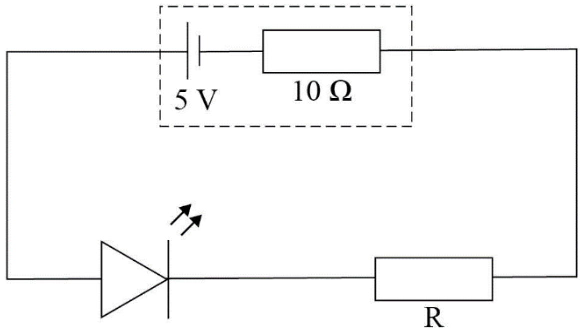
Q4. A battery is connected to a 10 Ω resistor and a switch in series. A voltmeter is connected across the battery. When the switch is open (off) the voltmeter reads 1.45 V. When the switch is closed the reading is 1.26 V.

What is the internal resistance of the battery?

A	0.66 Ω	◯
B	0.76 Ω	◯
C	1.3 Ω	◯
D	1.5 Ω	◯

(Total 1 mark)

Q5. In the circuit below, the potential difference across the light emitting diode (LED) is 1.8 V when it is emitting light. The current in the circuit is 20 mA.

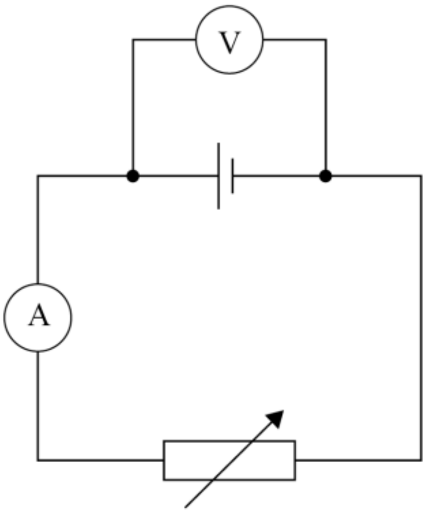


What is the value of the resistor R?

A	80 Ω	◯
B	90 Ω	◯
C	150 Ω	◯
D	160 Ω	◯

(Total 1 mark)

Q6. In the circuit shown, the cell has an emf of 12 V and an internal resistance which is not negligible.



When the resistance of the variable resistor is 10 Ω the voltmeter reads 10 V and the ammeter reads 1.0 A.

The resistance of the variable resistor is changed to 5 Ω.

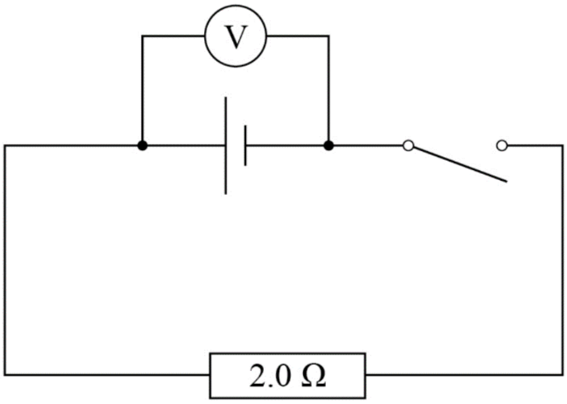
What is the new reading on the ammeter?

A	1.4 A	◯
B	1.7 A	◯
C	2.0 A	◯
D	2.4 A	◯

(Total 1 mark)

Q7. In the circuit, the reading of the voltmeter is V.

When the switch is closed the reading becomes $\frac{V}{3}$.



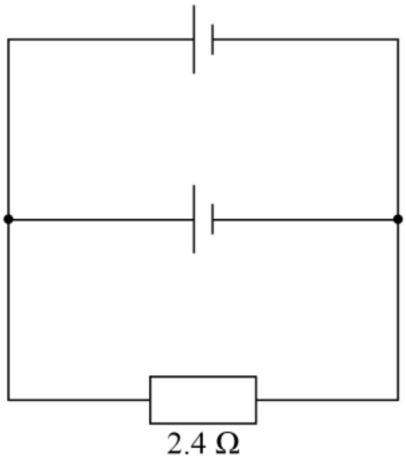
What is the internal resistance of the cell?

A	0.33 Ω	⬭
B	0.67 Ω	⬭
C	4.0 Ω	⬭
D	6.0 Ω	⬭

(Total 1 mark)

10 minutes on: 48 Cells in Series and Parallel

Q1. Two identical batteries each of emf 1.5 V and internal resistance 1.6 Ω are connected in parallel. A 2.4 Ω resistor is connected in parallel with this combination.

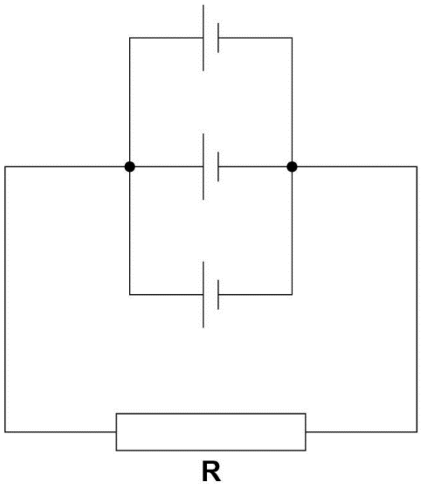


What is the current in the 2.4 Ω resistor?

A	0.38 A	⬭	**C**	0.75 A	⬭
B	0.47 A	⬭	**D**	0.94 A	⬭

(Total 1 mark)

Q2. Three identical cells, each of emf 1.5 V and internal resistance 6.0 Ω, are connected to resistor **R**. The resistance of **R** is 6.0 Ω.



