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Total Marks

**3220/402**NATIONAL  
QUALIFICATIONS  
2008FRIDAY, 23 MAY  
10.50 AM – 12.35 PM**PHYSICS**  
**STANDARD GRADE**  
Credit Level**Fill in these boxes and read what is printed below.**

Full name of centre

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Town

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Forename(s)

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Surname

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Date of birth

Day   Month   Year

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Scottish candidate number

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Number of seat

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Reference may be made to the Physics Data Booklet.

- 1 All questions should be answered.
- 2 The questions may be answered in any order but all answers must be written clearly and legibly in this book.
- 3 Write your answer where indicated by the question or in the space provided after the question.
- 4 If you change your mind about your answer you may score it out and rewrite it in the space provided at the end of the answer book.
- 5 Before leaving the examination room you must give this book to the invigilator. If you do not, you may lose all the marks for this paper.
- 6 Any necessary data will be found in the **data sheet** on page three.
- 7 Care should be taken to give an appropriate number of significant figures in the final answers to questions.



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## DATA SHEET

### *Speed of light in materials*

Material	Speed in m/s
Air	$3.0 \times 10^8$
Carbon dioxide	$3.0 \times 10^8$
Diamond	$1.2 \times 10^8$
Glass	$2.0 \times 10^8$
Glycerol	$2.1 \times 10^8$
Water	$2.3 \times 10^8$

### *Speed of sound in materials*

Material	Speed in m/s
Aluminium	5200
Air	340
Bone	4100
Carbon dioxide	270
Glycerol	1900
Muscle	1600
Steel	5200
Tissue	1500
Water	1500

### *Gravitational field strengths*

	Gravitational field strength on the surface in N/kg
Earth	10
Jupiter	26
Mars	4
Mercury	4
Moon	1.6
Neptune	12
Saturn	11
Sun	270
Venus	9

### *Specific heat capacity of materials*

Material	Specific heat capacity in J/kg °C
Alcohol	2350
Aluminium	902
Copper	386
Glass	500
Glycerol	2400
Ice	2100
Lead	128
Silica	1033
Water	4180

### *Specific latent heat of fusion of materials*

Material	Specific latent heat of fusion in J/kg
Alcohol	$0.99 \times 10^5$
Aluminium	$3.95 \times 10^5$
Carbon dioxide	$1.80 \times 10^5$
Copper	$2.05 \times 10^5$
Glycerol	$1.81 \times 10^5$
Lead	$0.25 \times 10^5$
Water	$3.34 \times 10^5$

### *Melting and boiling points of materials*

Material	Melting point in °C	Boiling point in °C
Alcohol	-98	65
Aluminium	660	2470
Copper	1077	2567
Glycerol	18	290
Lead	328	1737
Turpentine	-10	156

### *Specific latent heat of vaporisation of materials*

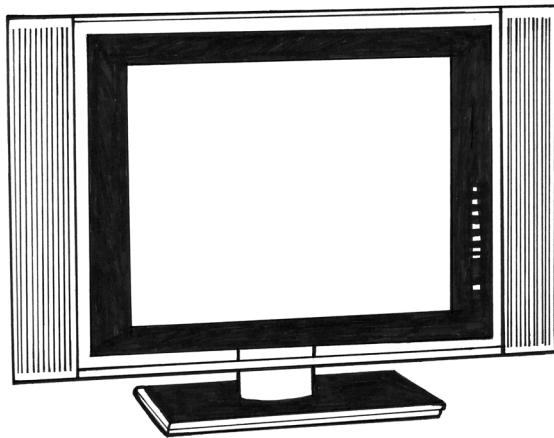
Material	Specific latent heat of vaporisation in J/kg
Alcohol	$11.2 \times 10^5$
Carbon dioxide	$3.77 \times 10^5$
Glycerol	$8.30 \times 10^5$
Turpentine	$2.90 \times 10^5$
Water	$22.6 \times 10^5$

### *SI Prefixes and Multiplication Factors*

Prefix	Symbol	Factor
giga	G	$1\ 000\ 000\ 000 = 10^9$
mega	M	$1\ 000\ 000 = 10^6$
kilo	k	$1000 = 10^3$
milli	m	$0.001 = 10^{-3}$
micro	μ	$0.000\ 001 = 10^{-6}$
nano	n	$0.000\ 000\ 001 = 10^{-9}$

Marks

1. A high definition television picture has 1080 lines and there are 25 pictures produced each second.



- (a) (i) Calculate how long it takes to produce one picture on the screen.

*Space for working and answer*

1

- (ii) Explain why a continuous moving picture is seen on the television screen and not 25 individual pictures each second.

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- (b) The television picture is in colour.

- (i) Which **two** colours are used to produce magenta on the screen?

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1

- (ii) Due to a fault, the colour yellow appears as orange on the screen. Which colour should be reduced in brightness to correct this problem?

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1

Marks

2. A television company is making a programme in China.

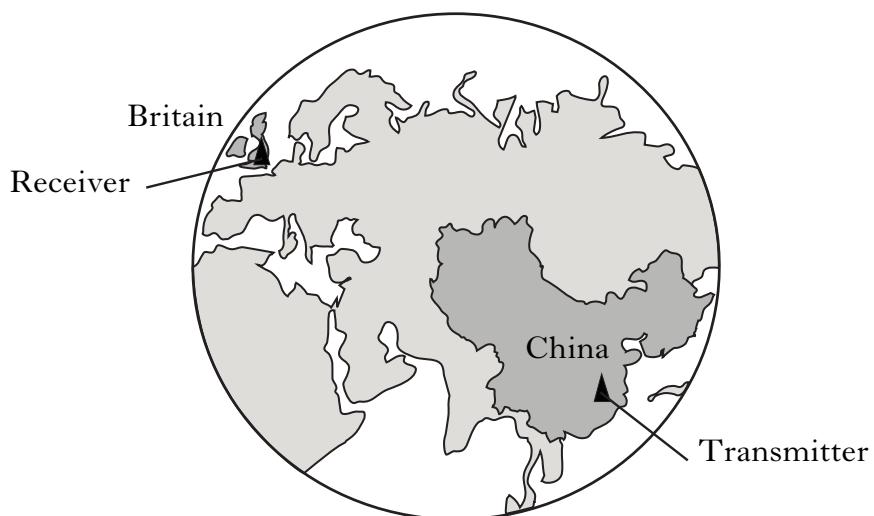
Britain receives television pictures live from China. The television signals are transmitted using microwaves. The microwave signals travel from China **via** a satellite, which is in a geostationary orbit.

