Pearson Edexcel

Additional Assessment Materials

Summer 2021

# Pearson Edexcel GCE AS Physics

## Topic 3: Electric Circuits

## Test 1

(Public release version)

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Additional Assessment Materials, Summer 2021

## General guidance to Additional Assessment Materials for use in 2021

### Context

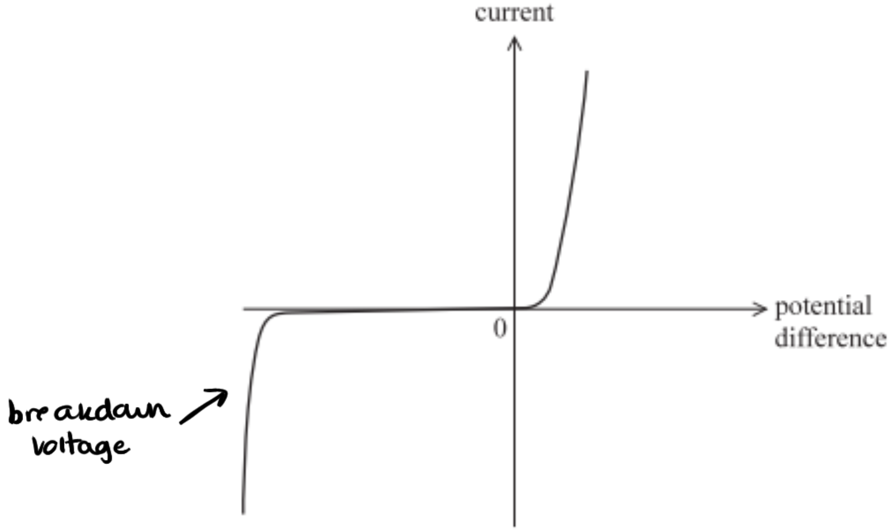
- Additional Assessment Materials are being produced for GCSE, AS and A levels (with the exception of Art and Design).
- The Additional Assessment Materials presented in this booklet are an **optional** part of the range of evidence teachers may use when deciding on a candidate's grade.
- 2021 Additional Assessment Materials have been drawn from previous examination materials, namely past papers.
- Additional Assessment Materials have come from past papers both published (those materials available publicly) and unpublished (those currently under padlock to our centres) presented in a different format to allow teachers to adapt them for use with candidate.

### Purpose

- The purpose of this resource to provide qualification-specific sets/groups of questions covering the knowledge, skills and understanding relevant to this Pearson qualification.
- This document should be used in conjunction with the mapping guidance which will map content and/or skills covered within each set of questions.
- These materials are only intended to support the summer 2021 series.

1

**9** The graph shows how current varies with potential difference for a component in a circuit.




Explain how the graph shows what the component is.

(3)

→ This graph shows a diode because the graph shows that the current can only flow in one direction (when pd is +ve, the diode shown is forward biased).

→ Another feature that the graph shows is that diodes tend to increase in current, dramatically, slightly right of the y-axis (normally at 0.6V). This is because at V<0.6, the diode has an extremely high resistance.

The graph also shows that there is no current for a lot of the -ve pd. This is because diodes, in theory, have infinity amount of resistance in the opposite direction.

However, at large -ve pd, there is a 'breakdown voltage' where the diode changes behaviour → shown on the graph also.

**(Total for Question 9 = 3 marks)**

2

(b) A filament bulb contains a tungsten filament of diameter $3.8 \times 10^{-5}$ m and uncoiled length 1.6 m. As the temperature of the filament increases, the resistance of the filament increases to a maximum which is 14 times greater than the initial resistance at room temperature.

(i) Determine the power of the filament at maximum brightness.

p.d. across filament = 240 V
resistivity of tungsten at room temperature = $5.6 \times 10^{-8}\ \Omega$m

(5)

$\rightarrow \frac{\rho L}{A} = R = \frac{5.6 \times 10^{-8} \times 1.6}{\left(\frac{3.8 \times 10^{-5}}{2}\right)^2 \pi} = 79.0043374\ \Omega$ (resistance at room temp)

$A = \pi r^2$

$\rightarrow 79.00\ldots \times 14 = 1106.060724\ \Omega$ (max resistance)