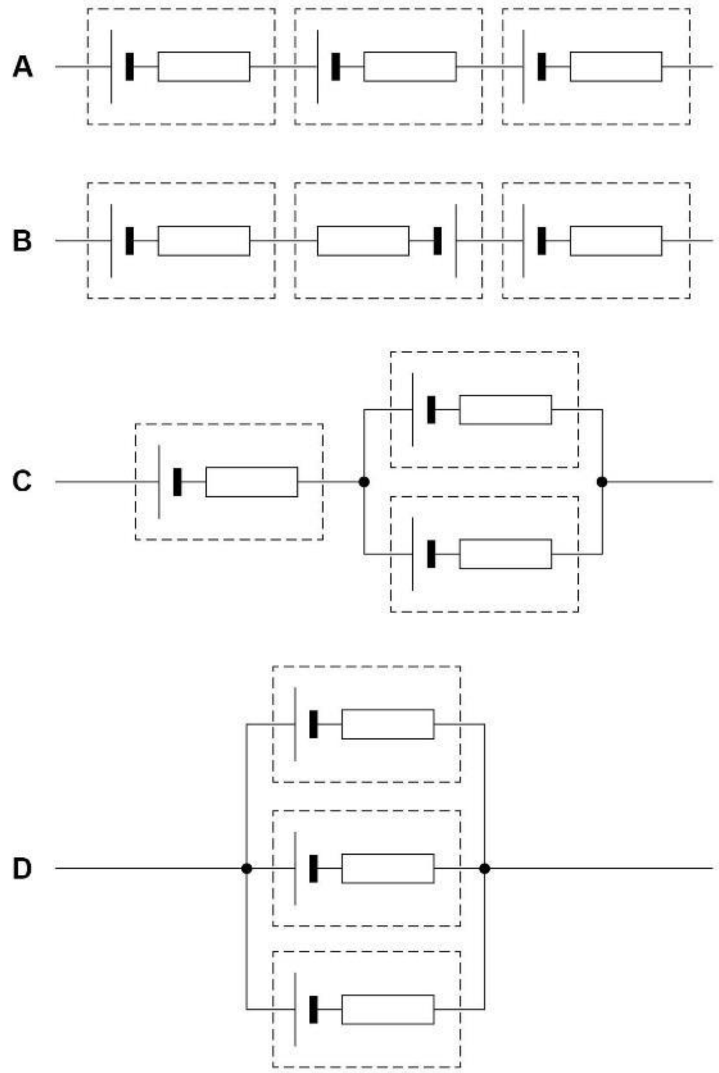
What is the current in **R**?

A	0.19 A	○
B	0.25 A	○
C	0.56 A	○
D	0.75 A	○

(Total 1 mark)

Q3. Three cells each have an emf ε = 1.5 V and an internal resistance r = 0.6 Ω.

Which combination of these cells will deliver a total emf of 1.5 V and a maximum current of 7.5 A?



A ○

B ○

C ○

D ○

(Total 1 mark)

Q4. Three identical cells, each of internal resistance *R*, are connected in series with an external resistor of resistance *R*. The current in the external resistor is *I*. If one of the cells is reversed in the circuit, what is the new current in the external resistor?

A $\frac{I}{3}$ ○

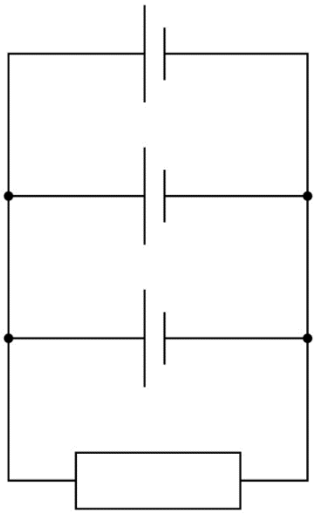
B $\frac{4I}{9}$ ○

C $\frac{I}{2}$ ○

D $\frac{2I}{3}$ ○

(Total 1 mark)

Q5. A resistor of resistance R and three identical cells of emf E and internal resistance r are connected as shown.



What is the current in the resistor?

A $\frac{3E}{(3R+r)}$ ○

B $\frac{9E}{(3R+r)}$ ○

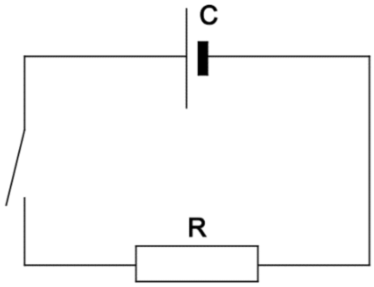
C $\frac{E}{R}$ ○

D $\frac{3E}{R}$ ○

(Total 1 mark)

Q6. A cell C of negligible resistance and a switch are in series with a resistor R. The switch is moved to the on (closed) position for a time t.

Which change reduces the amount of charge flowing through R in time t?



A add an identical cell in parallel with C ○

B add an identical cell in series with C ○

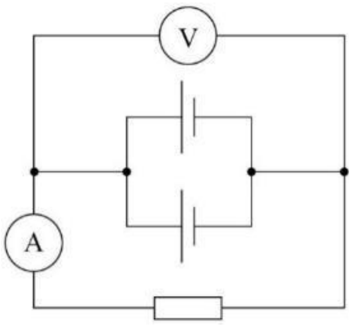
C add a second resistor in series with R ○

D add a second resistor in parallel with R ○

(Total 1 mark)

Q7. A circuit consists of two identical cells, a resistor, an ammeter and a voltmeter. The cells each have an emf of 3.0 V and the resistor has a resistance of 12 Ω

The cells have negligible internal resistance.



Which row shows the readings on the voltmeter and ammeter?

	Voltage / V	Current / A	
A	3.0	0.25	○
B	3.0	0.50	○
C	6.0	0.25	○
D	6.0	0.50	○

(Total 1 mark)

10 minutes on: 49 Electrical Energy

Q1. What quantity is measured in kW h?

A	charge	○
B	current	○
C	energy	○
D	power	○

(Total 1 mark)

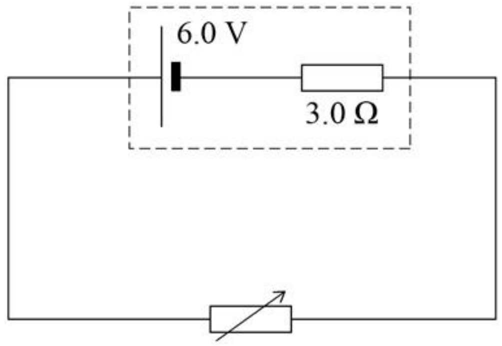
Q2. A battery of negligible internal resistance and an emf of 12 V is connected in series with a heating element. The heating element has a resistance of 6.5 Ω when in operation.

What is the energy transferred by the heating element when operating for 5 minutes?

