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Presenting Centre No.	Candidate No.	Subject No.	Level	Paper No.	Group No.	Marker's No.		K&U	PS
		3220							

Total Marks

[3220/249] 1993

SCOTTISH CERTIFICATE OF EDUCATION

PHYSICS

Standard Grade—CREDIT LEVEL

Wednesday, 19th May—1.30 p.m. to 3.15 p.m.

Fill in these boxes and read what is printed below.

Full Name of school or college

Town

Christian Name/First Name, Initial(s) (of other/middle name(s))

Surname

Date of Birth
Day *Month* *Year*

Number of seat occupied at examination

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.**

UCP 3220/249 6/3/25610

DATA SHEET

Speed of light in materials

Material	*Speed in m/s*
Air	$3{\cdot}0 \times 10^8$
Carbon dioxide	$3{\cdot}0 \times 10^8$
Diamond	$1{\cdot}2 \times 10^8$
Glass	$2{\cdot}0 \times 10^8$
Glycerol	$2{\cdot}1 \times 10^8$
Water	$2{\cdot}3 \times 10^8$

Speed of sound in materials

Material	*Speed in m/s*
Aluminium	5200
Air	340
Bone	3000
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
Diamond	530
Glass	500
Glycerol	2400
Ice	2100
Lead	128
Water	4180

Specific latent heat of fusion of materials

Material	*Specific latent heat of fusion in J/kg*
Alcohol	$0{\cdot}99 \times 10^5$
Aluminium	$3{\cdot}95 \times 10^5$
Carbon dioxide	$1{\cdot}80 \times 10^5$
Copper	$2{\cdot}05 \times 10^5$
Glycerol	$1{\cdot}81 \times 10^5$
Lead	$0{\cdot}25 \times 10^5$
Water	$3{\cdot}34 \times 10^5$

Melting and boiling points of materials

Materials	*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

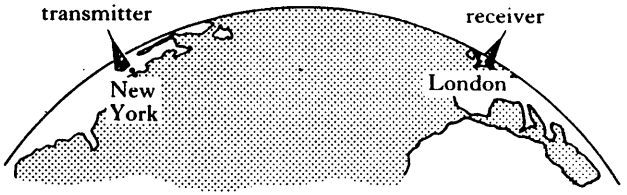
Material	*Specific latent heat of vaporisation in J/kg*
Alcohol	$11{\cdot}2 \times 10^5$
Carbon dioxide	$3{\cdot}77 \times 10^5$
Glycerol	$8{\cdot}30 \times 10^5$
Turpentine	$2{\cdot}90 \times 10^5$
Water	$22{\cdot}6 \times 10^5$

SI Prefixes and Multiplication Factors

Prefix	*Symbol*	*Factor*
mega	M	$1\,000\,000 = 10^6$
kilo	k	$1000 = 10^3$
milli	m	$0{\cdot}001 = 10^{-3}$
micro	μ	$0{\cdot}000\,001 = 10^{-6}$
nano	n	$0{\cdot}000\,000\,001 = 10^{-9}$

K&U	PS

1. Short wave television signals can travel only in a straight line from the transmitting aerial to the receiver. The diagram below shows a transmitter in New York and a receiver in London.



(*a*) Explain why UHF (ultra high frequency) television signals cannot be sent directly from New York to London.

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(*b*) Describe how UHF television signals are sent from New York to London.

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(*c*) What is the wavelength of a UHF television signal which is transmitted at a frequency of 625 MHz?

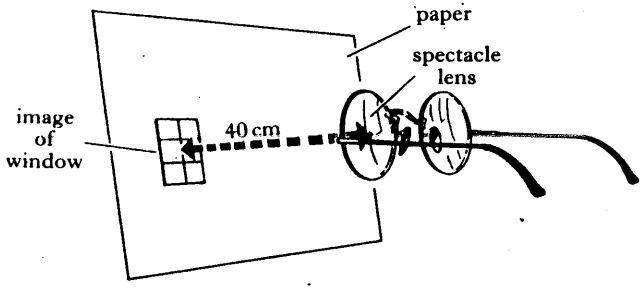
Space for working and answer

3

[Turn over

2. Karen is tidying the reading spectacles on display in a store. The spectacles on the display are labelled 4·0 D, 3·25 D, 2·75 D and 2·5 D. She notices that the label is missing from one pair.

