

Physics

UNIT: 4PH1

Science (Double Award) 4SD0

PAPER: 1PR

Total Marks
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Wednesday 22 May 2024 – Morning

Time: 2 hours

In the boxes below, write your name, centre number and candidate number.

Surname					
Other names					
Centre Number					
Candidate Number					

## **YOU MUST HAVE**

**Ruler, calculator, protractor, Equation Booklet (enclosed)**

## **YOU WILL BE GIVEN**

**Formulae Booklet**

**Diagram Booklet**

## **INSTRUCTIONS**

**Answer ALL questions.**

**Answer the questions in the spaces provided in this Question Paper or in the separate Diagram Booklet – there may be more space than you need.**

**Show all the steps in any calculations and state the units.**

## **INFORMATION**

**The total mark for this paper is 110.**

**The marks for EACH question are shown in brackets – use this as a guide as to how much time to spend on each question.**

**There may be spare copies of some diagrams.**

**ADVICE**

**Read each question carefully before you start to answer it.**

**Write your answers neatly and in good English.**

**Try to answer every question.**

**Check your answers if you have time at the end.**

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**Answer ALL questions.**

**Some questions must be answered with a cross in a box ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.**

- 1 Look at the table for Question 1(a) in the Diagram Booklet. It shows an incomplete electromagnetic spectrum.**

**Two parts of the electromagnetic spectrum are missing.**

**The missing parts are labelled **A** and **B**.**

- (a) (i) Name the part labelled **A**.  
(1 mark)**

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- (ii) Name the part labelled **B**.  
(1 mark)**

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**1 continued.**

**(b) (i) Give a use of microwaves.  
(1 mark)**

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**(ii) Give a use of gamma rays.  
(1 mark)**

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**(Total for Question 1 = 4 marks)**

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- 2 Look at the image for Question 2 in the Diagram Booklet. It shows an electric heater connected to the mains electricity supply.**

**The circuit the heater is connected to is fitted with a circuit breaker, which breaks the circuit if the current gets too high.**

- (a) Give an advantage of using a circuit breaker instead of using a fuse.  
(1 mark)**

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**(continued on the next page)**

**2 continued.**

**(b) The voltage of the mains electricity supply is 230 V.**

- (i) State the formula linking power, current and voltage.  
(1 mark)**

**(continued on the next page)**

**2(b) continued.**

- (ii) The normal operating current of the heater is 11 A.**

**Calculate the input power to the heater for this current.**

**Give your answer in kW.  
(3 marks)**

**power = \_\_\_\_\_ kW**

**(continued on the next page)**



**2 continued.**

**(c) The circuit breaker has a rating of 16A.**

**Suggest a reason why the heater may switch off before it reaches its normal operating current.**

**(1 mark)**

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**(Total for Question 2 = 6 marks)**

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**3 Look at the image for Question 3 in the Diagram Booklet. In 1947, the Railton Mobil Special was the first ground vehicle to achieve a speed of more than 400 miles per hour.**

**(a) During a test, the vehicle travelled at a speed of 403 miles per hour.**

**(continued on the next page)**

**3(a) continued.**

- (i) Calculate a speed of **403** miles per hour in metres per second (**m / s**).  
(2 marks)

[1 mile = **1600 m**]

speed = \_\_\_\_\_ m/s

(continued on the next page)

**Turn over**

**3(a) continued.**

- (ii) During the test, the vehicle travelled past two markers.**

**The markers were placed a known distance apart.**

**Describe how these markers could be used to determine the speed of the vehicle.  
(3 marks)**

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**Turn over**

**3 continued.**

- (b) Look at the diagram for Question 3(b) in the Diagram Booklet. It shows the vehicle travelling at a constant speed.**

**One of the horizontal forces acting on the vehicle has been drawn.**

**Complete the diagram by drawing a labelled arrow for the other horizontal force acting on the vehicle.  
(3 marks)**

**(Total for Question 3 = 8 marks)**

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**4 This question is about the Sun.**

- (a) Look at the table for Question 4(a) in the Diagram Booklet. It shows the different stages in the evolution of stars of different masses.**

