C

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Presenting Centre No.	Candidate No.	Subject No.	Level	Paper No.	Group No.	Marker's No.	
		3220					

K&U	PS

Total Marks

[3220/145] 1994

SCOTTISH CERTIFICATE OF EDUCATION

PHYSICS

Standard Grade—CREDIT LEVEL

Friday, 13th 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.**
6. **Any necessary data will be found in the DATA SHEET on page two.**

ES 3220/145 6/3/30110

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
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	$0{\cdot}99 \times 10^5$
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

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	$11{\cdot}2 \times 10^5$
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	0·001 $= 10^{-3}$
micro	μ	0·000 001 $= 10^{-6}$
nano	n	0·000 000 001 $= 10^{-9}$

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1. The table below gives information about the wavelength and output power of some types of laser.

Type of laser	*Wavelength* *m*	*Output power* *W*
Excimer	$3{\cdot}2 \times 10^{-7}$	20·0
Argon	$4{\cdot}9 \times 10^{-7}$	2·0
Dye	$5{\cdot}5 \times 10^{-7}$	0·5
Helium-neon	$6{\cdot}3 \times 10^{-7}$	0·005
Nd-YAG	$10{\cdot}6 \times 10^{-7}$	50·0

The visible spectrum has wavelengths ranging from $4{\cdot}0 \times 10^{-7}$ m to $7{\cdot}0 \times 10^{-7}$ m.

(*a*) Which laser emits infrared radiation?

..... **1**

(*b*) Name **one** medical use of infrared radiation.

..... **1**

(*c*) Calculate the frequency of light from the helium-neon laser.

Space for working and answer

3

(*d*) Light from an argon laser is used to treat a patient's eye. During the treatment, the laser fires 15 short pulses of light. Each pulse lasts 0·2 second.

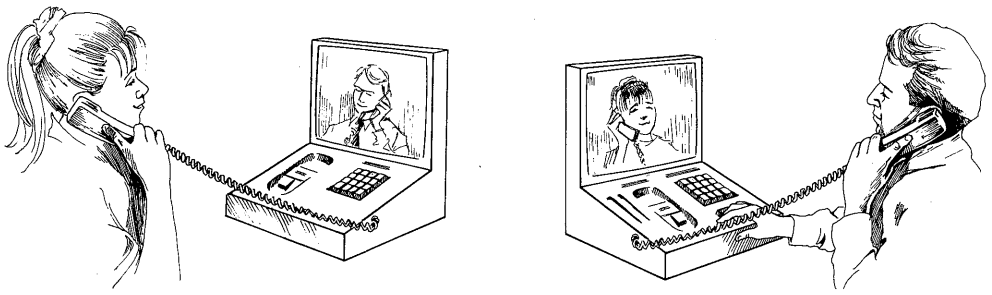
Calculate the energy given out by the laser during the treatment.

Space for working and answer

3

K&U	PS

2. Videophones are special telephones which can be used to send both pictures (video) and sound between Glasgow and London.

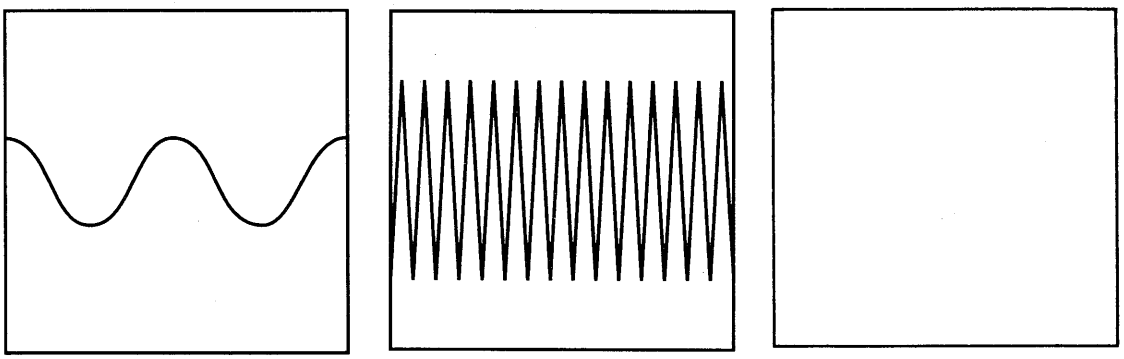


GLASGOW LONDON

The video signals of the videophone are produced by a small television camera.

