Surname	Centre Number	Candidate Number
Other Names		2

GCE A LEVEL

A420U20-1

S18-A420U20-1

PHYSICS – A level component 2
Electricity and the Universe

FRIDAY, 8 JUNE 2018 – MORNING

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**7**	
2.	**14**	
3.	**20**	
4.	**13**	
5.	**6**	
6.	**12**	
7.	**16**	
8.	**12**	
Total	**100**	

A420U201
01

ADDITIONAL MATERIALS

In addition to this examination paper, you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.
Write your answers in the spaces provided in this booklet.
Write your name, centre number and candidate number in the spaces at the top of this page.
Answer **all** questions.

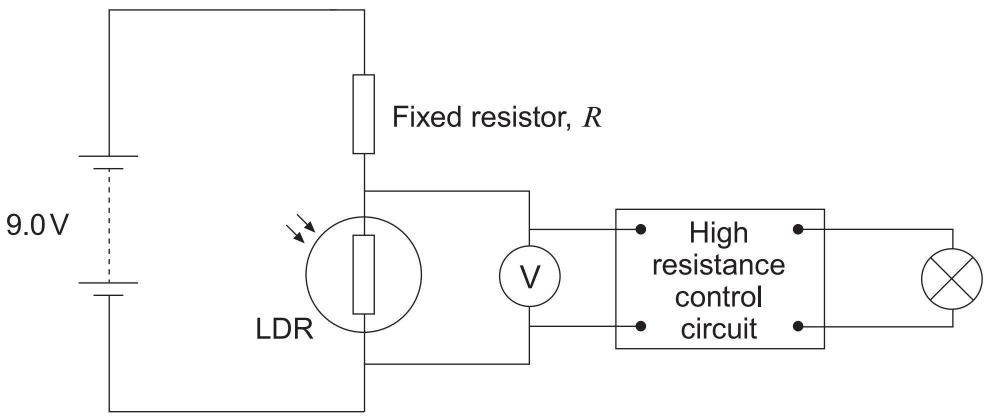
INFORMATION FOR CANDIDATES

The total number of marks is given in brackets at the end of each question or part-question.
The assessment of the quality of extended response (QER) will take place in **Q5**.

Examiner only

Answer **all** *questions.*

1. *(a)* An engineer investigates the use of a light dependent resistor (LDR) as a light sensor in a potential divider circuit. He designs the following sensing circuit to operate a 230 V lamp in the dark.



The control circuit draws a negligible current. During his research, the engineer determines the following facts:

The control circuit requires at least 4.0 V to activate.
The LDR the engineer intends to use has a resistance of 2.4 kΩ at the light intensity required to switch the lamp on.

(i) Explain how the current in the LDR changes as the light intensity decreases. [2]

....

....

....

(ii) Determine a suitable value for the fixed resistor R, which would allow the lamp to be switched on. [3]

....

....

....

....

....

Examiner only

(b) When installing the circuit, the engineer made the mistake of placing the lamp near to the LDR. The engineer noted that, when in the dark, the lamp kept turning on and off repeatedly rather than staying on. Explain why this was the case. [2]

....

....

....

....

....

7

A420U201 03

Examiner only

2. *(a)* (i) State what is meant by *electric current*. [1]

....

(ii) Show that the unit of resistance, the ohm (Ω), can be expressed as: [2]

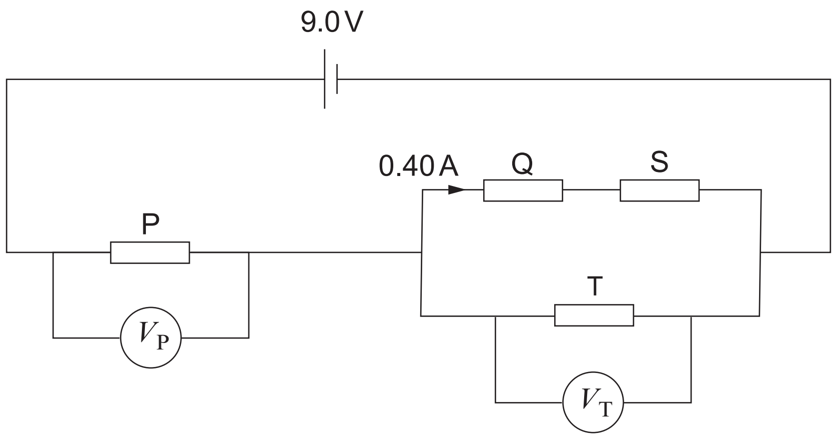
$$\mathrm{J\,s\,C^{-2}}$$

....