- (a) State what is meant by a geostationary orbit.

.....

1

- (b) The diagram shows the position of the transmitter and receiver. Complete the diagram to show the path of the microwave signals **from** China **to** Britain.



2

- (c) The frequency of the microwave signals being used for transmission is 8 GHz.

- (i) What is the speed of the microwaves?

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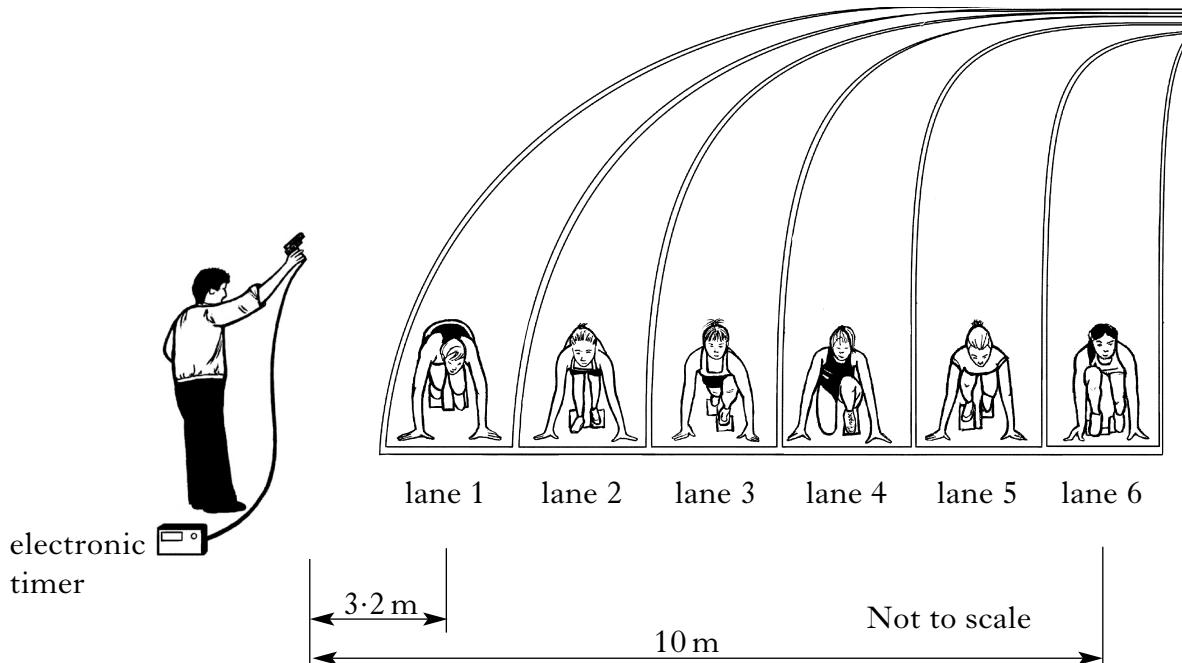
- (ii) Calculate the wavelength of these microwaves.

*Space for working and answer*

2

Marks

3. In a sprint race at a school sports day, the runners start when they hear the sound of the starting pistol. An electronic timer is also started when the pistol is fired into the air.



The runner in lane 1 is 3.2 m from the starting pistol. The runner in lane 6 is 10 m from the starting pistol.

- (a) The runner in lane 1 hears the starting pistol first.

Calculate how much later the runner in lane 6 hears this sound after the runner in lane 1.

*Space for working and answer*

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## 3. (continued)

- (b) A sensor detects each runner crossing the finishing line to record their time.

The table gives information about the race.

Place	Lane	Time (s)
1st	1	13·11
2nd	6	13·12
3rd	3	13·21

Using your answer to part (a), explain why the runner in lane 6 should have been awarded first place.

*Space for working and answer*

2

- (c) One runner of mass 60 kg has a speed of 9 m/s when crossing the finishing line.

Calculate the kinetic energy of the runner at this point.

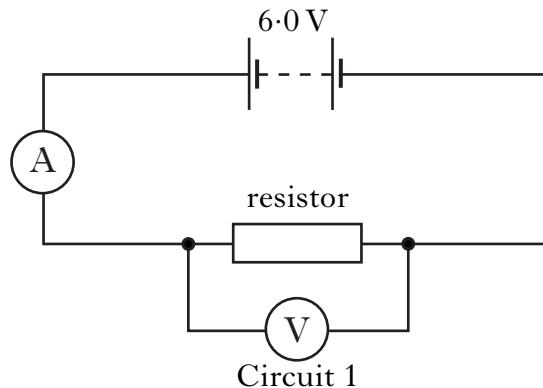
*Space for working and answer*

2

[Turn over

Marks

4. A student has four resistors labelled A, B, C and D. The student sets up Circuit 1 to identify the value of each resistor.



Each resistor is placed in the circuit in turn and the following results are obtained.