$\rightarrow P = \frac{V^2}{R} = \frac{240^2}{1106.06\ldots} = 52.07670679$

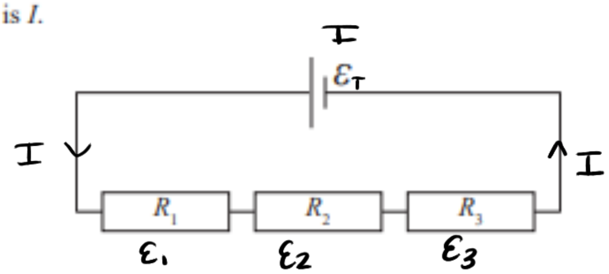
$= 52$ W (2sf)

Power = 52 W (2sf)

3

9 (a) Three resistors, of resistance $R_1$, $R_2$ and $R_3$, are connected in series across a cell. The cell has electromotive force (e.m.f.) $\mathcal{E}$ with negligible internal resistance. The current through the cell is $I$.

| | Voltage | Current |
|---|---|---|
| Series | Split | Same |
| Parallel | Same | Split |




Derive the formula for the total resistance $R_T$ of the circuit in terms of $R_1$, $R_2$ and $R_3$.

(3)

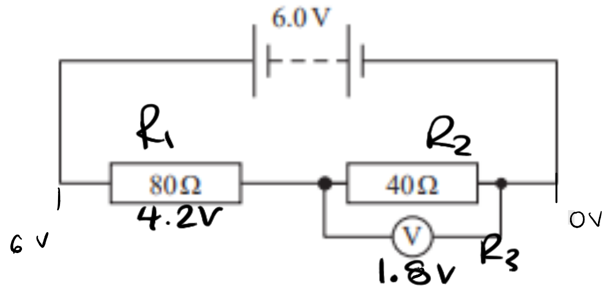
$\frac{\mathcal{E}_T}{I} = \frac{\mathcal{E}_1}{I} + \frac{\mathcal{E}_2}{I} + \frac{\mathcal{E}_3}{I}$

(Voltage splits)
(Currents stays constant)

$R_T = R_1 + R_2 + R_3$

$R = \frac{V}{I}$

(b) The circuit diagram shows two resistors in series across a battery of e.m.f. 6.0 V and negligible internal resistance. A voltmeter with low resistance is connected across the 40 Ω resistor.




The reading on the voltmeter is 1.8 V.

Calculate the resistance of the voltmeter.

(3)

$6.0 - 1.8 = 4.2V$

$\frac{V}{R} = I \Rightarrow \frac{4.2}{80} = 0.0525A$

$\frac{V_T}{I_T} = R_T \Rightarrow \frac{6.0}{0.0525} = \frac{800}{7} \Omega$

$R_T = R_1 + \left(\frac{1}{R_2} + \frac{1}{R_3}\right)^{-1}$

$\frac{1}{\frac{800}{7} - 80} = \frac{1}{40} + \frac{1}{R_3}$

$\left(\frac{1}{\frac{800}{7} - 80} - \frac{1}{40}\right)^{-1} = R_3$

$R_3 = 240 \Omega$

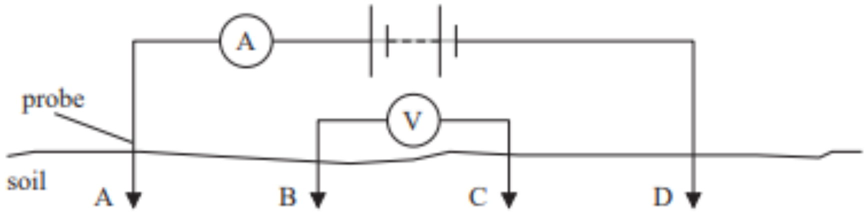
Resistance of voltmeter = 240 Ω

**(Total for Question 9 = 6 marks)**

4

**13** Archaeologists use resistivity surveying of soil to search for the remains of buildings and settlements under the ground.

A basic arrangement that can be used to determine the resistivity of a region of soil is shown.




Probes are placed at positions A and D so that the length AD of soil forms part of the circuit. The ammeter measures the current through the soil.

A second pair of probes connected to a voltmeter is placed at positions B and C. This measures the potential difference between positions B and C in the soil.

(a) Explain how the reading on the voltmeter will change if the length BC increases.

(2)

$L = \frac{RA}{\rho}$ $\quad\quad$ $R = \frac{V}{I}$

$\therefore \; L = \frac{VA}{\rho I}$

$\therefore \; L \propto V$ (if $A, \rho, I$ is constant)

The longer the length, the larger the voltage (or vice versa)

(b) The table gives the resistivity of some different materials.

| Material | Resistivity / $\Omega$ m |
|---|---|
| Undisturbed clay | 4–20 |
| Compacted clay | 100–200 |
| Limestone | 500–1000 |
| Sandstone | 1500–10 000 |

The probes connected to the voltmeter are kept at a constant separation of 0.75 m and are moved along the soil between positions A and D.