....

....

(b) The following circuit shows an arrangement of **identical resistors** labelled P, Q, S and T connected to a fixed pd of 9.0 V. V_P and V_T are the pds across P and T respectively. There is a current of 0.40 A in Q and S.



(i) Show that $V_P = 1.5\ V_T$. [2]

....

....

....

(ii) Hence or otherwise show that the values given in the diagram are consistent with the resistance of each resistor being 4.5 Ω. [3]

....

....

....

....

....

Examiner only

(c) Show that the total energy dissipated per second in the whole circuit is 15 times more than the energy dissipated per second in resistor Q. [3]

....

....

....

....

....

(d) Resistor T is now removed from the circuit. Explain the effect this will have on the ratio calculated in part *(c)*. [3]

....

....

....

....

....

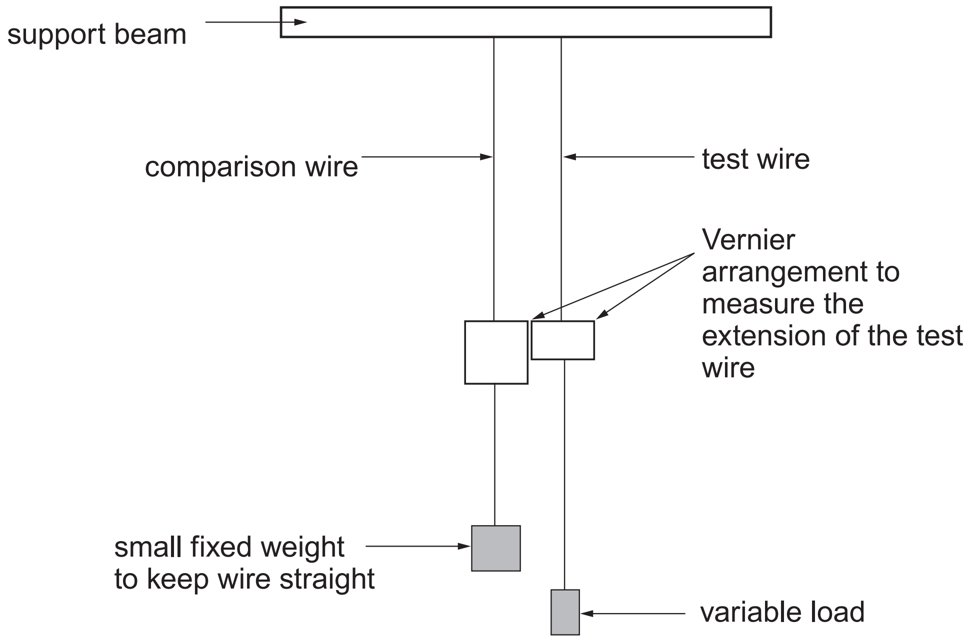
A420U201 05

14

BLANK PAGE

Examiner only

3. Kiera uses the following apparatus to find the Young modulus of a metal alloy in the form of a wire.



(a) Explain how the choice of a suitable comparison wire minimises the effect of a change in temperature. [2]

.....

.....

.....

(b) Kiera uses a micrometer of resolution 0.01 mm to measure the mean diameter of the wire. She determines the mean diameter to be 0.16 mm. Calculate the cross-sectional area of the wire **in m^2**, along with its **percentage uncertainty**. [3]

.....

.....

.....

.....

(c) Kiera then uses a metre ruler with a resolution of 1 mm to measure the initial length of the wire. She determines the length to be 1.680 m. Show, with an appropriate calculation, that the percentage uncertainty in this reading can be considered negligible. [2]

.....

.....

.....

A420U201 07

(d) Kiera adds various masses to the test wire and measures the extension. The table shows the extension of the wire for increasing load.