A	111 J	○
B	390 J	○
C	6650 J	○
D	23 400 J	○

(Total 1 mark)

Q3. The cell in the following circuit has an emf (electromotive force) of 6.0 V and an internal resistance of 3.0 Ω. The resistance of the variable resistor is set to 12 Ω.



How much electrical energy is converted into thermal energy **within the cell** in 1 minute?

A	0.48 J	○
B	29 J	○
C	45 J	○
D	144 J	○

(Total 1 mark)

Q4. An electric motor lifts a load of weight W through a vertical height h in time t.

The potential difference across the motor is V and the current through it is I.

What is the efficiency of the motor?

A $\frac{Wht}{VI}$ ⬭

B $\frac{VI}{Wht}$ ⬭

C $\frac{Wh}{VIt}$ ⬭

D $\frac{VIt}{Wh}$ ⬭

(Total 1 mark)

Q5. The capacity of a portable charger is rated in ampere hours (A h). A charger of capacity 1 A h can provide 1 A for 1 hour at its working voltage.

One charger has a capacity of 1800 mA h at a working voltage of 3.7 V.

What is the energy stored in this charger?

A 6.5 kJ ⬭

B 24 kJ ⬭

C 400 kJ ⬭

D 24 kJ ⬭

(Total 1 mark)

Q6. Which is equivalent to the ohm?

A J C^{-2} s^{-1} ⬭

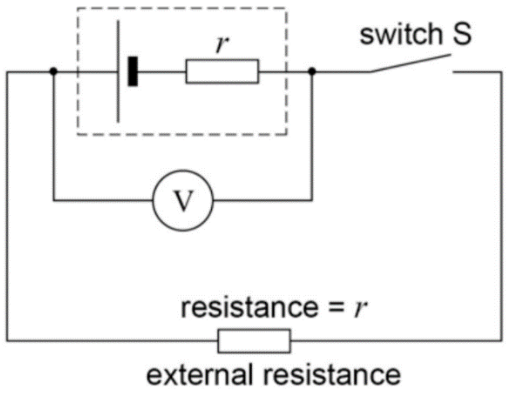
B J C^{-2} s ⬭

C J s ⬭

D J s^{-1} ⬭

(Total 1 mark)

Q7. In the circuit shown, V is a voltmeter with a very high resistance. The internal resistance of the cell, r, is equal to the external resistance in the circuit.



Which of the following is not equal to the emf of the cell?

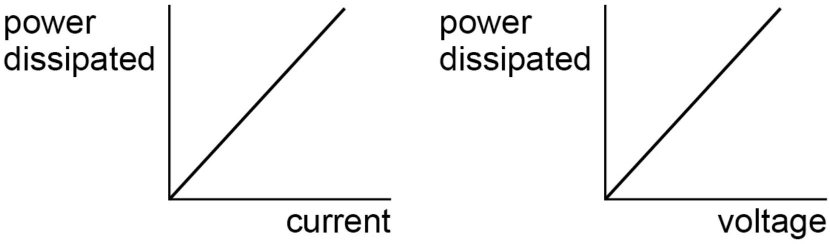
A	the reading of the voltmeter when the switch S is open	⬭
B	the chemical energy changed to electrical energy when unit charge passes through the cell	⬭
C	twice the reading of the voltmeter when the switch S is closed	⬭
D	the electrical energy produced when unit current passes through the cell	⬭

(Total 1 mark)

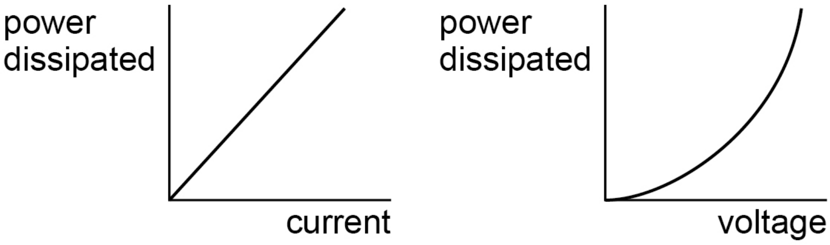
10 minutes on: 50 Electrical Power

Q1. Which pair of graphs shows the variation of power dissipated with current, and the variation of power dissipated with voltage, for a resistor of constant resistance?

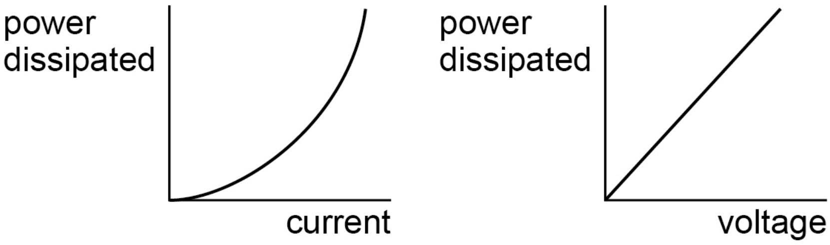
A



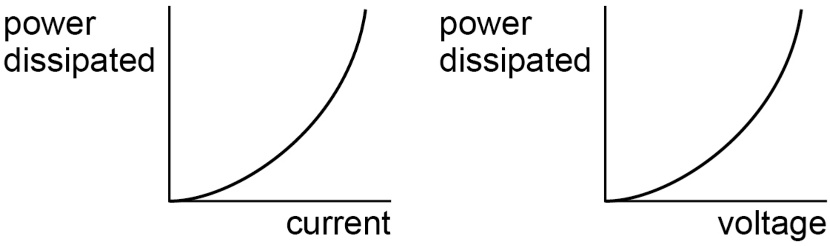
B



C



D



A ☐

B ☐

C ☐

D ☐

Q2. Which is a unit of power?

A	$C^2\ \Omega\ s^{-1}$	○
B	$J\ C^{-1}\ s^{-1}$	○
C	$V\ C\ s^{-1}$	○
D	$V^2\ \Omega$	○

(Total 1 mark)

Q3. A pd V is applied across a resistor. Another identical resistor is then connected in series with it and the same pd V is applied across the combination.

Which statement is **incorrect**?

A	The total resistance is doubled.	○
B	The pd across one resistor is $\frac{V}{2}$	○
C	The current in the resistors is halved.	○
D	The power dissipated in one resistor is halved.	○

(Total 1 mark)

Q4. A mobile phone operates at a constant power of 200 mW

It has a 3.7 V lithium-ion battery that has a charge capacity of 9400 C

What is the time taken for the battery to discharge completely?