(*a*) When a videophone is used, the video signal is combined with a carrier wave to produce a modulated signal. Diagrams representing the video signal and the carrier wave are shown below.

Draw the modulated signal in the space provided.



video signal carrier wave modulated signal

2

(*b*) A modulated signal from a videophone in Glasgow is converted into a light signal at a telephone exchange in Glasgow. This light signal is transmitted along a glass optical fibre to a telephone exchange in London. The length of the optical fibre is 700 km.

Calculate the time taken for the light signal to travel from Glasgow to London.

Space for working and answer

3

K&U	PS

2. (continued)

(*c*) A videophone picture received in London may be displayed on a large black and white television screen.

Describe, with the aid of a diagram, how the picture is built up on the television screen.

Space for diagram and answer

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..... **3**

[Turn over

K&U	PS

3. The heating elements of one make of toaster are connected as shown in figure 1. Figure 2 shows how the heating elements are arranged in a second make of toaster. The resistances of the heating elements are as indicated in the figures.

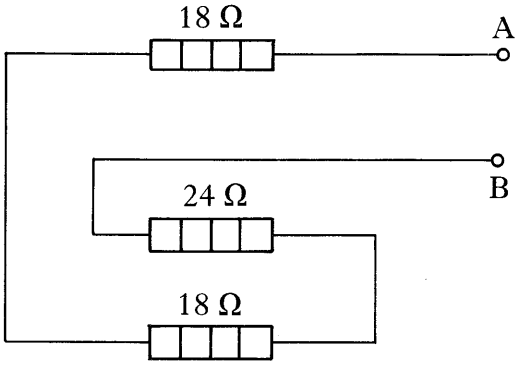

figure 1

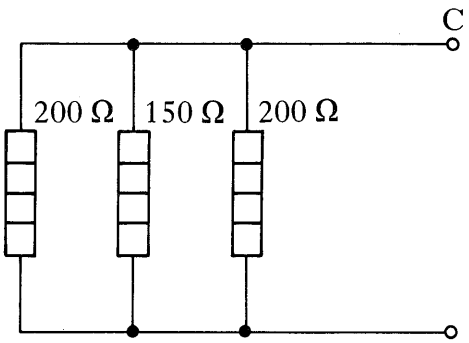

figure 2

(*a*) Calculate the resistance between points A and B in figure 1.

Space for working and answer

2

(*b*) Calculate the resistance between points C and D in figure 2.

Space for working and answer

2

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3. (continued)

(*c*) Calculate the power of the toaster shown in figure 2 when the 240 V mains supply is connected to C and D.

Space for working and answer — 2

(*d*) One of the heating elements shown in **figure 1** burns out and the toaster stops working. This fault cannot be seen.

An electrician tries to identify which heating element is faulty. She disconnects the toaster from the mains supply and uses a multimeter which can be set to measure either **current** or **voltage** or **resistance.**

She connects the multimeter across each element in turn.

(i) What quantity should the multimeter be set to measure?

..... 1

(ii) How does the electrician use the multimeter readings to identify the faulty element?

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.....

..... 1

(iii) The multimeter will indicate either an open or a short circuit when connected across the faulty element.