The current is constant at 9.5 mA. The voltmeter reading varies between 1.8 V and 8.0 V.

It can be assumed that the sample of soil under investigation has a cross-sectional area of 0.65 m².

Deduce two possible materials that could be present in the soil between positions A and D.

(4)

$\rho = \frac{RA}{L} = \rho = \frac{VA}{LI}$ (as $R = \frac{V}{I}$)

when $V = 1.8$v:

$\rho = \frac{1.8 \times 0.65}{0.75 \times 9.5 \times 10^{-3}} = 164.2105263\ \Omega m$

∴ can be Compacted Clay (100–200 Ωm)

when $V = 8.0$v:

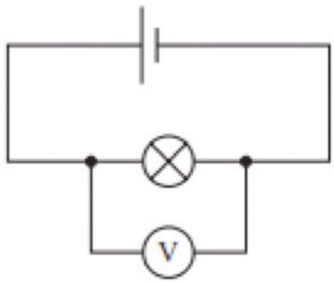
$\rho = \frac{8.0 \times 0.65}{0.75 \times 9.5 \times 10^{-3}} = 729.8245614$

∴ can be Limestone (500–1000 Ωm)

**(Total for Question 13 = 6 marks)**

**9** A torch uses a 1.5 V dry cell. Over time, the light intensity produced by the torch decreases as the cell 'goes flat'.

(a) Student A sets up the following circuit in an attempt to measure the e.m.f. of a cell.

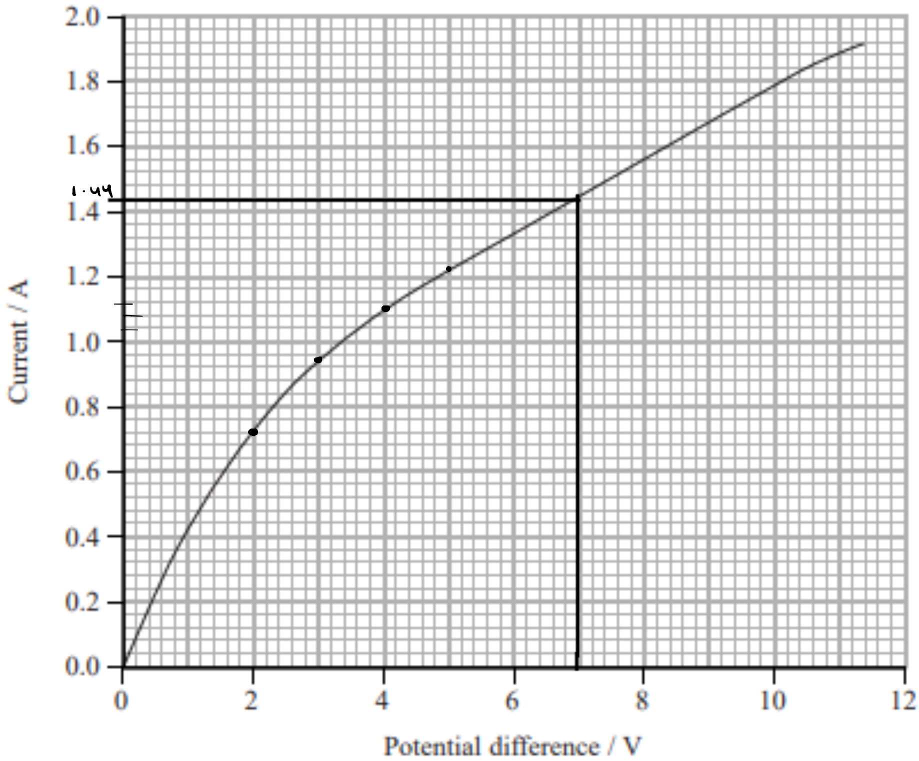



Explain why the voltmeter reading will **not** be the e.m.f. of the cell.

(2)

As there is internal resistance in the bulb
∴ there will lost volts.
Emf = (Voltmeter reading) − (lost volts)

14 The graph shows how the current through a filament bulb varies with the potential difference across the bulb.




(a) Determine the resistance of the filament bulb when the potential difference is 7.0 V.