A	2 hours	○
B	48 hours	○
C	120 hours	○
D	140 hours	○

(Total 1 mark)

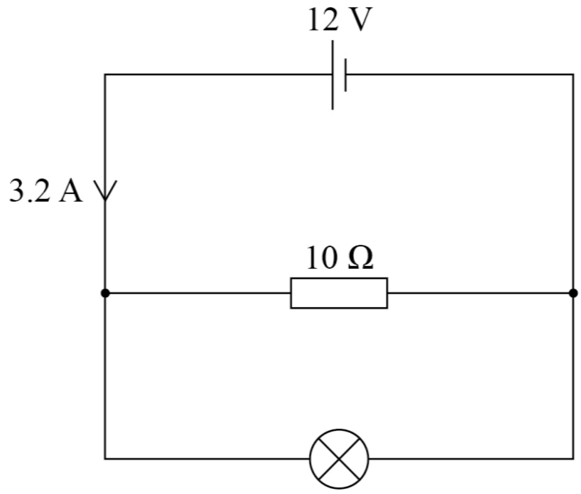
Q5. A filament lamp with resistance 12 Ω is operated at a power of 36 W.

How much charge flows through the filament lamp during 15 minutes?

A	26 C	○
B	1.6 kC	○
C	2.7 kC	○
D	6.5 kC	○

(Total 1 mark)

Q6. A cell of negligible internal resistance is connected to a resistor and a lamp in parallel as shown.



What is the power dissipated by the lamp?

A	14 W	○
B	16 W	○
C	24 W	○
D	38 W	○

(Total 1 mark)

Q7. A power of 100 kW at a potential difference of 10 kV is transmitted to a load resistor through cables of total resistance 5.0 Ω.

What is the power loss in the cables?

A	50 W	○
B	0.5 kW	○
C	100 kW	○
D	20 MW	○

(Total 1 mark)

Solutions (Task 1)

C1 Electric circuits

C1A $6+3 = 9\,\Omega$
$= 9.0\,\Omega$

C1B $\left(\left(1+2\right)^{-1} + 4^{-1}\right)^{-1} = \left(\frac{1}{3} + \frac{1}{4}\right)^{-1} = \left(\frac{7}{12}\right)^{-1} = \frac{12}{7} = 1.714$
$= 1.7\,\Omega$

C1C $\left(6^{-1}+3^{-1}\right)^{-1} = R_{\parallel} = \left(\frac{1}{6} + \frac{2}{6}\right)^{-1}$
$= \left(\frac{3}{6}\right)^{-1} = \frac{6}{3} = 2\,\Omega$
$= 2.0\,\Omega$

C1D $R_T = 2 + \left(4^{-1}+12^{-1}\right)^{-1}$
$= 2 + \left(\frac{1}{4} + \frac{1}{12}\right)^{-1} = 2 + \left(\frac{3}{12} + \frac{1}{12}\right)^{-1}$
$= 2 + \frac{12}{4} = 5.0\,\Omega$

C1E $3+4+12 = 19.0\,\Omega$.
$= 19\,\Omega$

C1F $R_{\parallel} = \left(3^{-1}+4^{-1}+12^{-1}\right)^{-1} = \left(\frac{4}{12} + \frac{3}{12} + \frac{1}{12}\right)^{-1}$
$= \left(\frac{8}{12}\right)^{-1} = \frac{3}{2} = 1.5\,\Omega$

C1.4 $R = \rho l/A = \dfrac{1.5\times10^{-8}\times 68}{2.1\times10^{-6}} = 0.4857\,\Omega = 0.49\,\Omega$

C1.5 $R = \rho l/A,\; l = \dfrac{RA}{\rho} = \dfrac{15\times 0.5\times10^{-6}}{4.9\times10^{-7}} = 15.31 = 15\,\text{m}$

C1.6 $R = \rho l/A = \dfrac{\rho l}{\pi r^2} = \dfrac{4.9\times10^{-7}\times 1}{\pi\left(10^{-3}\right)^2} = 0.15597 = 0.16\,\Omega$.

C1.7 $R = \rho l/A = \rho l/(\pi d^2/4) = \dfrac{4\rho l}{\pi d^2} = \dfrac{4\times1.5\times10^{-7}\times 1.5\times10^{4}}{\pi\times\left(10^{-2}\right)^2} = 28.6 = 29\,\Omega$

C1.8 $R = \rho l/A = \dfrac{1.5\times10^{-8}\times 20}{2.5\times\left(10^{-3}\right)^2} = 0.12\,\Omega$

C1.9 $R_m = \dfrac{\rho l}{A} = \dfrac{\rho l}{\pi r^2} = \dfrac{2.5\times10^{-8}\times 20\times10^{3}}{10\times\pi\times\left(2\times10^{-3}\right)^2} = 3.9788 = 4.0\,\Omega$.

$R_{a} = \rho l/A = \rho l/\pi r^2 = \dfrac{1.5\times10^{-8}\times 20\times10^{3}}{15\times\pi\times\left(2\times10^{-3}\right)^2} = 1.5915 = 1.6\,\Omega$

$R_T \approx \left(R_{al}^{-1} + R_m^{-1}\right)^{-1} =$
$= \left(1.592^{-1} + 3.979^{-1}\right)^{-1} = 1.137 = 1.1\,\Omega$

C2 CHARGE CARRIERS I

C2.1 $n = Q/e = \frac{-6.00}{1.6\times10^{-19}} = \underline{\underline{3.75\times10^{19}}}$

C2.2 $\frac{5\times10^{-3}}{1.6\times10^{-19}} = 3.125\times10^{16} = \underline{\underline{3.1\times10^{16}}}\ s^{-1}$

C2.3 $I = \frac{\Delta Q}{\Delta t} = \frac{\Delta(nq)}{\Delta t} = \frac{\Delta n}{\Delta t}q = 3000\times(2\times1.6\times10^{-19})$
$= \underline{\underline{+9.60\times10^{-16}\ A}}$

C2.4 $I = \frac{\Delta Q}{\Delta t} = \frac{\Delta(nq)}{\Delta t} = \frac{-3\times10^{21}\times1.6\times10^{-19}}{60\times2} = \underline{\underline{4.0A}}$