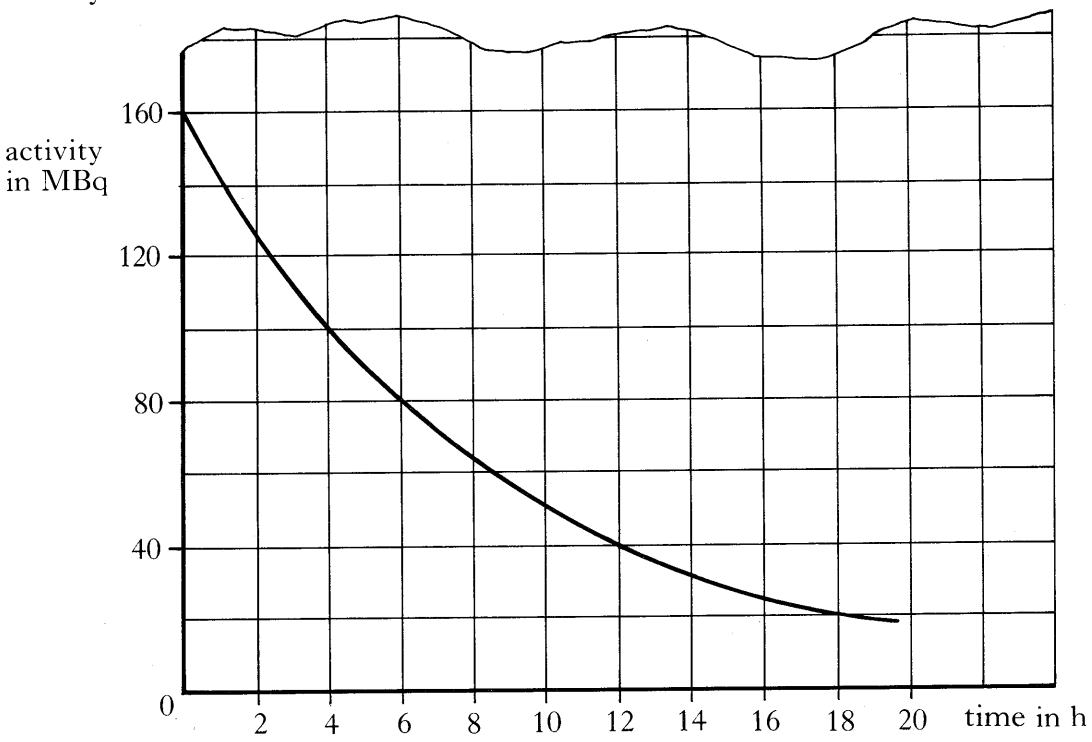
Which fault will it indicate in this case?

..... 1

[Turn over

K&U	PS

4. A radioactive element emits gamma radiation. The graph below shows how the activity of the element decreases with time.

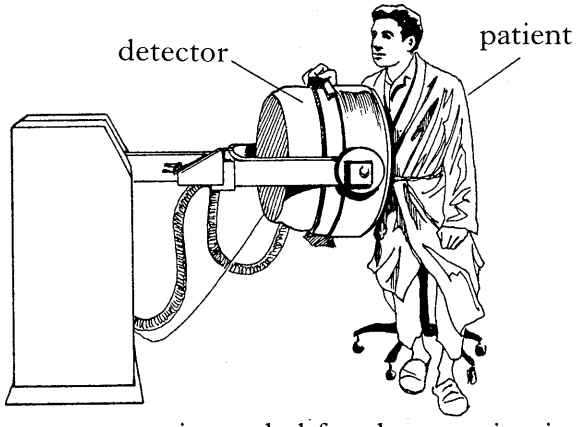


(*a*) What is the half-life of the radioactive element?

Space for working and answer

2

(*b*) As part of a medical examination, a patient has to drink a solution containing a sample of this radioactive element. The examination involves detecting the radiation coming from the radioactive element inside the patient's body.



Explain why a gamma source is needed for the examination.

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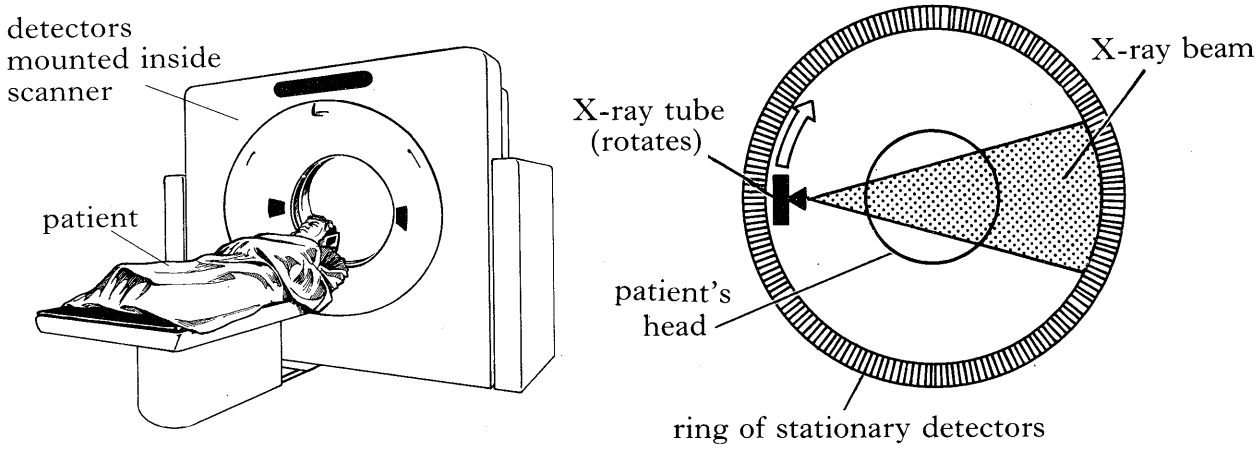
1