Resistor	Voltage across resistor (V)	Current (A)
A	6.0	0.017
B	6.0	0.027
C	6.0	0.050
D	6.0	0.033

- (a) (i) Show, **by calculation**, which of the resistors has a value of  $120\Omega$ .

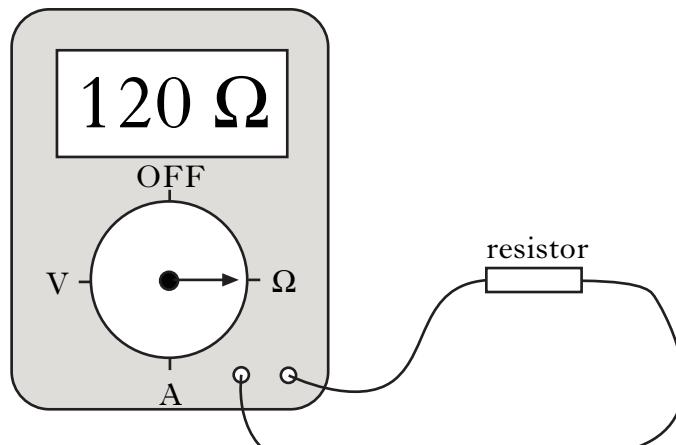
*Space for working and answer*

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## 4. (a) (continued)

- (ii) The student then sets up Circuit 2 to measure the resistance of each resistor.



Circuit 2

State **one** advantage of using Circuit 2 to measure the resistance compared to using Circuit 1.

.....

1

- (b) The resistances of the other three resistors are  $180\Omega$ ,  $220\Omega$  and  $360\Omega$ . The student connects all four resistors in series.

Calculate the total resistance.

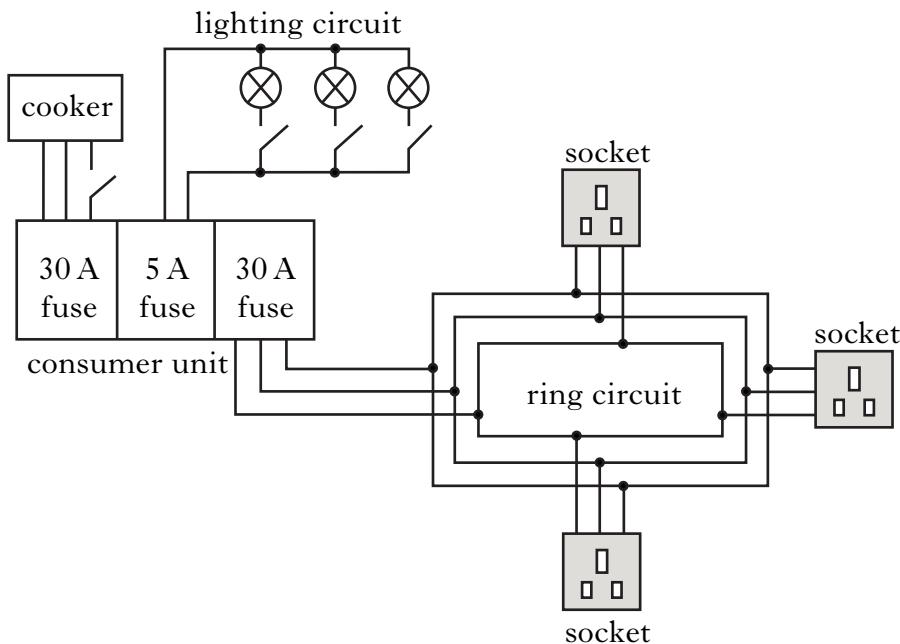
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[Turn over

Marks

5. The diagram shows three household circuits connected to a consumer unit.



- (a) (i) State **one** advantage of a ring circuit.

.....

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- (ii) State the value of mains voltage.

.....

1

- (b) Each of the lamps in the lighting circuit has a power rating of 100 W.  
One of the lamps is switched on.

- (i) Calculate the current in the lamp.

*Space for working and answer*

2

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

- (ii) Explain why a house with twenty 100W lamps requires two separate lighting circuits.

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6. A short-sighted person has difficulty seeing the picture on a cinema screen. Figure 1 shows rays of light from the screen entering an eye of the person until the rays reach the retina.

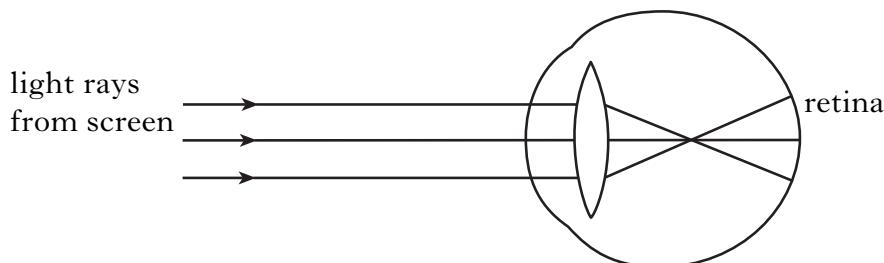


Figure 1

- (a) (i) In the dotted box in Figure 2, draw the shape of lens that would correct this eye defect.

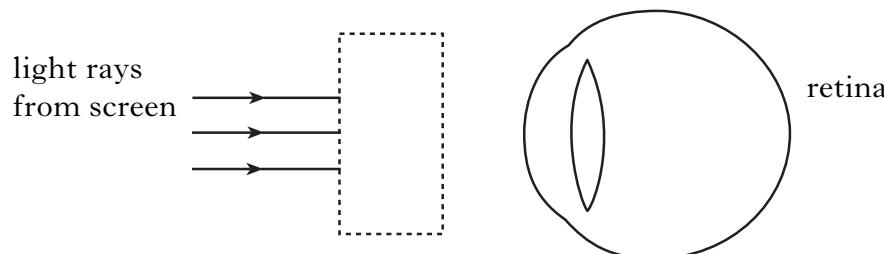


Figure 2

- (ii) In Figure 2, complete the path of the rays of light from this lens until they reach the retina.