Karen is asked to label correctly this pair of spectacles. She uses one of the spectacle lenses to focus a sharp image of a far-away window on to a piece of paper as shown below. The distance between the lens and the paper is 40 cm.

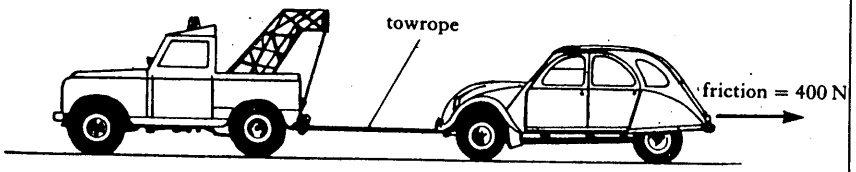


Which label should Karen attach to the spectacles? You **must** show clearly your working which leads you to your answer.

Space for working and answer

K&U	PS
	2

3. (*a*) A car of mass 1200 kg is being towed at a constant speed of 5 m/s by a breakdown lorry. The force of friction on the car at this speed is 400 N.



What size of force is exerted by the tow rope on the car?

Answer ____

K&U	PS
	1

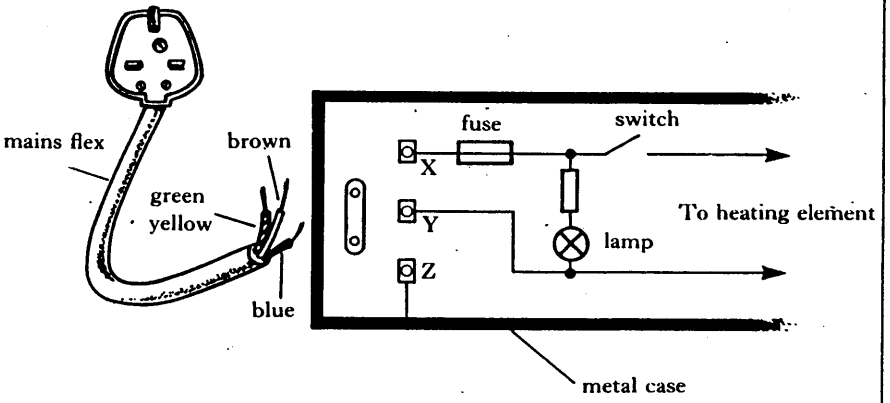
3. **(continued)**

(*b*) The force exerted by the tow rope on the car is increased to 2000 N. Assuming that the force of friction on the car remains constant at 400 N, find the acceleration of the car.

Space for working and answer

K&U	PS
	3

4. A mains flex is to be connected to a sandwich toaster. The flex and part of the layout of the toaster are shown below.



(*a*) State clearly which wire in the flex should be connected to terminals X, Y and Z.

X: ..... Y: ..... Z: .....

K&U	PS
	2

(*b*) What is the purpose of having the lamp connected as shown in the toaster circuit?

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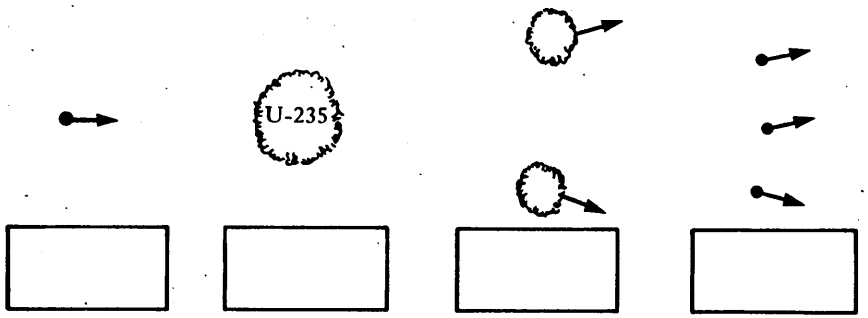
K&U	PS
	1

K&U	PS

5. The diagram below shows what happens when a uranium nucleus undergoes fission in a nuclear reaction. The diagram has not been labelled.



(*a*) Complete the diagram by selecting and inserting the correct labels from the following list.

uranium nucleus *fission fragment* *neutron.*

You may use a label more than once. **1**

(*b*) Describe how, inside a nuclear reactor, the above process can result in a chain reaction.

