OCR

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Monday 23 June 2014 – Morning

GCSE TWENTY FIRST CENTURY SCIENCE PHYSICS A/FURTHER ADDITIONAL SCIENCE A

A183/02 Module P7 (Higher Tier)

Candidates answer on the Question Paper.
A calculator may be used for this paper.

OCR supplied materials:
None

Other materials required:
- Pencil
- Ruler (cm/mm)

Duration: 1 hour

Candidate forename		Candidate surname	

Centre number						Candidate number				

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 quality of written communication is assessed in questions marked with a pencil (✎).
- A list of useful relationships is printed on pages 2 and 3.
- 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 **60**.
- This document consists of **16** pages. Any blank pages are indicated.

TWENTY FIRST CENTURY SCIENCE EQUATIONS

Useful relationships

The Earth in the Universe

distance = wave speed × time

wave speed = frequency × wavelength

Sustainable energy

energy transferred = power × time

power = voltage × current

$$\text{efficiency} = \frac{\text{energy usefully transferred}}{\text{total energy supplied}} \times 100\%$$

Explaining motion

$$\text{speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

momentum = mass × velocity

change of momentum = resultant force × time for which it acts

work done by a force = force × distance moved in the direction of the force

amount of energy transferred = work done

change in gravitational potential energy = weight × vertical height difference

$$\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times [\text{velocity}]^2$$

Electric circuits

power = voltage × current

$$\text{resistance} = \frac{\text{voltage}}{\text{current}}$$

$$\frac{\text{voltage across primary coil}}{\text{voltage across secondary coil}} = \frac{\text{number of turns in primary coil}}{\text{number of turns in secondary coil}}$$

Radioactive materials

$$\text{energy} = \text{mass} \times [\text{speed of light in a vacuum}]^2$$

Observing the Universe

$$\text{lens power} = \frac{1}{\text{focal length}}$$

$$\text{magnification} = \frac{\text{focal length of objective lens}}{\text{focal length of eyepiece lens}}$$

$$\text{speed of recession} = \text{Hubble constant} \times \text{distance}$$

$$\text{pressure} \times \text{volume} = \text{constant}$$

$$\frac{\text{pressure}}{\text{temperature}} = \text{constant}$$

$$\frac{\text{volume}}{\text{temperature}} = \text{constant}$$

$$\text{energy} = \text{mass} \times [\text{speed of light in a vacuum}]^2$$

Answer **all** the questions.

1 In the late 1700s, the Titius-Bode Law was published.

The law was used for calculating the distance of the planets from the Sun. The distance from the Earth to the Sun is 1AU. This is what the law says:

To find the distance in AU:

- take the sequence of numbers 0, 3, 6, 12, 24, 48, 96, … (each number after the first two is double the previous number)
- add 4 to each number in the sequence
- divide each number by 10 to give the distance.

Titius-Bode distance calculation in AU	Planet	Actual distance from Sun in AU
(0 + 4) / 10 = 0.4	Mercury	0.39
(3 + 4) / 10 = 0.7	Venus	0.72
(6 + 4) / 10 = 1.0	Earth	1.00
(12 + 4) / 10 = 1.6	Mars	1.52
(48 + 4) / 10 = 5.2	Jupiter	5.20
(96 + 4) / 10 = 10	Saturn	9.54

(a) Suggest why the Titius-Bode Law was only applied to the six planets out to Saturn in the first instance.

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.... **[1]**

(b) Bode thought there should be a planet between Mars and Jupiter.

(i) Calculate the distance using the Titius-Bode Law.

distance = ... AU **[2]**

(ii) In 1801, the astronomer Giuseppe Piazzi discovered a new planet, *Ceres*, at a distance of 2.77 AU from the Sun.
Does this support the Titius-Bode Law?
Explain why.

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.... **[1]**

(iii) Giuseppe Piazzi did not make enough observations to describe the orbit of *Ceres*. Other astronomers could not find the planet.

Why is it important that other astronomers observe the new planet?

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.... **[2]**

(c) The table below gives the data for other more recently discovered planets.

Titius-Bode calculation of distance in AU	**Planet**	**Actual distance from Sun in AU**
(192 + 4) / 10 = 19.6	Uranus	19.18
(384 + 4) / 10 = 38.8	Neptune	30.06
(768 + 4) / 10 = 77.2	Pluto	39.44

Discuss how these results affect confidence in the Titius-Bode Law.

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.... **[4]**

(d) Most scientists think the Titius-Bode Law was just an interesting coincidence.
What would be needed to persuade them that the law was not just a correlation?