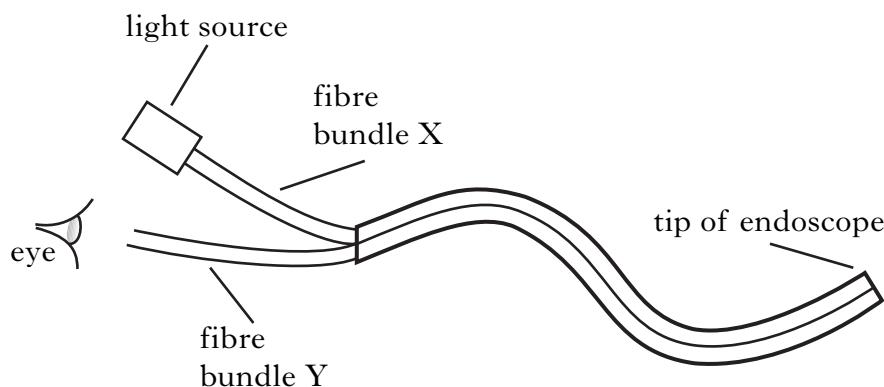
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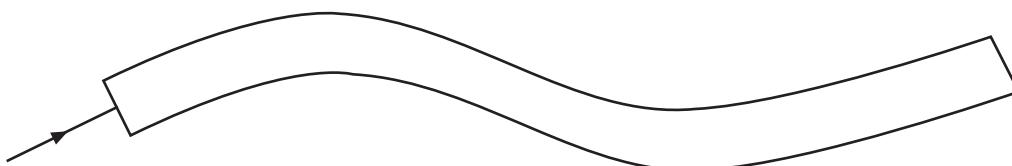
Marks

## 6. (continued)

- (b) Doctors can use an endoscope to examine internal organs of a patient. The endoscope has two separate bundles of optical fibres that are flexible.



A section of optical fibre used in the endoscope is shown below.



- (i) Complete the diagram to show how light is transmitted along the optical fibre. 2
- (ii) Explain the purpose of each bundle of optical fibres in the endoscope. 2

Fibre bundle X .....

.....

Fibre bundle Y .....

.....

- (iii) The tip of the endoscope that is inside the patient is designed to be very flexible. Suggest **one** reason for this. 1

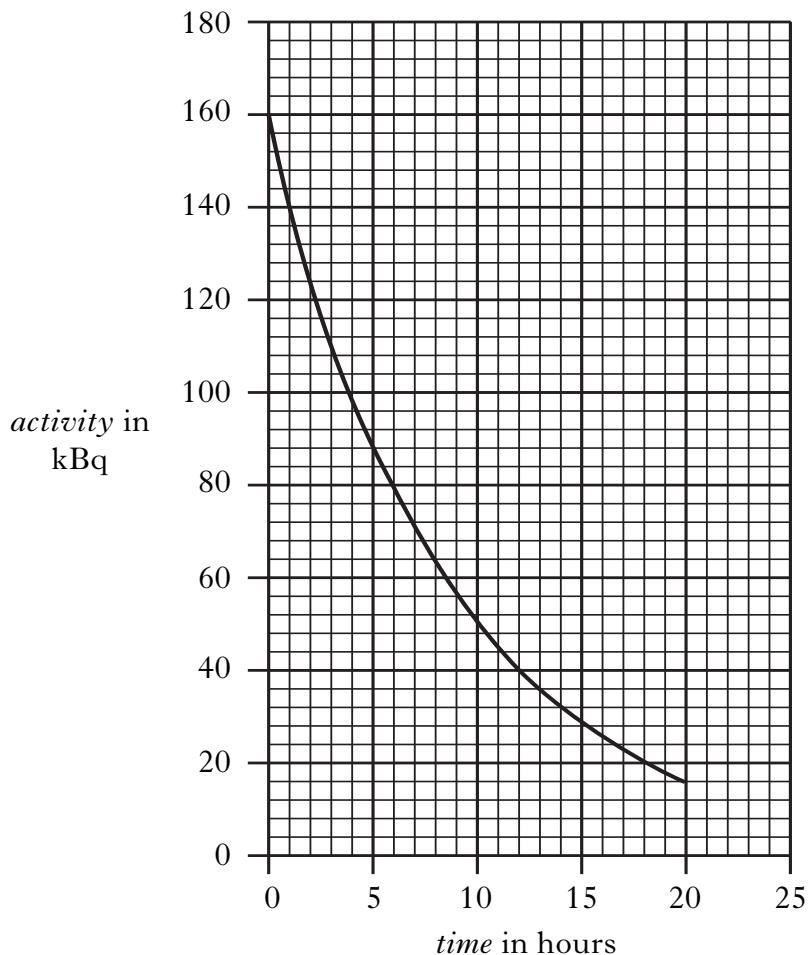
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[Turn over]

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7. A hospital technician is working with a radioactive source. The graph shows the activity of the source over a period of time.



- (a) (i) State what is meant by the term *half-life*.

.....

1

- (ii) Use information from the graph to calculate the half-life of the radioactive source.