C4 KIRCHHOFF'S LAWS

C4.1 a $\underline{\underline{0.40A}}$

C4.4 a $\underline{\underline{30mA}}$

C4.1 b $\underline{\underline{0.40A}}$

C4.1 c $V = 6 - 2 = \underline{\underline{4.0V}}$

C4.4 b $\underline{\underline{30mA}}$

C4.4 c $9.0 - 1.5 = \underline{\underline{7.5V}}$

C4.2 a $0.4 - 0.2 = \underline{\underline{0.20A}}$

C4.2 b $\underline{\underline{6.0V}}$

C4.5 a $\underline{\underline{3.0A}}$

C4.2 c $\underline{\underline{6.0V}}$

C4.5 b $9 - 2 = \underline{\underline{7.0V}}$

C4.3 a $0.4 - 0.2 = \underline{\underline{0.20A}}$

C4.3 b $\underline{\underline{6.0V}}$

C4.5 c $3 - 2 = \underline{\underline{1.0A}}$

C4.3 c $6 - 3 = \underline{\underline{3.0V}}$

C4.5 d $\underline{\underline{2.0V}}$

C4.3 d $\underline{\underline{0.20A}}$

C5 POTENTIAL DIVIDERS

$\boxed{V_R = V_T\ \frac{R}{R_T}}$ => **C5.1** $\underline{\underline{3.0V}}$

C5.2 a $V = 12\times\frac{4\times10^{3}}{6\times10^{3}} = \underline{\underline{8.0V}}$

C5.3 $V = 24\times\frac{8}{23} = 8.348V$
$= \underline{\underline{8.3V}}$

C5.4 $V = 240\times\frac{1}{48} = \underline{\underline{5.0V}}$

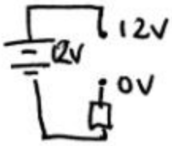
C5.5 $V = 5\times10^{3}\times\frac{0.2\times10^{6}}{10.2\times10^{6}} = \frac{10^{3}}{10.2} = 98.04 = \underline{\underline{98V}}$

C5.6 $R_{\parallel}^{-1} = (6^{-1}+3^{-1})^{-1} = (\frac{1}{6}+\frac{2}{6})^{-1}$
$= 6/3 = 2.0\Omega$

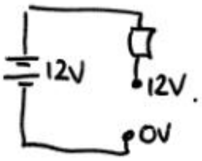
$\therefore V = 12\times\frac{4}{6} = \underline{\underline{8.0V}}$ (4.0V across ∥ combination)

(NOTE: these questions refer to potential, not p.d.)

C5.2b $R \to \infty$ ∴ all pd EMF dropped across gap (none across $4.0\,k\Omega$) ∴

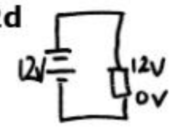


C5.2c



$\underline{\underline{V = 12V}}$

C5.2d



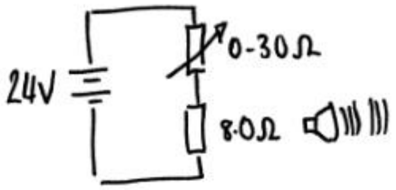
∴ $\underline{\underline{V = 12V}}$.

C5.2e

$\Rightarrow R_{\parallel} = (4^{-1} + 10^{-1})^{-1} = 2.857\,k\Omega$

$V = 12 \times \frac{2.857}{2 + 2.857} = 7.0588 = \underline{\underline{7.1V}}$

C5.7

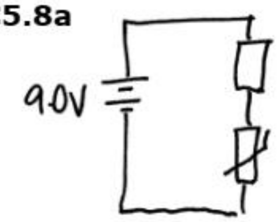


$R_v = 0\Omega$, $V = 24 \times 8/8 = \underline{\underline{24V}}$

$R_v = 30\Omega$, $V = 24 \times \frac{8}{38} = 5.053 = \underline{\underline{5.1V}}$

$5.1 \le V_{sp} \le 24\,V$

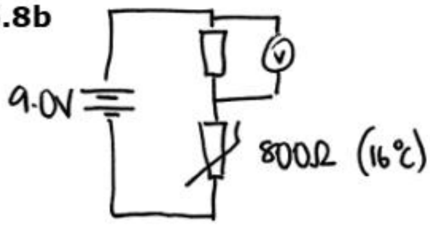
C5.8a



if ↑T, ↓R_{Th} and ↑V $\quad V_{Th} = V\frac{R_{Th}}{R_T}$, $\underbrace{V_R = V\, R/R_T}$

∴ Need across fixed resistor as R/R_T ↑

C5.8b



$V_R = V\frac{R}{R + R_{Th}}$

$V_R/V = R/(R + R_{Th})$

$\frac{V}{V_R}(R + R_{Th}) = R \quad$ [i]

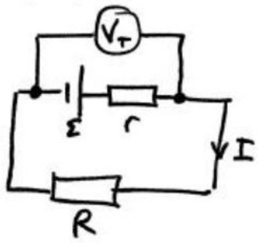
from (i).

$R_{Th} + R = RV/V_R$

$R_{Th} = R(V/V_R - 1)$

$R = \frac{R_{Th}}{V/V_R - 1} = \frac{800}{9/3 - 1} = \underline{\underline{400\Omega}}$

C6 INTERNAL RESISTANCE



C6.1a $V_T = \varepsilon - v$, $v = \varepsilon - V_T = 12 - 10.2 = 1.8\,V$

$v = Ir$, $r = v/I = \dfrac{1.8}{20} = \underline{\underline{0.090\,\Omega}} = 90\,m\Omega$

C6.1b $V_T = \varepsilon - v = \varepsilon - Ir = 12 - 72 \times 0.12 = 3.36 = \underline{\underline{3.4\,V}}$

C6.1c $V_T = \varepsilon - Ir$

$Ir = \varepsilon - V_T$, $I = \dfrac{\varepsilon - V_T}{r} = \dfrac{230 - 227.5}{0.53} = 4.717 = \underline{\underline{4.7A}}$

C6.1d $\varepsilon = I(R + r)$ $\qquad I = V_T/R = \dfrac{4.2}{4.3} = 0.9767\,A.$

$\varepsilon = V_T + Ir \Rightarrow r = \dfrac{\varepsilon - V_T}{I} = \dfrac{6 - 4.2}{0.9767} = 1.843 = \underline{\underline{1.8\,\Omega}}$

C6.1e $I = V_T/R = \dfrac{21.3}{12} = 1.775A$, $\qquad V_T = \varepsilon - Ir$

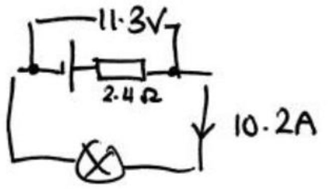
$\varepsilon = V_T + Ir = 21.3 + 1.775 \times 3.2$

$= 26.98 = \underline{\underline{27V}}$

C6.2 $\varepsilon = I(R + r)$ if $R = 0$, $\varepsilon = Ir$.

