

**Friday 20 January 2012 – Morning**

**AS GCE PHYSICS A**

**G482** Electrons, Waves and Photons

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| --- |
| \* G 4 1 1 5 8 0 1 1 2 \* |



Candidates answer on the Question Paper.

**OCR supplied materials:**

* Data, Formulae and Relationships Booklet (sent with general stationery)

**Other materials required:**

* Electronic calculator



**Duration:** 1 hour 45 minutes

\* G 4 8 2 \*

**INSTRUCTIONS TO CANDIDATES**

* Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
* Use black ink. HB pencil may be used for graphs and diagrams only.
* Answer **all** the questions.
* Read each question carefully. Make sure you know what you have to do before starting your answer.
* Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
* Do **not** write in the bar codes.

**INFORMATION FOR CANDIDATES**

* The number of marks is given in brackets **[ ]** at the end of each question or part question.
* The total number of marks for this paper is **100**.
* You may use an electronic calculator.
* You are advised to show all the steps in any calculations.



• Where you see this icon you will be awarded marks for the quality of written

communication in your answer.

This means for example you should:

* + ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
	+ organise information clearly and coherently, using specialist vocabulary when appropriate.
* This document consists of **20** pages. Any blank pages are indicated.

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**2**

Answer **all** the questions.

1. This question is about the rigid copper bars which carry the very large currents generated in a power station to the transformers. Fig. 1.1 shows such a copper bar.

bar



cross-sectional area *A*

**Fig. 1.1**

1. Write down a suitable word equation to define the *resistivity* of a material.

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............................................................................................................................................. **[1]**

1. **(i)** The cross-sectional area*A*of the bar is 6.4 × 10–3m2. Calculate the resistance of a 1.0 mlength of the bar. The resistivity of copper is 1.7 × 10–8 Ω m.

resistance = ...................................................... Ω **[2]**

**(ii)** The bar carries a constant current of 8000 A. Calculate the power dissipated as heat along a 1.0 m length of it.

power = ..................................................... W **[3]**

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**3**

1. The bar is 9.0 m long. Estimate the total energy in kW h lost from the bar in one day.

energy = ................................................ kW h **[2]**

1. Calculate the cost per day of operating the copper bar. The cost of 1kW h is 15p.

cost = ...................................................... p **[1]**

**(c)** Calculate the mean drift velocity *v* of the free electrons in the copper bar. The number of free electrons per unit volume in copper is 8.4 × 1028 m–3.

*v* = ............................................... m s–1**[3]**

**[Total: 12]**

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**2** **(a)** Fig. 2.1 shows combinations of resistors connected to a power supply of e.m.f.*E*.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | *E* |  |  |  |  |  |  | *E* |  |
|  |  |  |  |  |  |  |
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|  | 120 Ω |  |  | 240 Ω |  |  |  | 10 Ω |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  | 20 Ω |  |
|  |  |  |  |  |  |  |  |
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|  |  |  |  |  |  |  |  |  | 40 Ω |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **Fig. 2.1a** |  |  | **Fig. 2.1b** |  |



1. For the circuit of Fig. 2.1a

**1** calculate the total resistance *R*s

|  |  |  |
| --- | --- | --- |
|  | *R*s= ...................................................... | Ω **[1]** |
| **2** | state one electrical quantity which is the same for both resistors. |  |
|  | .............................................................................................................................. | **[1]** |
| **(ii)** For the circuit of Fig. 2.1b |  |
| **1** | calculate the total resistance *R*p |  |

*R*p= ......................................................Ω**[2]**

**2** state one electrical quantity which is the same for all the resistors.

.............................................................................................................................. **[1]**

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**6**

**(b)** Fig. 2.2 shows the *I* *–V* characteristics of two electrical components, a resistor, line **R** and a thermistor, line **T**.