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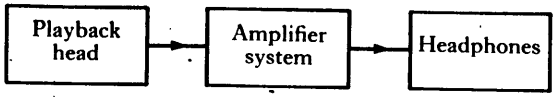
..... **3**

K&U	PS

6. A tape recorder is represented by the block diagram shown below.



(*a*) The amplifier system produces 0·02 W of power in the headphones which have a resistance of 18 Ω.

Calculate the voltage applied to the headphones.

Space for working and answer

2

(*b*) The amplifier system has a voltage gain of 20.

Calculate the size of the voltage signal produced by the playback head.

Space for working and answer

2

[Turn over

7. Carefully read the following information.

Special creams and liquids called sunscreens are used to protect the skin from the harmful effects of the ultra violet radiation (UV) from the sun. The sunscreens absorb some of the UV and prevent it reaching the skin.

Ultra violet radiation with wavelengths in the range 315–400 nm is called UVA. Radiation with wavelengths in the range 280–315 nm is called UVB.

The longer wavelength UVA can cause wrinkles and premature aging of the skin.

The shorter wavelength UVB gives a long-lasting tan but UVB causes sunburn.

Both UVA and UVB increase the risk of skin cancer.

The table below gives some properties of sunscreen chemicals P, Q, R and S at different wavelengths.

Sunscreen chemical	*Range of wavelengths absorbed*	*Effect of water*
P	250–320 nm	does not dissolve
Q	290–320 nm	dissolves
R	280–360 nm	dissolves
S	295–315 nm	dissolves

(*a*) Give **two** reasons why most sunscreens are made from a mixture of more than one of these chemicals.

Reason 1: .....

.....

Reason 2: .....

..... 2

(*b*) Which chemical gives most protection against premature aging of the skin?

Answer [ ] 1

(*c*) Sunscreens containing only chemicals listed in the table do not give complete protection against both aging and burning. Give a reason for this.

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(*d*) Although UV can harm our skin it can be used to our benefit.
Name **one** use of ultraviolet radiation in medicine.

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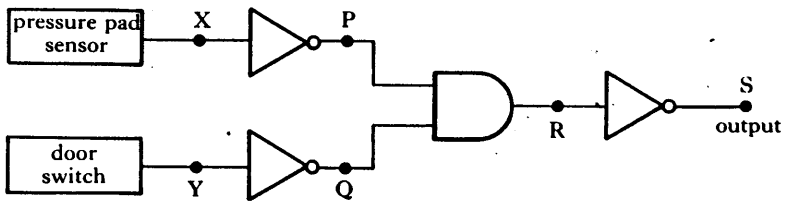
8. The diagram for an alarm system is shown below.



The alarm system is designed to operate if someone steps on a pressure pad or opens a door.

When someone stands on the pressure pad sensor, the logic level at X changes from 0 to 1.

When the door is opened, the logic level at Y changes from 0 to 1.

(*a*) Complete the table below to show the logic levels at P, Q, R and S when the logic levels at X and Y are as indicated.

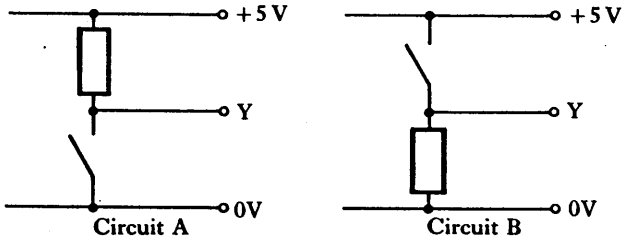
X	Y	P	Q	R	S
0	0				
0	1				
1	0				
1	1				

2

(*b*) The pupil could have designed the alarm system using only one logic gate. Name the gate he could have used.

..... 1

(*c*) Two possible circuits for the door switch are shown below. When the door closes, the switch closes.



Explain which circuit should be used in the above system.

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[Turn over

K&U	PS

9. (*a*) A set of Christmas tree lights contains 20 bulbs each labelled 12 V, 6 W. Each bulb is designed as shown in figure 1. The set is to be connected to the mains supply.

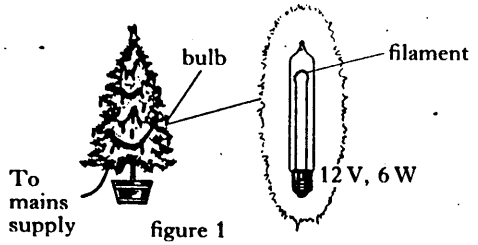

figure 1

(i) What is the voltage of the mains supply?