*Space for working and answer*

1

Marks

7. (a) (continued)

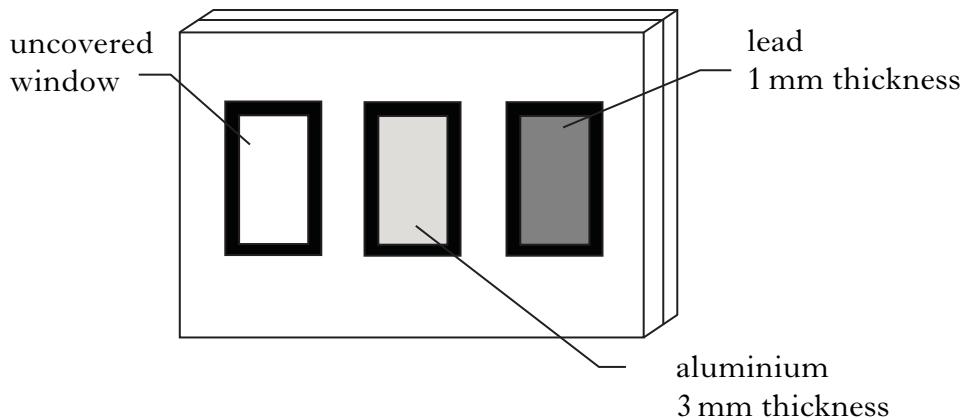
- (iii) The initial activity of the source is 160 kBq.

Calculate the activity, in kBq, of the radioactive source after four half-lives.

*Space for working and answer*

1

- (b) As a safety precaution the technician wears a film badge when working with radioactive sources. The film badge contains photographic film. Light cannot enter the badge.



Describe how the film badge indicates the **type** and **amount** of radiation received.

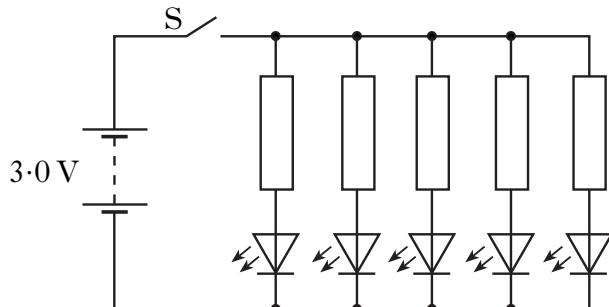
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2

[Turn over

Marks

8. A torch contains five identical LEDs connected to a 3.0 V battery as shown.



- (a) State the purpose of the resistor connected in series with each LED.

.....

1

- (b) When lit, each LED operates at a voltage of 1.8 V and a current of 30 mA.

- (i) Calculate the value of the resistor in series with each LED.

*Space for working and answer*

3

- (ii) Calculate the total current from the supply when all five LEDs are lit.

*Space for working and answer*

1

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**8. (b) (continued)**

- (iii) Calculate the power supplied by the battery when all five LEDs are lit.

*Space for working and answer*

2

- (c) State **one** advantage of using five LEDs rather than a single filament lamp in the torch.

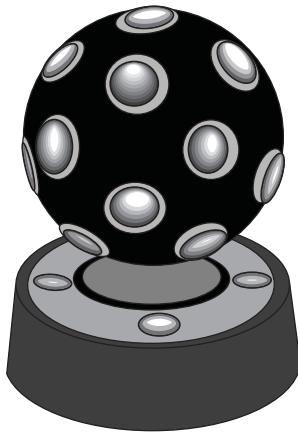
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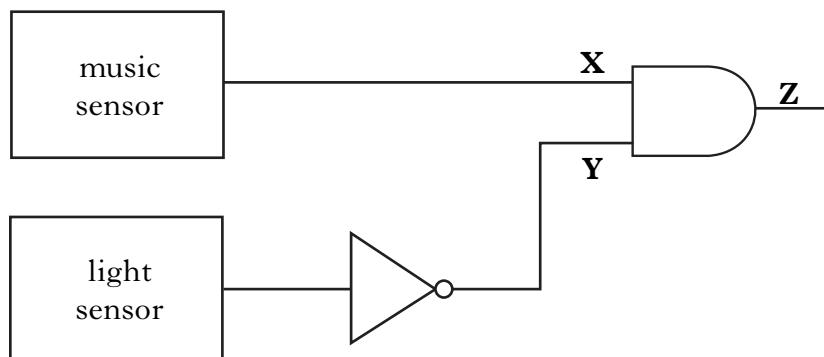
**[Turn over**

Marks

9. An electronic device produces a changing light pattern when it detects music, but only when it is in the dark.



The device contains the logic circuit shown.



The music sensor produces logic 1 when the music is on and logic 0 when the music is off.

The light sensor produces logic 1 when it detects light and logic 0 when it is dark.

- (a) (i) Suggest a suitable input device for the light sensor.

.....

1

- (ii) Complete the truth table for the logic levels at points **X**, **Y** and **Z** in the circuit.

Music	Light level	<b>X</b>	<b>Y</b>	<b>Z</b>
off	dark			
off	light			
on	dark			
on	light			

3

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## 9. (continued)

- (b) The device detects music from a CD player. The CD player contains an amplifier that produces an output voltage of  $5.6\text{ V}$  when connected to a loudspeaker of resistance  $3.2\Omega$ .
- (i) Calculate the output power of the amplifier.

*Space for working and answer*

2

- (ii) The input power to the amplifier is  $4.9\text{ mW}$ .  
Calculate the power gain of the amplifier.

*Space for working and answer*

2

- (iii) One particular signal from the CD to the amplifier has a frequency of  $170\text{ Hz}$ .  
What is the frequency of the output signal from the amplifier?

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1

[Turn over]

10. A railway train travels uphill between two stations.



Information about the train and its journey is given below.

average speed of train	5 m/s
time for journey	150 s
power of train	120 kW
mass of train plus passengers	20 000 kg

- (a) Calculate the energy used by the train during the journey.

*Space for working and answer*

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**10. (continued)**

- (b) Calculate the height gained by the train during the journey.