0.6



0.4

*I* / A

**R**

0.2

**T**

0

0 1.0 2.0 3.0 4.0 5.0

*V* / V

**Fig. 2.2**

1. State Ohm’s law. Use Fig. 2.2 to explain why component **R** obeys Ohm’s law.

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1. The resistor and the thermistor can be connected to a variable voltage supply of negligible internal resistance in two ways as shown in Fig. 2.3a and Fig. 2.3b.

|  |  |
| --- | --- |
| *E* | *E* |
| 0.60 A |  |
|  | 0.60 A |
|  | **R** |
| **R** | **T** |
|  | **T** |
| **Fig. 2.3a** | **Fig. 2.3b** |



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The voltage of the supply is varied in each circuit until the current drawn from it is 0.60 A. Use data from Fig. 2.2 to explain why the e.m.f. *E* of the supply is

1. 9.0 V in Fig. 2.3a

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.............................................................................................................................. **[2]**

1. 3.0 V in Fig. 2.3b.

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1. The thermistor is now connected on its own across the terminals of the supply set at 4.5 V. Fig. 2.4 shows the variation of current *I* with time *t* from the moment the thermistor is connected to the supply.

0.8



0.6

*I* / A

0.4

0.2

0

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 0 | 1.0 | 2.0 | 3.0 | 4.0 |
|  |  |  |  | *t* / s |

**Fig. 2.4**

Explain the shape of the graph in Fig. 2.4.

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**[Total: 15]**

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**8**

1. A cell is a source of e.m.f. When the cell is connected into a circuit the potential difference measured between its terminals, called the *terminal p.d.*, is less than its e.m.f.
	1. **(i)** Define the term*e.m.f.*

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..................................................................................................................................... **[2]**

1. Explain why the terminal p.d. is less than the e.m.f.

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..................................................................................................................................... **[2]**

1. In the circuit of Fig. 3.1 the cell of e.m.f. 1.6 V and internal resistance *r* is delivering a current of 0.20 A to a resistor of resistance *R.* The voltmeter reads the terminal p.d. It is 1.2 V.
	* 1. A
	1. V



*R* V

*r*

**Fig. 3.1**

Calculate the values of

1. the resistance *R*

*R* = ......................................................Ω**[2]**

1. the internal resistance *r*.

*r* = ......................................................Ω**[2]**

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**(c) (i)** The current in the resistor of Fig. 3.1 remains constant at 0.20 A for several hours.Calculate

**1** the charge which passes through the resistor in 1.5 hours

charge = .................................... unit .............. **[3]**

**2** the energy dissipated by the resistor in 1.5 hours.

energy = ...................................................... J **[2]**

1. The cell is left connected to the resistor for 12 hours. The graph of Fig. 3.2 shows the variation of current *I* with time *t*.

0.25



0.20

*I* / A

0.15

0.10

0.05

0

0 2 4 6 8 10 12 time / hours

**Fig. 3.2**

Describe how the current varies with time. Suggest reasons why it varies in this way.



*In your answer you should link each feature of the graph to the reason for it.*

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**11**

1. **(a)** Explain what is meant by a*progressive wave*.

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1. Describe how a *transverse* wave differs from a *longitudinal* wave.

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*.............................................................................................................................................* **[2]**

**(c)** **(i)** Explain what is meant by*diffraction*of a wave.

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*.....................................................................................................................................* **[1]**

1. Describe how you would demonstrate that a sound wave of wavelength 0.10 m emitted from a loudspeaker can be diffracted.

*In your answer you should make clear how your observations show that diffraction is occurring.*



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**12**

1. Fig. 4.1 shows two loudspeakers connected to a signal generator, set to a frequency of 1.2 kHz. A person walks in the direction **P** to **Q** at a distance of 3.0 m from the loudspeakers.

|  |  |  |
| --- | --- | --- |
| loudspeakers | **Q** |  |
|  |  |



 3.0 m  **P**

**Fig. 4.1**

1. Calculate the wavelength *λ* of the sound waves emitted from the loudspeakers. speed of sound in air = 340 m s–1

*λ* = ..................................................... m **[2]**

1. Explain, either in terms of path difference or phase difference, why the intensity of the sound heard varies as the person moves along **PQ**.

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**(iii)** The distance *x* between adjacent positions of maximum sound is 0.50 m. Calculate the separation *a* between the loudspeakers. Assume that the equation used for the interference of light also applies to sound.