Answer _____ 1

(ii) Why must the bulbs in the set be connected in series?

.....

.....

..... 1

(iii) Calculate the current in a bulb when the tree lights are lit.

Space for working and answer

2

(iv) How much charge flows through one of the bulbs in 20 seconds?

Space for working and answer

2

K&U	PS

9. (*a*) **(continued)**

(v) Calculate the resistance of the filament in a bulb.

Space for working and answer

2

(*b*) An improved design of bulb contains a resistor connected in parallel with the filament as shown in figure 2.

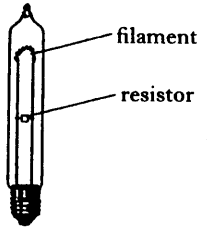

figure 2

The filament has a resistance of 45 Ω and the resistor has a resistance of 30 Ω.

(i) Calculate the resistance of the bulb.

Space for working and answer

2

(ii) Explain the purpose of the resistor in the improved design.

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10. (*a*) John attends hospital for an X-ray. X-rays cause ionisation.

(i) What is meant by ionisation?

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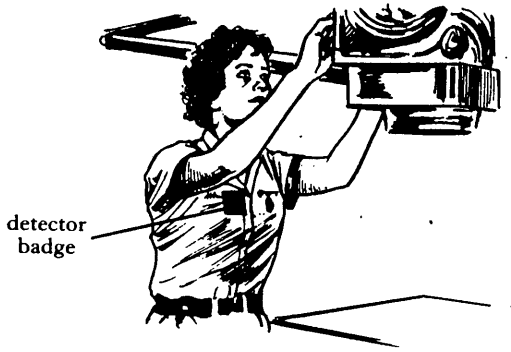
(ii) Name **two** other radiations which cause ionisation.

(1) ..... (2) 2

(*b*) The radiographer who was taking John's X-ray wore a detector badge containing a small piece of photographic film.



Each month, the film from her badge is developed and checked.

(i) How does the developed film show the amount of radiation to which she has been exposed?

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.....

..... 2

(ii) Why is it important to check on her exposure to radiation?

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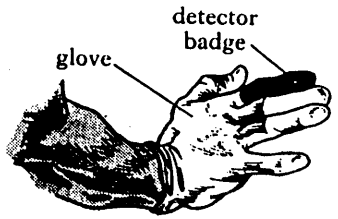
K&U	PS
2	
2	
2	
1	

10. (*b*) **(continued)**

(iii) When hospital technicians are making up doses of radioactive chemicals for patients, they wear detector badges on their gloves rather than on their laboratory coats.



Suggest a reason for this.

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(*c*) When John arrived at the X-ray department, he was told that he was to have a CAT-scan. CAT means computer assisted tomography.

What is the advantage of a CAT scan compared to a normal X-ray?

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[Turn over

K&U	PS
	2
1	

11. Figure 1 shows an electronic system which can be used as a timer.

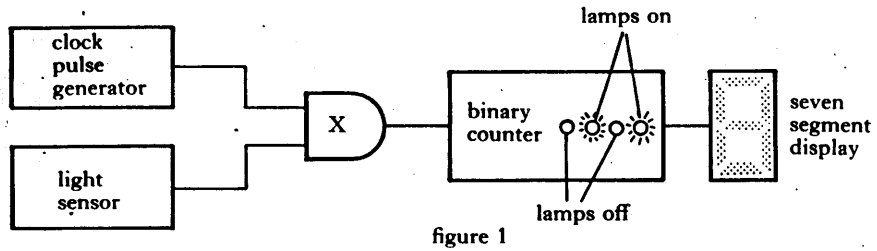
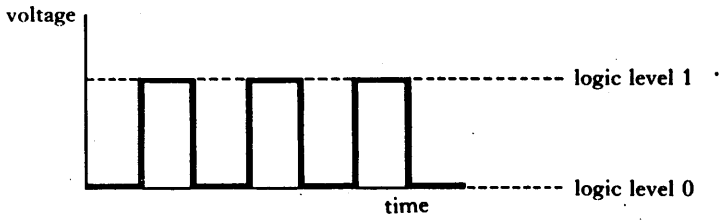


figure 1

The timer is switched on and off using a beam of light and a light sensor. The logic level at the output from the light sensor is shown in the table below.