*Space for working and answer*

2

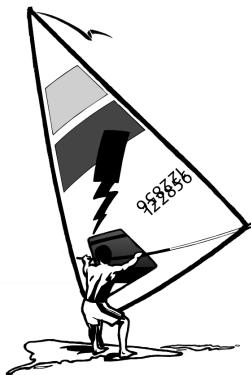
- (c) Suggest why the actual height gained by the train is less than the value calculated in part (b).

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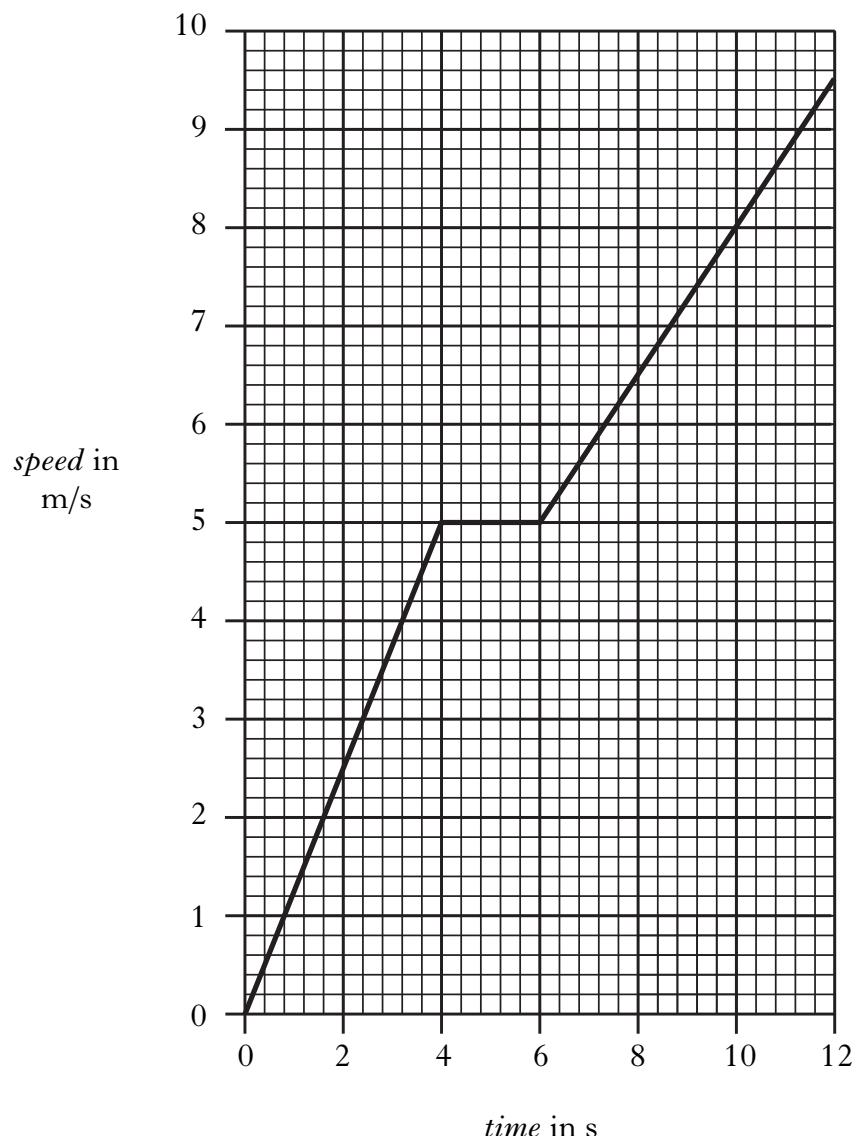
1

**[Turn over**

11. A windsurfer takes part in a race. The windsurfer takes 120 seconds to complete the race. The total mass of the windsurfer and the board is 90 kg.



The graph shows how the speed of the windsurfer and board changes with time during part of the race.



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**11. (continued)**

- (a) (i) Calculate the acceleration of the windsurfer and board during the first 4 s of the race.

*Space for working and answer*

2

- (ii) Calculate the unbalanced force causing this acceleration.

*Space for working and answer*

2

- (b) Calculate the total distance travelled by the windsurfer during the 12 s time interval shown on the graph.

*Space for working and answer*

2

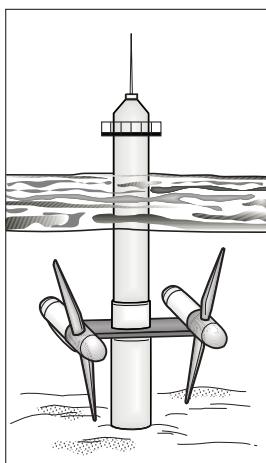
- (c) What can be said about the horizontal forces acting on the windsurfer between 4 s and 6 s?