**Complete the table by adding ticks (✓) to show which stages of evolution occur in the life cycle of the Sun.**

**(4 marks)**

**(continued on the next page)**

**4 continued.**

- (b) When viewed from Earth, the surface of the Sun is yellow in colour.**

**The surface of another star, Betelgeuse, is red in colour.**

**Explain the difference between the Sun and Betelgeuse, based on the different colours of their surfaces.**

**(2 marks)**

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**4 continued.**

**(c) The Sun transfers energy to the Earth by radiation.**

**(i) Give a reason why energy is not transferred from the Sun to the Earth by conduction or convection.**

**(1 mark)**

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**(continued on the next page)**



**4(c) continued.**

- (ii) A satellite orbiting the Earth contains sensitive equipment that can be damaged if it gets too hot.**

**Explain which colour would be most appropriate for the outer surface of the satellite to protect the equipment.  
(2 marks)**

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**(Total for Question 4 = 9 marks)**

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**Turn over**

- 5 Look at the diagram for Question 5 in the Diagram Booklet. A student needs to determine the density of some small rocks that appear to all be made of the same material.**
- (a) The student decides to measure the mass and the volume of each rock.**

**Describe a method the student could use to accurately determine the mass and the volume of each rock.**

**You may draw a diagram to help your answer.  
(5 marks)**

**Answer space continues on the next 2 pages.**

**5(a) continued.**

**5(a) continued.**

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**Turn over**

**5 continued.**

**(b) Look at the table for Question 5(b) in the Diagram Booklet. It shows the student's results for three of the rocks.**

- (i) State the formula linking density, mass and volume.  
(1 mark)**

**(continued on the next page)**

**5(b) continued.**

- (ii) After looking at the data, the student concludes that one of the rocks may be made of a different material from the others.**

**Using the data from the table, justify the student's conclusion.**

**(4 marks)**

**Answer space continues on the next page.**

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**5(b)(ii) continued.**

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**(Total for Question 5 = 10 marks)**

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- 6 Look at the diagram for Question 6 in the Diagram Booklet. It shows two rays of green light entering a semicircular glass block.**

- (a) (i) Measure the angle of incidence and the angle of refraction for ray **A** as it enters the glass block.**

**(2 marks)**

**angle of incidence =**

**\_\_\_\_\_ degrees**

**angle of refraction =**

**\_\_\_\_\_ degrees**

- (ii) State the formula linking refractive index, angle of incidence and angle of refraction.**  
**(1 mark)**

**(continued on the next page)**



**6(a) continued.**

- (iii) Calculate the refractive index of the glass.  
(3 marks)**

**refractive index = \_\_\_\_\_**

**(continued on the next page)**

**6 continued.**

- (b) (i) Look again at the diagram for Question 6 in the Diagram Booklet. Complete the path of ray **A** until it crosses ray **B**.**

**Label the point where the rays cross with the letter **F**.**

**(2 marks)**

**(continued on the next page)**

**6(b) continued.**

- (ii) The refractive index of glass for red light is lower than for green light.**

**Explain what would happen to point **F** if red light were used instead of green light.**

**You may draw a diagram to help your answer.  
(3 marks)**

**Answer space continues on the next 2 pages.**

**6(b)(ii) continued.**

**6(b)(ii) continued.**

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**(Total for Question 6 = 11 marks)**

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**7 A student investigates the voltage-current characteristics of an unknown component, X.**

**(a) The student is given this equipment to investigate component X.**

- battery
- variable resistor
- ammeter
- voltmeter
- connecting wires

**Look at the diagram for Question 7(a) in the Diagram Booklet. It shows an incomplete circuit containing the battery and component X.**

**Complete the diagram by drawing a circuit the student could use for their investigation.  
(4 marks)**

**(continued on the next page)**

**7 continued.**

**(b) Look at the graph for Question 7(b) in the Diagram Booklet. It shows the results of the investigation.**

**(i) Draw a line of best fit on the graph.  
(1 mark)**

**(ii) Calculate the resistance of component X  
when the voltage is  $4.2\text{ V}$ .**

**Give the unit.  
(5 marks)**

**Answer space continues on the next page.**

**7(b)(ii) continued.**

**resistance = \_\_\_\_\_**

**unit \_\_\_\_\_**

**(continued on the next page)**



7(b) continued.