Lighting condition at light sensor	*Logic level at output from light sensor*
dark	1
light	0

The clock pulse generator produces an output voltage which changes with time as shown in the graph below. The logic levels are indicated on the graph.



(*a*) (i) What name is given to logic gate X?

..... 1

(ii) Explain why no counts are recorded on the binary counter when the light beam shines on the light sensor.

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..... 2

(iii) What number appears on the seven segment display when the binary counter displays 0101 as shown in figure 1?

Answer ☐ 1

K&U	PS
	1
	2
	1

11. (continued)

(*b*) Saeed makes use of the electronic system in figure 1 on the previous page to help him measure the speed of a toy car. He sets up the apparatus as shown in figure 2 below and resets the binary counter and seven segment display to zero.

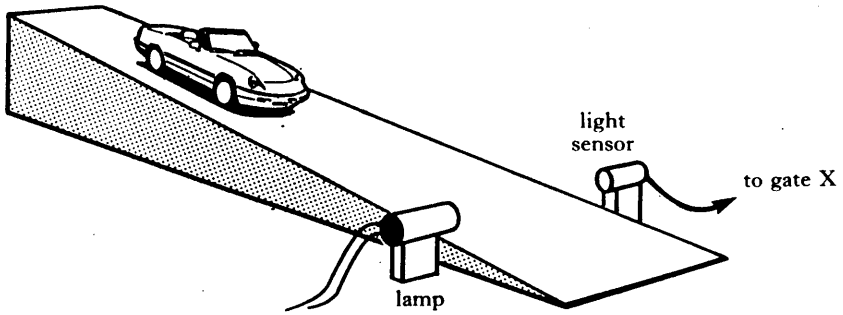

figure 2

When the car has passed through the light beam between the lamp and the light sensor, the seven segment display shows the number eight. The time for each clock pulse is shown in figure 3.

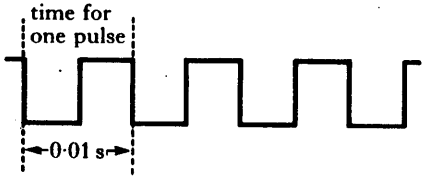

figure 3

(i) Calculate the time taken for the car to pass the light beam.

Space for working and answer

1

(ii) What other measurement is required so that Saeed can calculate the speed of the car as it passes through the light beam?

..... 1

(iii) How would Saeed use his measurements to calculate this speed?

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K&U	PS
	1
	1
	1

11. (continued)

(c) The electronic circuit which produces the clock pulses is shown in figure 4.

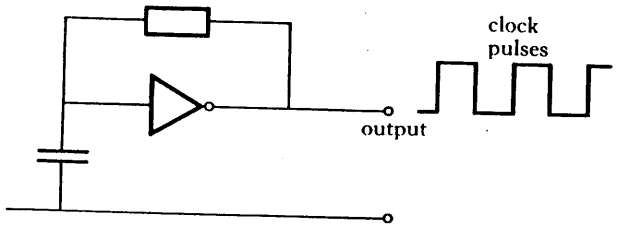

figure 4

(i) Saeed increases the value of the capacitor.

What effect does this have on the frequency of the clock pulses?

..... 1

(ii) What effect should this have on the accuracy of Saeed's time measurement?

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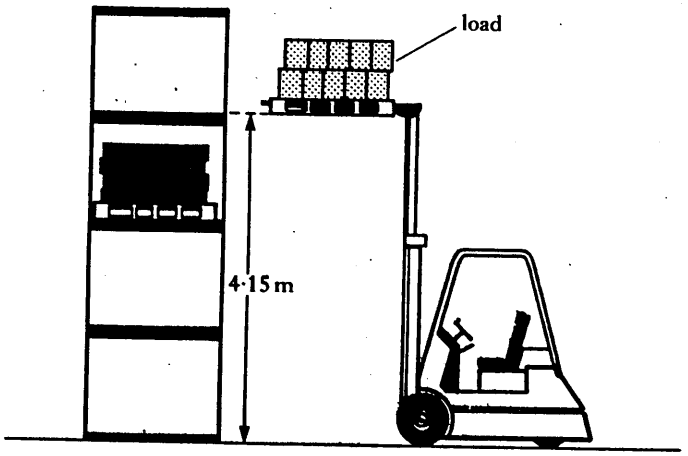
12. Tests are being carried out on a fork lift truck. The truck is designed to lift a load from the floor to a storage shelf.