*a* = ..................................................... m**[2]**

1. The connections to one of the loudspeakers are reversed. Describe the similarities and differences in what the person hears.

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**[Total: 18]**

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**14**

1. Fig. 5.1 shows a uniform string which is kept under tension between a clamp and a pulley. The frequency of the mechanical oscillator close to one end is varied so that a stationary wave is set up on the string.

|  |  |  |
| --- | --- | --- |
|  | 0.45 m |  |
| **X** | **Z** |  |
| clamp | pulley |  |
|  | **Y** |  |
| oscillator | masses |  |
|  |  |



**Fig. 5.1**

1. State two features of a stationary wave.

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1. Explain how the stationary wave is formed on the string.

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**(c)** The distance between the clamp and the pulley is 0.45 m. **X**, **Y** and **Z** are three points on the string. **X** and **Y** are each 0.040 m from the nearest node and **Z** is 0.090 m from the pulley. State, giving a reason for your choice, which of the points **Y** or **Z** or both oscillate

1. with the same amplitude as **X**

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**15**

1. with the same frequency as **X**

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1. in phase with **X**.

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**[Total: 10]**

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**16**

1. **(a)** X-rays and radio waves are two examples of electromagnetic waves.
	1. Name **two** other examples of electromagnetic waves.

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..................................................................................................................................... **[1]**

1. State **one** similarity and **one** difference between X-rays and radio waves.

similarity ............................................................................................................................

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difference ...........................................................................................................................

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..................................................................................................................................... **[2]**

1. Explain why X-rays are easily diffracted by layers of atoms, about 2 × 10–10 m apart, but radio waves are not.

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1. On the Earth, we are all exposed to ultraviolet radiation coming from the Sun. State **one** advantage and **one** disadvantage of UV-B radiation.

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**(c)** **(i)** Circle a typical value for the wavelength of an X-ray from the list below.

2 × 10–4 m 2 × 10–7 m 2 × 10–10 m 2 × 10–13 m **[1]**

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**17**

1. Use your answer to **(i)** to determine how many X-ray photons must be collected to produce an energy of 1.0 × 10–6 J.

number of photons = ......................................................... **[4]**

1. A plane polarised radio wave is transmitted from a vertical aerial to a nearby receiving aerial as shown in Fig. 6.1.

transmitting aerial



receiving aerial



**P**



**Q**

**Fig. 6.1**

A diode, resistor and ammeter are connected in series across the terminals **P** and **Q**.

1. Draw the circuit between terminals **P** and **Q** on Fig. 6.1 in the space to the right of **PQ**.

**[2]**

1. The entire receiving aerial is rotated slowly through 180° in the direction shown by the arrow. Explain clearly what will be observed on the ammeter and how the detected signal varies.

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**[Total: 17]**

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**Turn over**

**18**

1. **(a)** State **one** experiment for each case which provides evidence that electromagnetic radiationcan behave like
	1. a stream of particles, called *photons*

..................................................................................................................................... **[1]**

1. waves.

..................................................................................................................................... **[1]**

1. A beam of ultraviolet light is incident on a clean metal surface. The graph of Fig. 7.1 shows how the maximum kinetic energy *KE*max of the electrons ejected from the surface varies with the frequency *f* of the incident light.



40

*KE*max/ 10–20J

20

0

0 5 10 15

*f* / 1014Hz

**Fig. 7.1**

1. Define the work function *φ* of the metal.

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1. Write down the relationship between *KE*max and *f*. Use it to explain why the *y*-intercept of the graph in Fig. 7.1 is equal to the work function of the metal and the gradient of the line is equal to the Planck constant.

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1. Use data from Fig. 7.1 to find a value of

**1** the Planck constant

|  |  |  |
| --- | --- | --- |
|  | Planck constant = .................................................... | J s **[2]** |
| **2** | the threshold frequency of the metal |  |

threshold frequency = .................................................... Hz **[1]**

**3** the work function of the metal.

work function = ...................................................... J **[2]**

**[Total: 11]**

**END OF QUESTION PAPER**

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