Load (negligible absolute uncertainty) / N	Mean extension / mm	Absolute uncertainty in extension / mm
1.96	1.4	± 0.2
3.92	2.7	± 0.2
5.89	4.1	± 0.2
7.85	5.5	± 0.2
9.81	6.8	± 0.2

Kiera plots a graph (shown opposite) of load against extension from her data, but does not include error bars.

(i) I. **Add error bars** for the extension on the plotted points. [1]

II. Draw lines of maximum gradient and minimum gradient and determine the gradients of both lines. [3]

....

....

....

....

(ii) Hence, calculate the mean gradient and the **percentage** uncertainty in its value. [2]

....

....

....

....

(e) Determine the Young modulus of the metal alloy, along with its **absolute** uncertainty. Give your answer to an appropriate number of significant figures. [5]

....

....

....

....

....

....

....

....

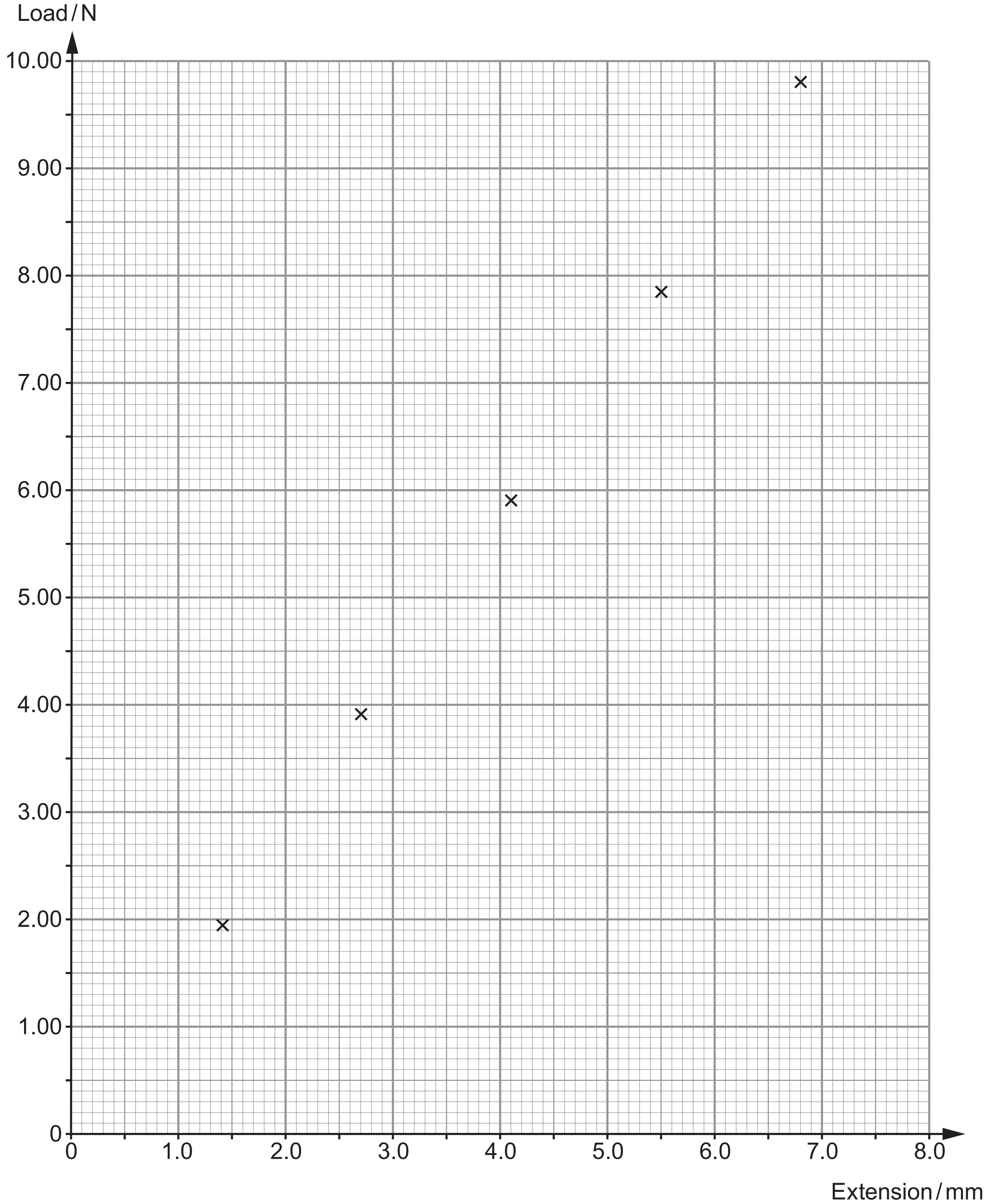
Examiner only

(f) State which of the measurements contributes most to the overall uncertainty in your answer and suggest **one** change Kiera could make to her experiment which would reduce the size of this uncertainty. [2]