The following measurements are recorded during a test.

Time taken to raise load	=	20·0 s
Current in motor	=	6·25 A
Voltage applied to motor	=	60·0 V
Mass of load	=	150 kg
Height of shelf from floor	=	4·15 m

(a) Calculate the electrical energy supplied to the motor to raise the load to the shelf.

Space for working and answer

3

(b) Calculate the gain in potential energy of the load after it has been raised.

Space for working and answer

2

12. (continued)

(*c*) Calculate the efficiency of the fork lift truck motor during this test.

Space for working and answer

2

(*d*) Explain why the efficiency of the fork lift truck is not 100%.

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1

13. (*a*) A model of a rooftop solar panel is used to heat water as shown in figure 1.

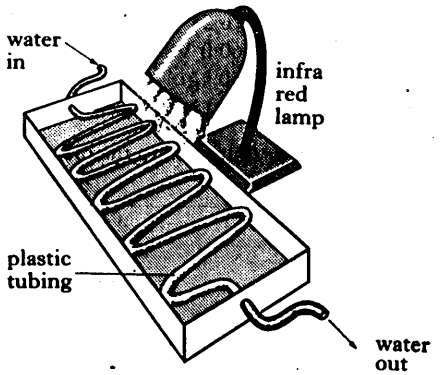

figure 1

A class tests the model in the laboratory and obtains the following results:

Temperature of water flowing into panel = 15 °C
Temperature of water flowing out of panel = 24 °C
Mass of water flowing through panel each minute = 0·30 kg

(i) Calculate the amount of heat absorbed by the water in one minute.

Space for working and answer

3

13. (*a*) **(continued)**

(ii) Suggest **two** changes to the design of the model which would increase the temperature of the water flowing out of the model.

First change: .....

.....

Second change: .....

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2

(*b*) Figure 2 shows lines joining places in Britain which receive the same solar energy during one year. The number of kilowatt hours of energy received on each square metre is marked beside the lines.

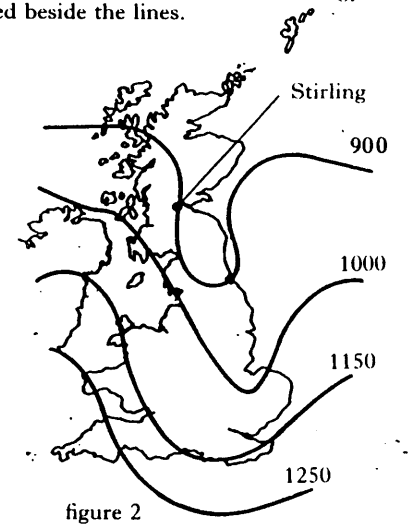

figure 2

(i) What is the solar energy which is received by each square metre in one year in Stirling?

Answer .....

1

(ii) Calculate the area of a rooftop solar panel in Stirling which would receive 3000 kWh of energy in one year.

Space for working and answer

2

(iii) A family in Stirling plans to use a solar panel which can produce 3000 kWh each year for heating water.

Why would a panel of the area you calculated in part (ii) be unable to provide this amount of energy?