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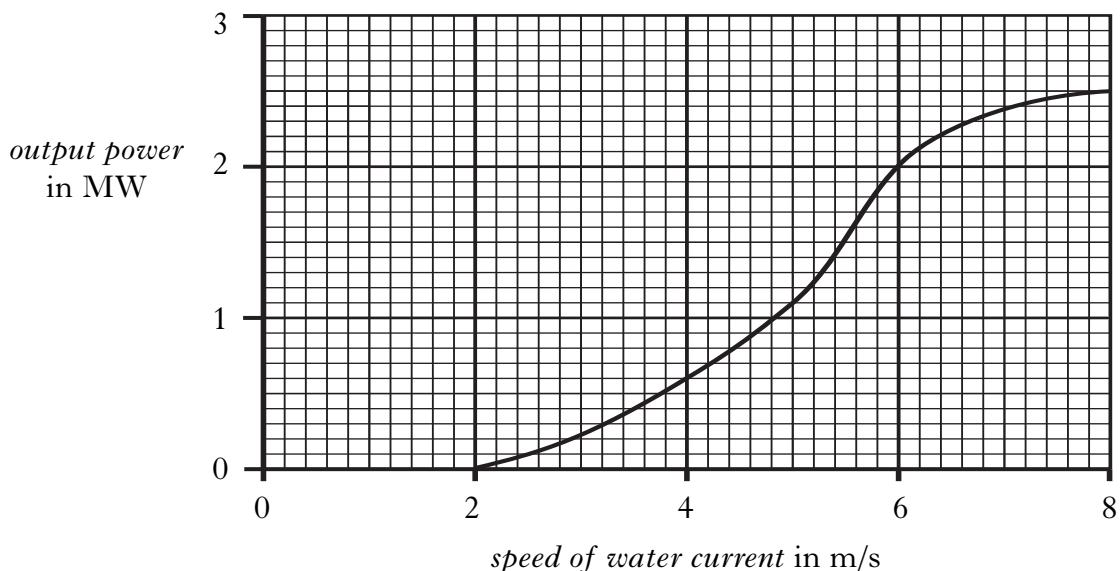
**[Turn over]**

12. An underwater generator is designed to produce electricity from water currents in the sea.



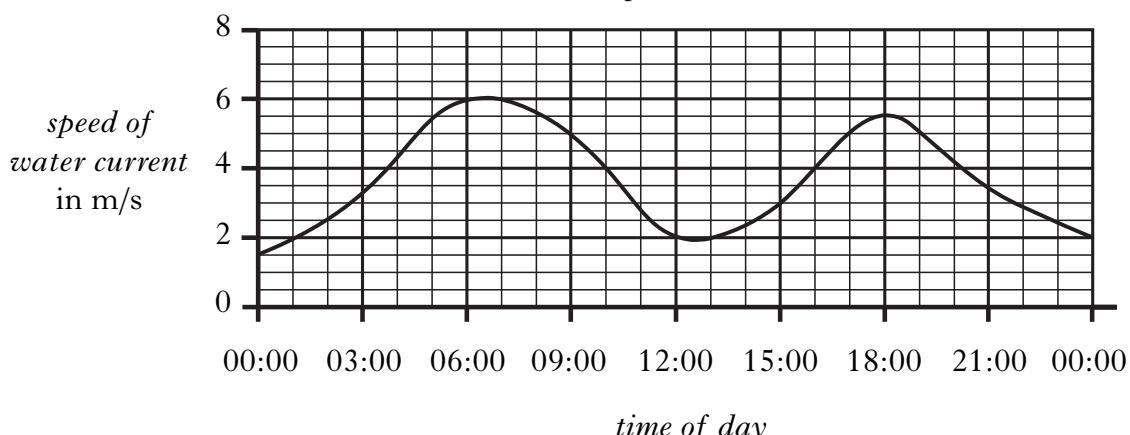
The output power of the generator depends on the speed of the water current as shown in Graph 1.

Graph 1



The speed of the water current is recorded at different times of the day shown in Graph 2.

Graph 2



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12. (continued)

- (a) (i) State the output power of the generator at 09:00.

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1

- (ii) State **one** disadvantage of using this type of generator.

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1

- (b) The voltage produced by the generator is stepped-up by a transformer.

At one point in the day the electrical current in the primary coils of the transformer is 900 A and the voltage is 2000 V.

The transformer is 96% efficient.

- (i) Calculate the output power of the transformer at this time.

*Space for working and answer*

3

- (ii) State **one** reason why a transformer is not 100% efficient.

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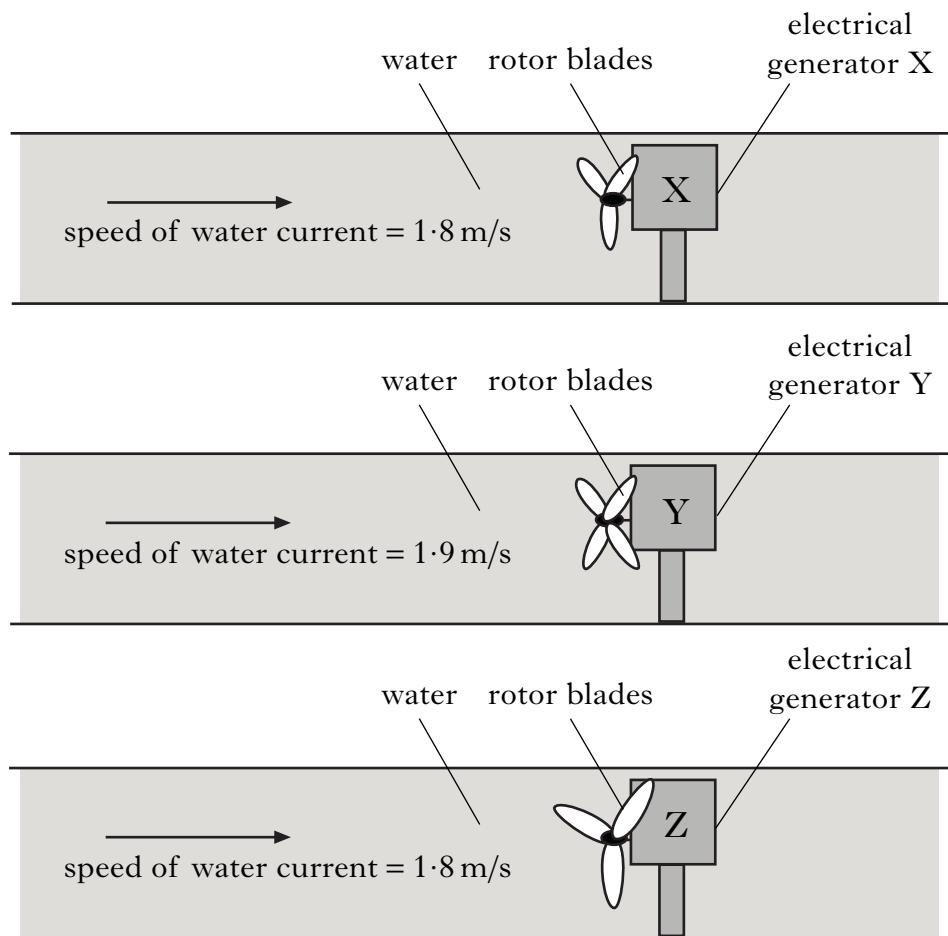
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[Turn over

Marks

## 12. (continued)

- (c) Three different types of electrical generator, X, Y and Z are tested in a special tank with a current of water as shown to find out the efficiency of each generator.