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.... **[1]**

[Total: 11]

2 One of the most distant objects visible to the naked eye is the Andromeda galaxy.

Edwin Hubble first measured the distance to the Andromeda galaxy using Cepheid variables. He measured the distance as about 1 million light years. Modern measurements using Cepheid variables, give a distance of 2.5 million light years.

Telescopes in space have made it possible to make better measurements of parallax and of the brightness of stars.

Explain:

- how using space telescopes gives better measurements of parallax and brightness
- how this improves measurement of distance to Cepheid variables.

The quality of written communication will be assessed in your answer.

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.... **[6]**

[Total: 6]

3 Measurements of the distance to galaxies give a value of the Hubble constant as 71 km / s per Mpc.

(a) At what distance is a galaxy with a speed of recession of 1800 km / s?

distance = ... units .... **[3]**

(b) Explain why there is a relationship between the distances to far galaxies and their speeds of recession.

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.... **[2]**

(c) Scientists can only observe galaxies. They cannot do experiments on the galaxies. Why are scientists confident that the relationship between speed of recession and distance of far galaxies is correct?

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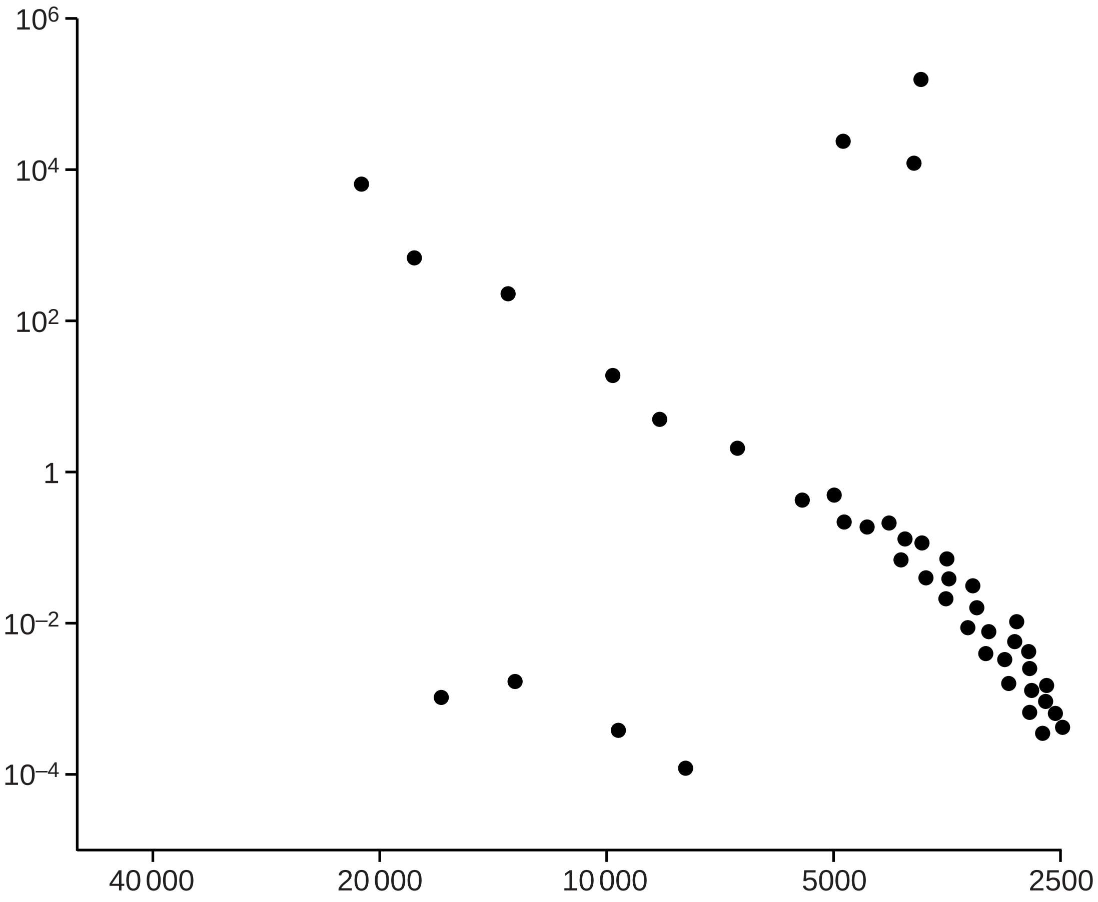
.... **[2]**

[Total: 7]

Question 4 begins on page 8

4 This graph is a Hertzsprung-Russell diagram.



(a) The labels on the axes of the Hertzsprung-Russell diagram are missing.
What should they be?

horizontal axis .... unit ....

vertical axis ....