$r = \varepsilon/I = \dfrac{5 \times 10^3}{5 \times 10^{-3}} = 1.0 \times 10^6\,\Omega = \underline{\underline{1.0\,M\Omega}}$

C6.3



$V_T = \varepsilon - v$

$= \varepsilon - Ir$

$\varepsilon = V_T + Ir = 11.3 + 10.2 \times 2.4$

$= 35.78 = \underline{\underline{36V}}$

8. $\underline{12.4V}$

as voltmeter has

$R \to \infty$, $\quad I \to 0A$

$\therefore v = Ir \to 0V$

& $\varepsilon = V_T$.

C6.4a $\varepsilon = 12.4\ V$

C6.4b $V_T = \varepsilon - Ir$, $r = \dfrac{\varepsilon - V_T}{I} = \dfrac{12.4 - 11.5}{64} = 0.01406$

$= \underline{\underline{0.014\,\Omega}}$

C6.5 $0 \le I \le 10A$, $\varepsilon = 13.5V$ $\qquad V_T = \varepsilon - v$

$= \varepsilon - Ir$, $r = \dfrac{\varepsilon - V_T}{I} = \dfrac{13.5 - 10.5}{10} = 3/10 = \underline{\underline{0.30\,\Omega}}$

G3 Heat capacity

(3.1) 1 a. $Q = mc\Delta\theta = 0.29 \times 880 \times (82-15) = 17098.4 = \underline{17\ kJ}.$

b. $Q = mc\Delta\theta, \ \Delta\theta = Q/mc = \theta_2 - \theta_1, \ \theta_2 = Q/mc + \theta_1 = \frac{45200}{2.3 \times 2130} + 3$

$= 12.22 = \underline{12°C}$

c. $\theta_2 = Q/mc + \theta_1 = \frac{81 \times 10^3}{1.5 \times 4180} + 11 = 23.92 = \underline{24°C}$

(3.4) 2. $Q = P\Delta t = mc\Delta\theta, \ \Delta t = \frac{mc\Delta\theta}{P} = \frac{2.31 \times 4180 \times (100-12)}{2300} = 369.4 = \underline{370\ s}$

(3.5) 3. $P = \frac{\Delta Q}{\Delta t} = \frac{\Delta M}{\Delta t} c\Delta\theta, \ \Delta M/\Delta t = \frac{\Delta Q/\Delta t}{c\Delta\theta} = \frac{4200}{4180 \times (41-12)} = 0.03465 = \underline{0.035\ kg}$

[<u>OR</u> Consider one second.
$Q = 4200\ J$ (every second) $\therefore Q = mc\Delta\theta, \ m = Q/c\Delta\theta = \frac{4200}{4180 \times (41-12)} = 0.03465$
$= 0.035\ kg$]

(3.6) 4. $Q = P\Delta t = mc\Delta\theta, \ \Delta t = \frac{mc\Delta\theta}{P} = \frac{0.024 \times 4180 \times (80-35)}{4200} = 1.0749 = \underline{1.1\ s}$

(3.7) 5. $Q_T = Q_{Fe} + Q_{H_2O}$

$Q_T/\Delta\theta = Q_{Fe}/\Delta\theta + Q_{H_2O}/\Delta\theta = M_{Fe}C_{Fe} + M_{H_2O}C_{H_2O} = 5.4 \times 435 + 7.3 \times 4180 = 32863$

$= \underline{33\ kJ.K^{-1}}$

(3.8) 6 a. $Q_{H_2O} + Q_P = 0$

$M_{H_2O}C_{H_2O}\Delta\theta_{H_2O} + M_P C_P \Delta\theta_P = 0$ [<u>NOTE</u> always final − initial]

$3.2 \times 4180 \times (\theta_2 - 83) + 4.3 \times 2130(\theta_2 - 18) = 0$

$22535\theta_2 - 1275070 = 0 \quad \therefore \theta_2 = 56.58 = \underline{57°C}$

b. $Q_{H_2O} + Q_{Fe} = 0, \quad 0.34 \times 4180 \times (\theta_2 - 14) + 0.15 \times 435 \times (\theta_2 - 230) = 0$

$1486.45\theta_2 - 34904.3 = 0, \quad \theta_2 = 23.48 = \underline{23°C}$

c. $Q_{H_2O} + Q_P = 0, \quad 1.25 \times 4180(84-56) + M_P \times 2130 \times (84-170) = 0$

$146300 - 183180M_P = 0 \quad \therefore M_P = 0.7987 = \underline{0.80\ kg}$

d. $Q_{Al} + Q_P = 0 \quad 3.2 \times 880 \times (51-12) + 2.1 \times 2130(51 - \theta_{P_1}) = 0$

$337947 - 4473\theta_{P_1} = 0 \quad \therefore \theta_{P_1} = 75.55 = \underline{76°C}$

(3.12) 7. $Q_{H_2OA} + Q_{H_2OB} = 0$

$mc\Delta\theta_A + mc\Delta\theta_B = 0, \quad 19 \times \cancel{4180} \times (37-21) + M \times \cancel{4180} \times (37-52) = 0$

$304 - 15M = 0, \quad M = 20.27 = \underline{20\ kg}$

(3.13) 8. $Q_R + Q_{H_2O} = 0$

$M_R C_R \Delta\theta_R + M_{H_2O}C_{H_2O}\Delta\theta_{H_2O} \rightarrow 0.21C_R(34-303) + 0.5 \times 4180 \times (34-15)$

$-56.49C_R + 39710 = 0, \quad C_R = 703.0 = \underline{700\ J.kg.K^{-1}}$

GH Latent Heat & Heat Capacity.