....

....

....



A420U201 09

20

Examiner only

4. *(a)* (i) Use the Principle of Conservation of Energy to show that the critical density, ρ_c, of the universe is given by: [4]

$$\rho_c = \frac{3H_0^2}{8\pi G}$$

....

....

....

....

....

....

....

....

....

....

(ii) Use the above equation to show that the critical density of the universe corresponds to approximately 5 atoms of hydrogen per m^3. [2]

....

....

....

....

....

Examiner only

(b) Astronomers analysing the wavelengths of the dark lines from the line spectrum of a distant galaxy note that they are increased by 16 % compared with their normal wavelengths.

(i) State why there is an increase in wavelength. [1]

....

....

(ii) Calculate the distance of the galaxy from Earth. [3]

....

....

....

....

....

(c) Stating an assumption, estimate the age of the universe in years. [3]

....

....

....

....

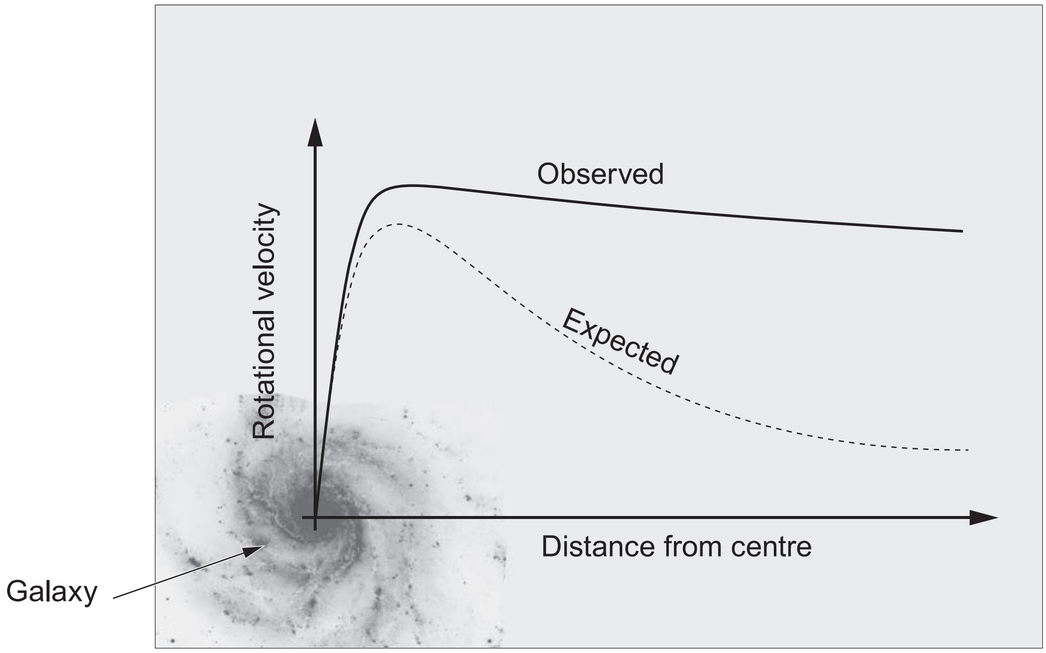
....

....