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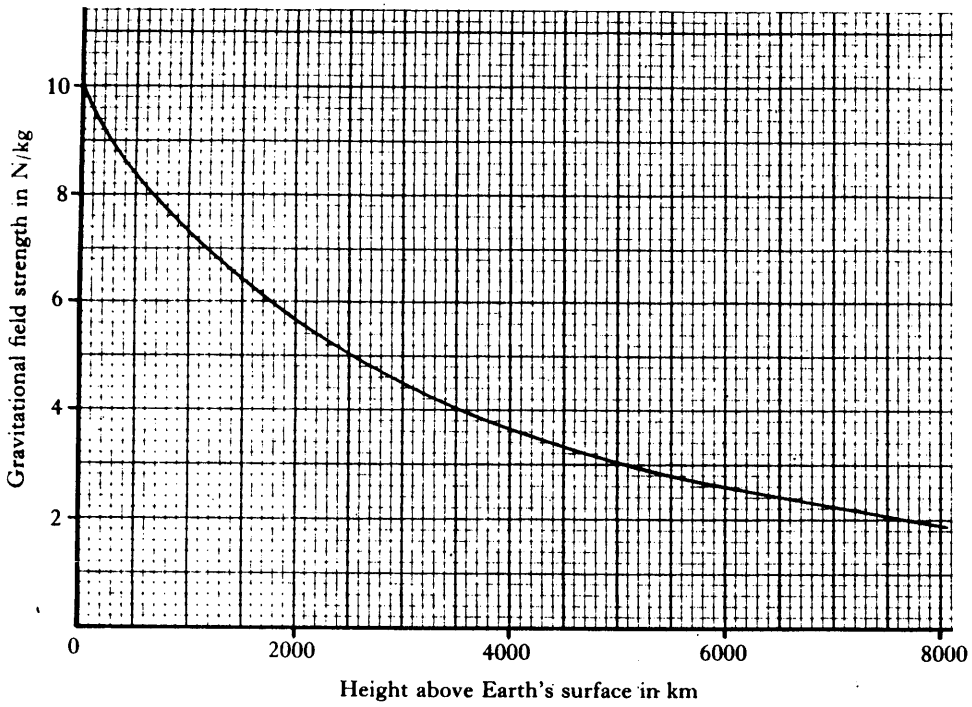
14. (*a*) The graph below shows the value of the gravitational field strength at various heights above the Earth's surface.



An astronaut of mass 80 kg orbits in a capsule at a height of 3000 km.

(i) What is the gravitational field strength at this height?

Answer _____ 1

(ii) Calculate the astronaut's weight at this height.

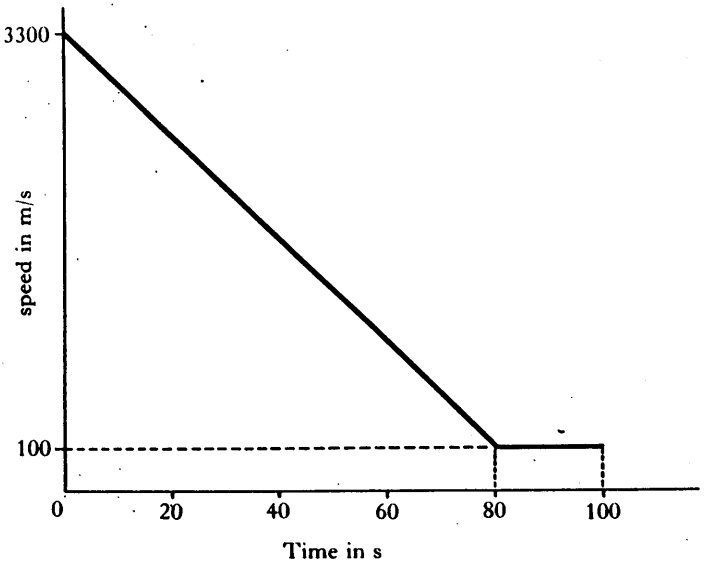
Space for working and answer 2

(iii) What is the mass of the astronaut when he returns to Earth?

Answer _____ 1

14. **(continued)**

(*b*) The sketch graph below shows how the speed of the space capsule changes with time during part of its journey back to Earth.



(i) How far did the capsule travel in the 100 s shown?

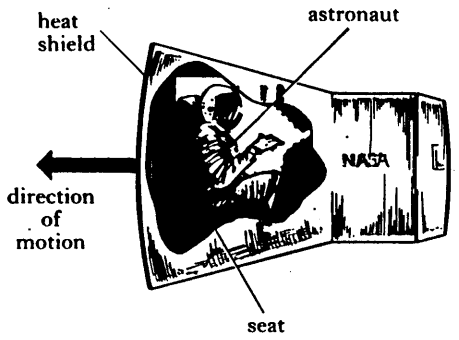
Space for working and answer 2

(ii) Calculate the deceleration of the capsule before it reaches a constant speed.

Space for working and answer 2

14. (continued)

(*c*) During re-entry, the astronaut sits in the capsule as shown below.



Sitting in this position, the astronaut feels as if he is being pushed against the back of his seat during re-entry.

Using Newton's laws, explain why he experiences this feeling.

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(*d*) During re-entry some of the heat shield on the capsule melts.

Explain why this helps to keep the capsule cool.

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[END OF QUESTION PAPER]

K&U	PS

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

K&U	PS