(iii) Which of these is equivalent to  $4.2\text{ V}$ ?  
(1 mark)

- ☐ A  $4.2$  coulombs per second ( $\text{C/s}$ )
- ☐ B  $4.2$  seconds per joule ( $\text{s/J}$ )
- ☐ C  $4.2$  joules per second ( $\text{J/s}$ )
- ☐ D  $4.2$  joules per coulomb ( $\text{J/C}$ )

(continued on the next page)

**7(b) continued.**

**(iv) The student concludes that component **X** is a filament lamp.**

**Comment on the student's conclusion.  
(2 marks)**

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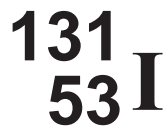
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**(Total for Question 7 = 13 marks)**

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- 8 This question is about radioactive isotopes used for medical imaging.

(a) **Iodine-131** is represented by this symbol.



- (i) How many neutrons are in the nucleus of an atom of **iodine-131**?  
(1 mark)

- ☐ A 53
- ☐ B 78
- ☐ C 131
- ☐ D 184

(continued on the next page)

8(a) continued.

- (ii) **Iodine-131** is radioactive and decays with a half-life of 8 days.

State what is meant by the term **HALF-LIFE**.  
(2 marks)

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(continued on the next page)

8(a) continued.

- (iii) Look at the graph for Question 8(a)(iii) in the Diagram Booklet. The cross (X) on the graph shows the initial number of atoms in a sample of **iodine-131**.

Draw three more crosses (X) on the graph to show how the number of atoms of **iodine-131** in the sample changes during three half-lives.

(3 marks)

**[iodine-131 half-life = 8 days]**

(continued on the next page)

**8(a) continued.**

- (iv) Use a curve of best fit on the graph to estimate the time taken for the number of atoms in the sample to decrease to **5000** (2 marks)**

**time taken = \_\_\_\_\_ days**

**(continued on the next page)**

8 continued.

- (b) When **iodine-131** decays, it emits beta radiation and gamma radiation.

A patient swallows a tablet containing **iodine-131**. The radiation emitted can be detected outside the body.

- (i) State the name of a piece of equipment that can detect the radiation emitted by **iodine-131**.  
(1 mark)

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**8(b) continued.**

- (ii) Give a reason why gamma radiation is more likely to be detected outside the body than beta radiation.  
(1 mark)**

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8 continued.

- (c) **Technetium-99m** is another radioactive isotope.

**Iodine-131** and **technetium-99m** are both used as medical tracers. Medical tracers use radiation detected outside the body to diagnose illnesses.

Look at the table for Question 8(c) in the Diagram Booklet. It gives information about some of the properties of **iodine-131** and **technetium-99m** when they undergo radioactive decay.

Explain why **technetium-99m** is likely to be safer than **iodine-131** when used as a medical tracer.

(3 marks)

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Turn over

**8(c) continued.**

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**(Total for Question 8 = 13 marks)**

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**9 A student stretches a rubber band.**

**(a) Look at the images for Question 9(a) in the Diagram Booklet. It show a rubber band before and after it has been stretched.**

**(i) State which energy store increases in the rubber band after it has been stretched.  
(1 mark)**

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**(ii) State the main method of energy transfer when the rubber band is stretched.  
(1 mark)**

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**(iii) State the source of the energy transferred to the rubber band.  
(1 mark)**

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**(continued on the next page)**

**Turn over**

**9 continued.**

**(b) Look at the diagram for Question 9(b) in the Diagram Booklet. It shows a force-extension graph for a rubber band.**

**(i) State how the graph shows that the rubber band does not obey Hooke's law.  
(1 mark)**

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**(ii) Explain how the graph shows that the rubber band is elastic.  
(2 marks)**

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**Turn over**

**9 continued.**

**(c) The student stretches the rubber band and then releases it. The band moves vertically upwards.**

**(i) The band travels with an initial speed of  $13 \text{ m/s}$ .**

**When the band reaches its maximum height above the student's hand, the band has a speed of  $0 \text{ m/s}$ .**

**Calculate the maximum height that the band reaches.**

**Give your answer to 2 significant figures.  
(4 marks)**

**[acceleration due to gravity =  $-10 \text{ m/s}^2$ ]**

**Answer space continues on the next page.**

9(c)(i) continued.