13

Examiner only

5. The diagram shows the key features of the rotation curves for a distant spiral galaxy. Explain how these features relate to the structure and motion of the galaxy. [6 QER]



6

BLANK PAGE

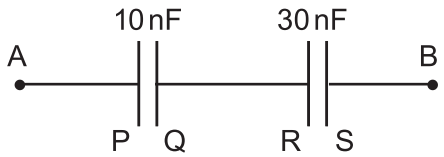
Examiner only

6. *(a)* Define the *capacitance* of a capacitor. [1]

....

....

(b) Two capacitors, initially uncharged, are arranged in series as shown. When a battery is connected across A and B, the charge on plate P is found to be +75 nC.



(i) Write down the charges on each of the plates Q, R and S. Give a reason for your answer to the charge on plate S. [3]

Charge on Q: ....

Charge on R: ....

Charge on S: ....

Reason:

....

....

....

(ii) Calculate the pd across A and B. [2]

....

....

....

....

Examiner only

(iii) A Physics student makes the following comment:

For capacitors in series, a capacitor of higher capacitance stores more energy than a capacitor of smaller capacitance.

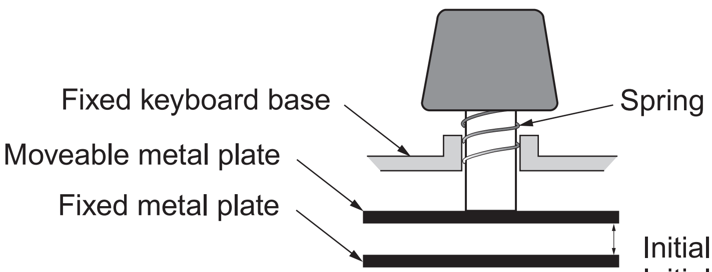
By considering this combination of capacitors, investigate whether or not the student is correct. [2]

....

....

....

(c) Some computer keyboards work on the principle of varying capacitance. When a key is pressed, a spring is compressed and the separation of two parallel metal plates is decreased. The computer responds if the increase in capacitance of the plates is 0.20 pF or more.
The diagram shows how a single key is constructed.



Initial separation of plates = 5.2×10^{-3} m
Initial capacitance = 0.27 pF
Plate area = $1.6 \times 10^{-4}\,m^2$

The designers of a keyboard require that the increase in capacitance of 0.20 pF occurs when a force of 0.20 N is exerted on a key. Different springs are available, of spring constant $90\,N\,m^{-1}$, $120\,N\,m^{-1}$ and $150\,N\,m^{-1}$. Determine which (if any) of these springs would be suitable in meeting the designer's requirements. The capacitor is filled with air. [4]

....

....

....

....

....

....

....

....

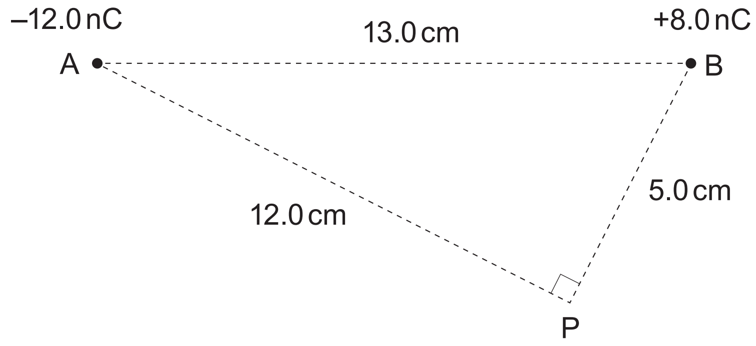
12

Examiner only

7. *(a)* Complete the following table: [3]

Quantity	Definition	Vector or Scalar
Electric field strength, E	....	....
Electric potential, V	....	....

(b) Point charges of –12.0 nC and +8.0 nC are placed at A and B, 13.0 cm apart as shown. P is a point in space which is 12.0 cm from A and 5.0 cm from B.