(4.1) 1a. $Q = ml_f = 5.6 \times 3.35 \times 10^5 = 1.876 \times 10^6\ J = \underline{1.88\ MJ}$

b. $mc\Delta\theta + ml_f. = 5.6 \times 2030 \times (0 - {}^-3.5) + 1.876 \times 10^6 = 39788 + 1.876 \times 10^6$

$= 1915788\ J = \underline{1.9\ MJ}$

(4.2) 2a. $Q = mc\Delta\theta = mc(\theta_2 - \theta_1)$, $\theta_1 = -Q/mc = \frac{-10}{m \times 2030} = {}^-16.503 = \underline{{}^-16.5\ °C}$

$Q = ml_f$, $m = Q/l_f = \frac{100}{3.35 \times 10^5} = 2.985 \times 10^{-4}\ kg$

b. $Q = mc\Delta\theta = mc(\theta_2 - 0)$, $\theta_2 = Q/mc = \frac{100}{4180 \times 2.985 \times 10^{-4}} = 80.1455$

$= \underline{80.1\ °C}$

(4.5) 3. $\frac{Q_v}{Q_H} = \frac{\cancel{m} l_v}{\cancel{m} c\,\Delta\theta} = \frac{l_v}{c \times 100} = \frac{2.26 \times 10^6}{100 \times 4.18 \times 10^3} = \frac{22.6}{4.18} = 5.4067 = \underline{5.41}$

(4.6) 4 a. $Q = P\Delta t = mc\Delta\theta$, $\Delta t = \frac{mc\Delta\theta}{P} = \frac{2.25 \times 2030 \times (0 - {}^-40)}{3.2 \times 10^3} = 57.09 = \underline{57s}$

b. $Q = P\Delta t = ml_f$, $\Delta t = \frac{ml_f}{P} = \frac{2.25 \times 3.35 \times 10^5}{3.2 \times 10^3} = 235.55 = \underline{240s}$

c. $Q = P\Delta t = mc\Delta\theta$, $\Delta t = \frac{mc\Delta\theta}{P} = \frac{2.25 \times 4180 \times (100 - 0)}{3.2 \times 10^3} = 293.9 = \underline{290s}$

d. $Q = P\Delta t = ml_v$, $\Delta t = ml_v/P = \frac{2.25 \times 2.26 \times 10^6}{3.2 \times 10^3} = 1589 = \underline{1600s}$

PTO.

(4.10) 5a. $Q_{Heat\,ice} + Q_{melt} + Q_{Heat\,water\,melt} + Q_{water\,cool} = 0$ [$Ch\Theta$].

$$M_I C_I \Delta\Theta_I + M_I L_f + M_I C_w \Delta\Theta + M_w C_w \Delta\Theta = 0$$

$$\underbrace{0.35 \times 2030 \times (0 - {}^-15)}_{10657.5\,J} + \underbrace{0.35 \times 3.35 \times 10^5}_{117250\,J} + 0.35 \times 4180 \times (\Theta_2 - 0) + 0.61 \times 4180 \times (\Theta_2 - 59) = 0$$

$$-22530.7 + 4012.8\,\Theta_2 = 0$$

$$\Theta_2 = 5.6147 = 5.6°C$$

(4.11) b. $Q_{Heat\,ice} + Q_{water\,cool.} + Q_{water\,freezing} = 0$ releasing energy!

$$10657.5 + M \times 4180 \times (0 - 59) - 3.35 \times 10^5 \times M = 0$$

$$581620m = 10657.5 \qquad M = 0.01832 = \underline{0.018\,kg}$$

(4.12) c. $Q_{Heat\,ice} + Q_{melt} + Q_{water\,cool} = 0$

$$10657.5 + 117250 + MC\Delta\Theta = 0$$

$$127907.5 + M \times 4180 \times (0 - 59) = 0$$

$$246620\,M = 127907.5$$

$$M = 0.5186 = \underline{0.52\,kg}$$

Circuit questions solutions (Task 2)

M20.(a) potential divider formula used or current found to be 0.25 A

C1
A1

allow 1 s.f.

2.0 V

1.0 V (with working) gains 1 mark

2

(b) main current =1.2 V / 4 Ω = 0.3 (A)

C1

R_{total} = 1.8 V / 0.3 A = 6 Ω or I_8 = 0.225 (A)

C1

R_V = 24 Ω

A1

3

[5]

M26. (a) (i) *(use of P=VI)*
I = 36/12 + 6/12 ✓ = 3.5 (A) ✓

2

(ii) *(use of V=IR)*
R = 12/3 = 4 (Ω) ✓

1

(iii) *R* = 12/0.50 = 24✓(Ω)

1

(b) terminal pd/voltage across lamp is now less OR current is less ✓
due to lost volts across internal resistance OR due to higher resistance ✓
lamps less bright ✓

3

(c) (i) current through lamps is reduced as resistance is increased **or**pd across lamps is reduced as voltage is shared ✓
hence power is less OR lamps dimmer ✓

2

(ii) lamp Q is brighter ✓
lamp Q has the <u>higher resistance</u> hence <u>pd/voltage</u> across is greater ✓
current is the same for both ✓
hence power of Q greater ✓

3

[12]

Circuit questions 2: solutions

M31. (a) (use of $P = V/I$)
$I = 36/12 = 3.0$ A ✓
$I = 2.0/4.5 = 0.44$ A ✓

2

(b) (i) pd = 24 − 12 = 12 V ✓

1

(ii) current = 3.0 + 0.44 = 3.44 A ✓

1

(iii) $R_1 = 12/3.44 = 3.5\ \Omega$ ✓

1

(iv) pd = 12 − 4.5 − 7.5 V ✓

1

(v) $R_2 = 7.5/0.44 = 17\ \Omega$ ✓

1

(c) (i) (circuit) resistance increases ✓
current is lower (reducing voltmeter reading) ✓
or correct potential divider argument

2

(ii) pd across Y **or** current through Y increases ✓
hence power/rate of energy dissipation greater **or** temperature of lamp increases ✓

2

[11]

M32. (a) (i) (use of $V = IR$)
$R_{total} = 1$ (ohm) ✓
$V = 1 \times 1 = 1.0$ V ✓