[3]

(b) One of the axes can also be shown as the colour of a star.

(i) On the Hertzsprung-Russell diagram label this axis with the colours blue, red and yellow. **[2]**

(ii) Explain the relationship between the colours and the numbers on this axis.

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.... **[2]**

(c) **(i)** On the Hertzsprung-Russell diagram, put a (ring) around a star that produces most of its energy by the fusion of hydrogen. **[1]**

(ii) Explain how scientists know that there is hydrogen in stars.

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.... **[2]**

(d) Why can black holes not be plotted on the Hertzsprung-Russell diagram?

.... **[1]**

[Total: 11]

Question 5 begins on page 10

5 **(a)** A star's mass is one of the most significant factors affecting the life of the star.

Describe and explain how mass affects the life of a star.

The quality of written communication will be assessed in your answer.

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.... **[6]**

(b) A star with a mass of the Sun converts about 10^{-5} of its mass to energy in the fusion of hydrogen.

The Sun's mass is 2×10^{30} kilograms.

(i) How much mass is converted to energy during the fusion of hydrogen for the star?

mass converted .... kg **[1]**

(ii) The luminosity of the star is about 4.5×10^{26} J/s.

Show that the star converts about 5×10^{9} kg to produce this amount of energy each second.
speed of light = 3×10^{8} m/s

[2]

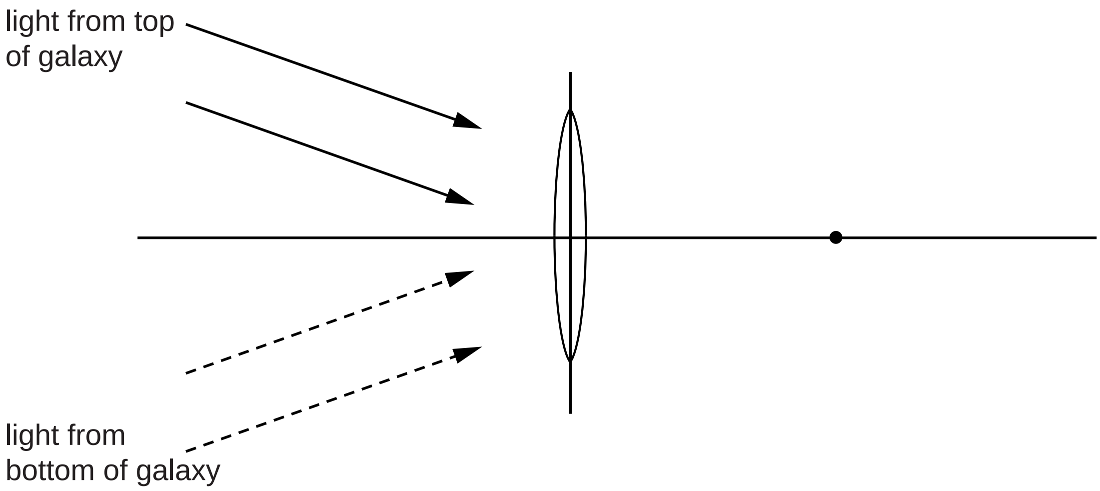
(iii) A similar star, with the same luminosity, fuses 3×10^{25} kg during the main part of its lifetime.

Calculate how long the main part of its lifetime is.

lifetime = ... seconds **[2]**

[Total: 11]

6 **(a)** Complete the ray diagram to show how an image of a distant galaxy is formed.
The point to the right of the lens is the focal point.
Label the image.



[4]

(b) In a telescope, the objective lens has a longer focal length than the eyepiece lens.
Explain why.

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.... **[2]**

(c) What are the advantages of using a mirror in place of the objective lens in a telescope?

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.... **[2]**

[Total: 8]

7 The table gives some information about possible sites for a new astronomical observatory.

Site	A	B	C	D
Height above sea level in m	5000	1000	6000	500
Average cloudless nights per year	360	120	270	230
Average % water in air	10	20	0	15
Distance to nearest town in km	100	150	50	30
Result of Environmental survey	local rare species	no survey	very few living organisms	no survey

Which site would be the best for an astronomical observatory?
By considering each site, explain and justify your choice.

The quality of written communication will be assessed in your answer.

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.... **[6]**

[Total: 6]

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