(i) Draw on the diagram **two** arrows to show the directions of the field strength at P due to each charge. [1]

(ii) Hence draw on the diagram **one** arrow to represent the direction of the resultant field strength at P. **Label this arrow R**. [1]

Examiner only

(iii) Calculate the **magnitude and direction** of the electric field strength at P. [4]

(c) (i) Show that the potential at P is + 540 V. [2]

(ii) Calculate the gain in kinetic energy in joules of an electron as it moves from infinity to P. [2]

(d) Without calculation, explain how the de Broglie wavelength of the electron changes as it moves towards P. [3]

16

Examiner only

8. *(a)* Diagram 1 shows how the intensity of electromagnetic radiation from the Sun varies with distance from its centre. Diagram 2 shows how the intensity of the radiation incident on the Earth from the Sun is distributed across the spectrum.

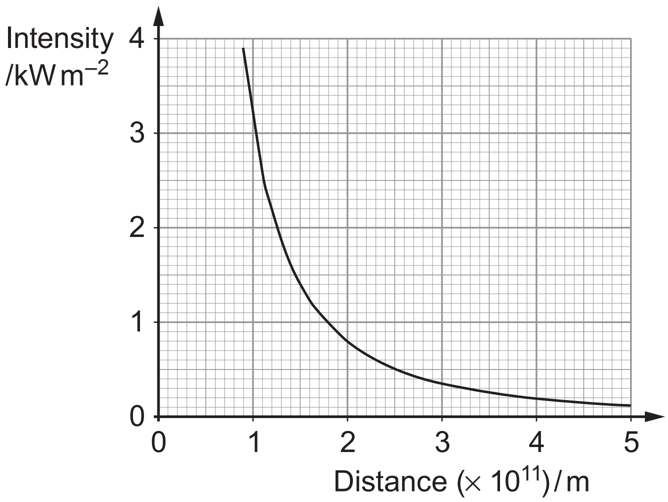


Diagram 1

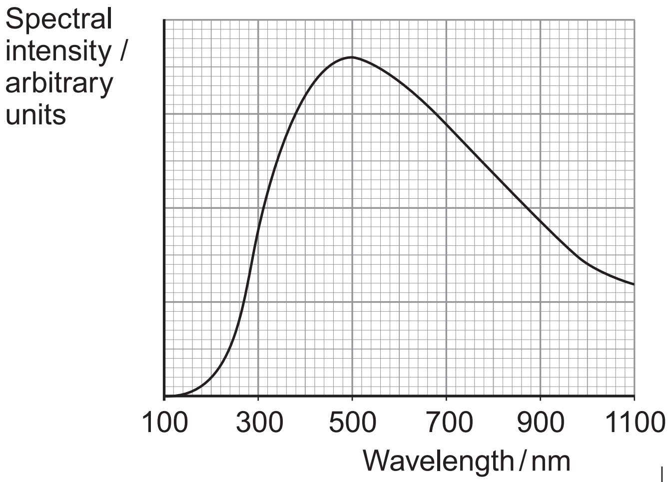


Diagram 2

(i) Confirm that Diagram 1 shows the expected relationship between intensity and distance. [3]

....

....

....

....

....

(ii) Use Diagram 1 to show that the Sun's luminosity is about 4×10^{26} W. [2]

....

....

....

Examiner only

(b) In 2006 scientists from the University of Hawaii used a solar telescope aboard NASA's Solar and Heliospheric Observatory satellite to measure the radius of the Sun with (they quote) "unprecedented accuracy". They measured it to be:

$$R_{\text{sun}} = 696\,342\,\text{km}$$

Use information from Diagram 2 along with your answer to *(a)*(ii) to evaluate whether the information from Diagrams 1 and 2 are consistent with the scientists' findings. [5]

....

....

....

....

....

....

....

....

(c) For centuries scientists have attempted to measure the Sun's diameter accurately. The following article is taken from a scientific paper written in 2004:

The solar diameter, and its possible variation, have been the subject of careful measurements for over 350 years, with ever increasing accuracy. Different techniques have been used, and the instrumentation has evolved in time. However, the long-term evolution of the Sun is still a controversial subject. Even for the short term, the results are inconsistent even with the most advanced instruments presently in use. These discrepancies probably have several origins.

[Past, present and future measurements of the solar diameter: Gerard Thuillier, Sabatino Sofia, Margit Haberreiter November 2004]

Suggest **two** reasons why it has been difficult for scientists to determine an accurate value for the Sun's diameter. [2]

....

....

....

....

12

END OF PAPER