[acceleration due to gravity =  $-10 \text{ m/s}^2$ ]

maximum height = \_\_\_\_\_ m

(continued on the next page)

**9(c) continued.**

**(ii) The band reaches its maximum height.**

**Explain the motion of the band as it falls from its maximum height to the ground.**

**Refer to forces in your answer.**

**You may assume**

- the band does not rotate
- the band does not reach terminal velocity

**(5 marks)**

**Answer space continues on the next page.**

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**9(c)(ii) continued.**

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**(Total for Question 9 = 15 marks)**

**Turn over**



**10 Look at Diagram 1 for Question 10 in the Diagram Booklet. It shows a generator inside a small wind turbine. The generator is connected to a lamp and the windmill blades.**

**(a) When the coil rotates in the direction of the arrow, the ammeter displays a small current.**

**Explain how the generator produces a current.  
(2 marks)**

**Answer space continues on the next page.**

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**10(a) continued.**

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**(continued on the next page)**

**10 continued.**

- (b) The generator in the wind turbine acts as an alternating current (a.c.) power supply.**

**Look at Diagram 2 for Question 10(b) in the Diagram Booklet. It shows an electric circuit containing the generator being used to charge a mobile phone battery.**

- (i) Direct current (d.c.) is needed to charge the battery.**

**Explain why there is a diode in the circuit.  
(2 marks)**

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**(continued on the next page)**

**10(b) continued.**

- (ii) Explain how the current in the battery will change if the wind speed increases.  
(2 marks)**

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**10 continued.**

**(c) The mean voltage across the battery is  $7.2\text{ V}$ .**

**The battery gains  $14\text{ kJ}$  of energy  
in  $8400$  seconds.**

**Calculate the mean current in the battery.  
(3 marks)**

**mean current = \_\_\_\_\_ A**

**(Total for Question 10 = 9 marks)**

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**Turn over**

**11 This question is about gas pressure.**

- (a) Look at Diagram 1 for Question 11(a) in the Diagram Booklet. It shows some of the molecules of a gas in a sealed container.**

**The molecules collide with all the surfaces of the container. This exerts an outward force on the container and causes pressure.**

**Describe how the motion of the gas molecules causes an equal pressure on all the walls of the container.**

**You may add to diagram 1 to help your answer.  
(2 marks)**

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**(continued on the next page)**

**Turn over**

**11 continued.**

- (b) The width of the container is slowly decreased so that the volume of the container is smaller than before.**

**Look at Diagram 2 for Question 11(b) in the Diagram Booklet. It shows the width of the container before and after this change. All other dimensions of the container remain the same.**

**The initial volume of the gas is  $130 \text{ cm}^3$**

**The initial pressure of the gas is  $100 \text{ kPa}$ .**

**Calculate the pressure of the gas after the width of the container is decreased.**

**Assume the temperature of the gas remains constant.**

**(4 marks)**

**Answer space continues on the next page.**

**11(b) continued.**

**pressure = \_\_\_\_\_ kPa**

**(Total for Question 11 = 6 marks)**

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- 12 Air is trapped in a boiling tube by sealing the boiling tube with a rubber bung.**

**Look at the diagram for Question 12 in the Diagram Booklet. The boiling tube is placed in a beaker containing hot water.**

- (a) Energy is transferred from the thermal store of the water to the thermal store of the air in the boiling tube with an efficiency of 16%**

**The air in the boiling tube gains 1800 J of energy during this process. This is defined as the useful energy transfer.**

**Calculate the amount of energy wasted during this process.  
(4 marks)**

**Answer space continues on the next page.**

12(a) continued.

energy wasted = \_\_\_\_\_ J

(continued on the next page)

**12 continued.**

**(b) Give two ways that the apparatus could be modified to improve the efficiency of the energy transfer.**  
**(2 marks)**

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**(Total for Question 12 = 6 marks)**

**TOTAL FOR PAPER = 110 MARKS**  
**END OF PAPER**