(2)

$V = IR$

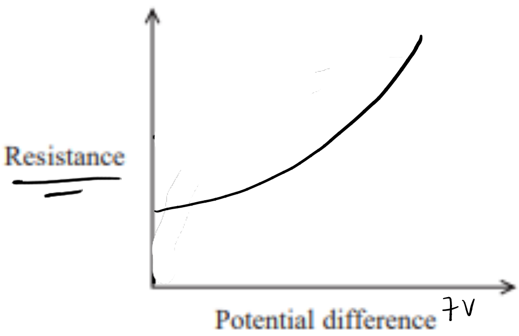
$R = \frac{V}{I} = \frac{7.0}{1.44} = 4.86\dot{1}$

$= 4.9\,\Omega$ (2sf)

Resistance = $4.9\,\Omega$

(b) Sketch a graph of resistance against potential difference for the filament bulb over the range 0 V to 7 V.

(3)




*(c) Explain the variation of resistance with potential difference for the filament bulb in terms of particle behaviour.

(6)

As potential difference increases the curent increases ($V = \frac{I}{R}$, $V \propto I$), this means that atoms in the filament bulb vibrate faster due to the electrons moving. This vibration in the filament bulb makes it heat up, therefore temperature increases. This increase in temperature means it is harder for the electrons to move due to the movement of the atoms. Therefore resistance in the filament bulb goes up.

(Total for Question 14 = 11 marks)

7

**16** In 2010, Andre Geim and Konstantin Novoselov were awarded the Nobel Prize in Physics for producing, identifying and studying graphene.

Graphene is a form of carbon which exists only as a single atomic layer of graphite. It has a breaking stress of 130 GPa compared to 0.5 GPa for steel. Some scientists claim that graphene is the strongest material ever measured.

(a) Explain why graphene, despite its greater strength, is unlikely to replace steel in many applications.

(2)

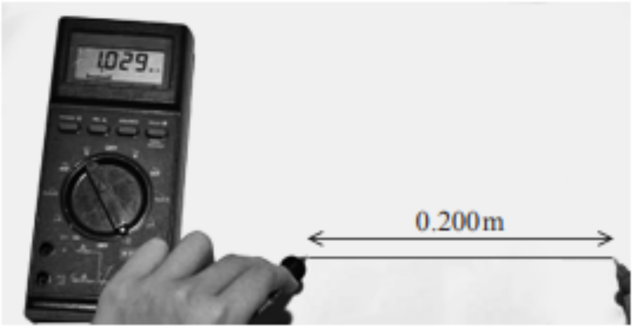
It is only 1 atomic layer thick and ∴ when added to other layers of graphene there is only weak forces (van der waals forces) holding the layers together. Therefore, they are weaker than steel. Graphene, by itself, is too thin for any use.

* Van der Waals forces are easily broken.

(b) Graphite used in pencils consists of many layers of carbon. It can be assumed that a pencil deposits approximately 100 layers of carbon atoms when drawn across a piece of paper.

A student carried out an experiment to determine the resistivity of the graphite in a pencil.

A line of length 0.200 m and width 0.50 mm was drawn on a piece of paper. An ohmmeter was then used to measure the resistance of the graphite line.




Calculate the resistivity of graphite.

resistance = $1.029 \times 10^6\ \Omega$
diameter of carbon atom = $1.4 \times 10^{-10}$ m

(4)

$$\rho = \frac{RA}{L} = \frac{1.029 \times 10^6 \times \left(\frac{1.4 \times 10^{-10}}{2}\right)^2 \pi \times 100}{0.2}$$

$$= 7.92011259 \times 10^{-10}$$

$$= 7.9 \times 10^{-10} \quad (2sf)$$

Resistivity of graphite = $7.9 \times 10^{-10}\ \Omega m$

(c) Photocells traditionally use silicon to generate electricity using visible light. Research demonstrates that unlike silicon, graphene is able to respond at all wavelengths and releases multiple electrons as it absorbs one photon.

Deduce why it would be an advantage to use graphene in photocells to generate electricity.

(3)

Electricity is the flow of $e^-$.
Graphene releases multiple electrons as it absorbs a photon ∴ the graphene will generate a higher current (as the rate of charge is larger (more $e^-$ released)).
Meanwhile silicon releases less $e^-$, producing a weaker current ∴ less electricity.
It is also good that graphene responds to all $\lambda$ as visible light has a range of $\lambda$ ∴ it is more efficient.

(Total for Question 16 = 9 marks)

**TOTAL FOR PAPER IS 42 MARKS**