Give **two** reasons why this is not a fair test.

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1

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13. In the reactor of a nuclear power station, neutrons split uranium nuclei to produce heat in what is known as a “chain reaction”.

- (a) Explain what is meant by the term “chain reaction”.

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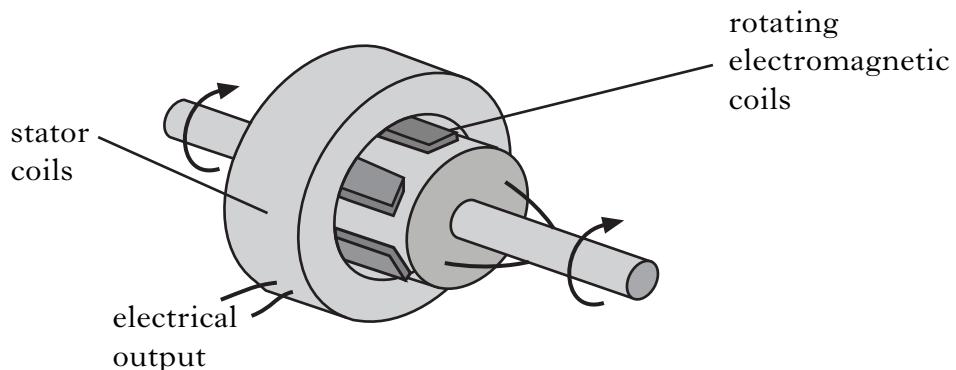
2

- (b) In the nuclear power station, 1 kg of uranium fuel produces 4 200 000 MJ of heat. In a coal-fired power station 1 kg of coal produces 28 MJ of heat. Calculate how many kilograms of coal are required to produce the same amount of heat as 1 kg of uranium.

*Space for working and answer*

1

- (c) A power station uses an a.c. generator to convert kinetic energy from a turbine into electrical energy. A diagram of an a.c. generator is shown.



- (i) Explain how the a.c. generator works.

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2

- (ii) State **two** changes that can be made to the generator to increase the output power.

Change 1: .....

Change 2: .....

2

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14. A team of astronomers observes a star 200 light-years away.

- (a) State what is meant by the term “light-year”.

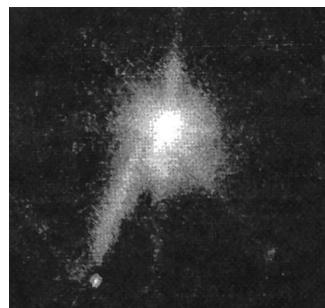
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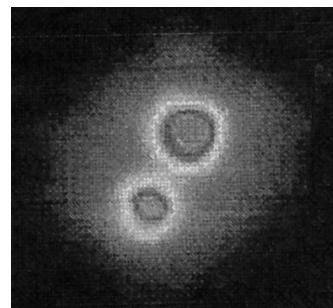
- (b) Images of the star are taken with three different types of telescope as shown.



Telescope A  
visible light



Telescope B  
infrared



Telescope C  
X-ray

- (i) Explain why different types of telescope are used to detect signals from space.

.....

2

- (ii) Place the telescopes in order of the increasing wavelength of the radiation which they detect.

.....

1

- (iii) State a detector that could be used in telescope C.

.....

1

- (c) Telescope A is a refracting telescope with an objective lens of focal length 400 mm and diameter 80 mm.

- (i) Calculate the power of the objective lens.

*Space for working and answer*

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**14. (c) (continued)**

- (ii) One of the astronomers suggests replacing the objective lens in this telescope with one of larger diameter.

State an advantage of doing this.

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**[Turn over for Question 15 on *Page thirty*]**

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15. (a) A spacecraft is used to transport astronauts and equipment to a space station. On its return from space the spacecraft must re-enter the Earth's atmosphere. The spacecraft has a heat shield made from special silica tiles to prevent the inside from becoming too hot.



- (i) Why does the spacecraft increase in temperature when it re-enters the atmosphere?

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1

- (ii) The mass of the heat shield is  $3.5 \times 10^3 \text{ kg}$  and the gain in heat energy of the silica tiles is  $4.7 \text{ GJ}$ .

Calculate the increase in temperature of the silica tiles.

*Space for working and answer*

3

- (iii) Explain why the actual temperature rise of the silica tiles is less than the value calculated in (a)(ii).

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1

- (b) When a piece of equipment was loaded on to the spacecraft on Earth, two people were required to lift it.

One person was able to lift the same piece of equipment in the Space Station.

Explain why one person was able to lift the equipment in the Space Station.

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[END OF QUESTION PAPER]

K&U	PS

**YOU MAY USE THE SPACE ON THIS PAGE TO REWRITE ANY ANSWER YOU HAVE DECIDED TO CHANGE IN THE MAIN PART OF THE ANSWER BOOKLET. TAKE CARE TO WRITE IN CAREFULLY THE APPROPRIATE QUESTION NUMBER.**

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