2

(ii) (use of $V = IR$)
$R = 9.0/1.0 = 9.0\ \Omega$ ✓
$r = 9.0 - 1.0 - 6.0 = 2.0\ \Omega$ ✓
or use of ($E = I(R + r)$)
$9.0 = 1(7 + r)$ ✓
$r = 9.0 - 7.0 = 2.0\ \Omega$ ✓

2

(iii) (use of $W = VIt$)
$W = 9.0 \times 1.0 \times 5 \times 60$ ✓
$W = 2700$ J ✓

2

(iv) energy dissipated in internal resistance = $1^2 \times 2.0 \times 5 \times 60 = 600$ (J) ✓
percentage = 100 × 600/2700 = 22% ✓ CE from part aii

2

(b) internal resistance limits current ✓
hence can provide higher current ✓
or energy wasted in internal resistance/battery ✓
less energy wasted (with lower internal resistance) ✓
or charges quicker ✓
as current higher or less energy wasted ✓
or (lower internal resistance) means higher terminal pd/voltage ✓
as less pd across internal resistance or mention of lost volts ✓

2

[10]

Circuit questions ChQ: solutions

M1.(a) A combination of resistors in series connected across a voltage source (to produce a required pd) ✓

Reference to splitting (not dividing) pd

1

(b) When R increases, pd across R increases ✓

Pd across R + pd across T = supply pd ✓

So pd across T / voltmeter reading decreases ✓

Alternative:

Use of $V = V_{tot}\left(\frac{R_1}{R_1+R_2}\right)$ ✓

V_{tot} and R_2 remain constant ✓

So V increases when R_1 increases ✓

3

(c) At higher temp, resistance of T is lower ✓

1

So circuit resistance is lower, so current / ammeter reading increases ✓

1

(d) Resistance of T = 2500 Ω

Current through T = V / R = 3 / 2500 = 1.2×10^{-3} A ✓

(Allow alternative using $V_1/R_1 = V_2/R_2$)

pd across R = 12 − 3 = 9 V

The first mark is working out the current

1

Resistance of R = V / I = 9 / 1.2×10^{-3} = 7500 Ω✓

The second mark is for the final answer

1

(e) Connect the alarm across R instead of across T ✓

allow: use a thermistor with a ptc instead of ntc.

1

[9]

M9.(a) $I_3 = I_1 + I_2$ ✓

1

(b) 10 V ✓

1

(c) I_2 = (12 – 10) / 10 ✓

Allow ce for 10 V

1

= 0.2 A ✓

The first mark is for the pd

The second is for the final answer

1

(d) pd across R_2 increases

As R_1 increases, pd across R_1 increases as pd = $I_1 R_1$ ✓

First mark is for identifying that pd across R_1 increases (from zero).

1

pd across R_3 = 10 V – pd across R_1

Therefore pd across R_3 decreases ✓

Second mark is for identifying that pd across R_3 must decrease

1

pd across R_2 = 12 – pd across R_3

Therefore pd across R_2 increases ✓

Third mark is for identifying that this means pd across R2 must increase

1

[7]

Solutions for 10 minutes on:
(FULL WORKED SOLUTIONS ON TEAMS)

39 Circuit Basics	40 I-V Graphs	41 Resistivity
Q1. B	**Q1.** C	**Q1.** C
Q2. C	**Q2.** C	**Q2.** B
Q3. B	**Q3.** A	**Q3.** B
Q4. C	**Q4.** A	**Q4.** D
Q5. B	**Q5.** B	**Q5.** B
Q6. C	**Q6.** B	**Q6.** A
Q7. C	**Q7.** C	**Q7.** B
42 Resistance and Temperature	**43 Resistors in Series and Parallel**	**44 Series and Parallel Circuits**
Q1. C	**Q1.** C	**Q1.** D
Q2. C	**Q2.** B	**Q2.** D
Q3 B	**Q3.** A	**Q3.** D
Q4. C	**Q4.** B	**Q4.** B
Q5. A	**Q5.** D	**Q5.** A
Q6 B	**Q6.** B	**Q6.** B
Q7. A	**Q7.** B	**Q7.** D
45 Potential Dividers Basics	**46 Sensing Circuits**	**47 EMF and Internal Resistance**
Q1. B	**Q1.** D	**Q1.** D
Q2. A	**Q2.** B	**Q2.** D
Q3. A	**Q3.** D	**Q3.** A
Q4. D	**Q4.** D	**Q4.** D
Q5. C	**Q5.** A	**Q5.** C
Q6. B	**Q6.** B	**Q6.** B
Q7. B	**Q7.** D	**Q7.** C
48 Cells in Series and Parallel	**49 Electrical Energy**	**50 Electrical Power**
Q1. B	**Q1.** C	**Q1.** D
Q2. A	**Q2.** C	**Q2.** C
Q3. D	**Q3.** B	**Q3.** D
Q4. A	**Q4.** C	**Q4.** B
Q5. A	**Q5.** B	**Q5.** B
Q6. C	**Q6.** B	**Q6.** D
Q7. A	**Q7.** D	**Q7.** B

(FULL WORKED SOLUTIONS ON TEAMS)

Part 2: Strongly recommended work

Task 4 **(2 hrs + corrections and improvements)**

Following feedback on the progression exam, choose two or three areas to develop.

For each area consider the following.

WHAT: Improve your **exam technique**
HOW: Testing yourself with exam questions then correcting / improving your work
RESOURCES: Past Papers, 1234 questions, textbook questions, PhysicsAndMathsTutor, SaveMyExams, A-level physics online, TOPT, StudyMind, Isaac Physics, completing outstanding booklet questions etc

WHAT: Review the content & create **revision resources**
HOW: by using different sources to create condensed notes, flash cards, mind maps, summarising key definitions, annotated key diagrams / graphs etc.
RESOURCES: Notes, textbooks, SaveMyExams (topic qns & notes), videos, complete A3 placemats

WHAT: Improve your **retrieval**
HOW: Practice recall frequently.
RESOURCES: Try a mind dump on a topic, practice flash cards, or try to explain to topic out loud or to a friend, Quizlet, Seneca, Carousel learning, PMT flashcards etc.

Task 5 **(3 hrs + corrections and improvements)**

Complete AS past papers from 2020 (link)

- 2020 7407/1 question paper
- 2020 7407/2 question paper

then **correct** and **improve** your answers with the mark schemes. (click on QR code and follow individual links to find papers and mark schemes)