K&U	PS

4. (continued)

(*c*) A computerised tomography (CT) scanner has a moving X-ray tube and is surrounded by a number of stationary detectors as shown below. The scanner is used to display a picture of the inside of a patient's head.



State the advantage of this method compared to a single X-ray picture of the patient's head.

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(*d*) A small brain tumour can be treated using a chemical which emits alpha radiation. The chemical is absorbed by the tumour. The alpha radiation produces ionisation which destroys the tumour.

(i) What is meant by ionisation?

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..... **2**

(ii) Suggest why alpha radiation is used for this treatment rather than beta or gamma radiation.

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..... **1**

(*e*) When radiation is absorbed in tissue, the effect depends on the tissue and the type of radiation. A measure of the effect of the radiation on tissue is given by the dose equivalent.

State the unit of dose equivalent.

..... **1**

[Turn over

K&U	PS

5. When money is inserted into a drinks machine, a drink may be obtained and change given if necessary. The machine contains three coin chutes to enable it to give change. When the machine is able to give change, a light emitting diode (LED), at eye level, glows steadily. If the machine is unable to give change, the LED flashes on and off continuously to warn the customer.

Figure 1 shows part of the circuit which controls the operation of the LED.

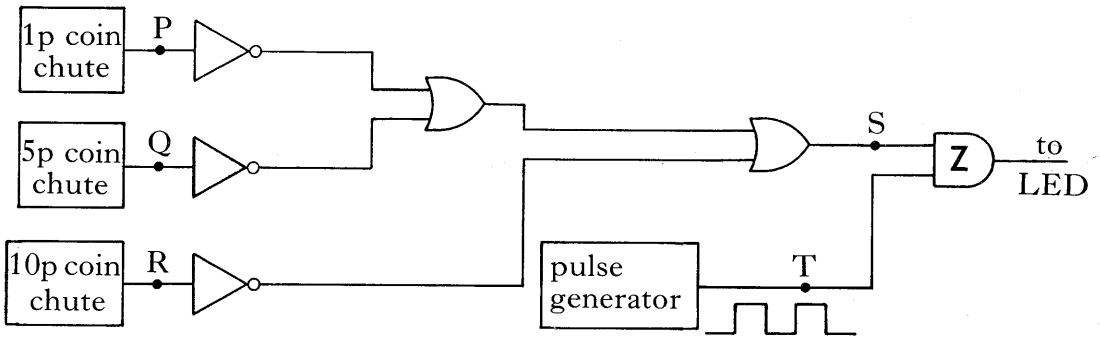

figure 1

The electronic outputs from the coin chutes are labelled P, Q and R.

When there are no coins in a chute, then its output is at logic level 0.

When there are coins in a chute, then its output is at logic level 1.

(*a*) A table may be constructed to show the logic levels at P, Q, R and S shown in figure 1. Part of the table is shown below.

Complete the table to show the logic levels at P, Q, R and S for the two rows shown.

P	Q	R	S
0	1	1	
			0

2

(*b*) The pulse generator produces an output at T in figure 1. This output is shown in figure 2.

figure 2

What happens to the logic output of gate Z when the logic level at S is 1?

Explain your answer.

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2

K&U	PS

5. (continued)

(*c*) An LED is connected to the output of gate Z as shown in figure 3.

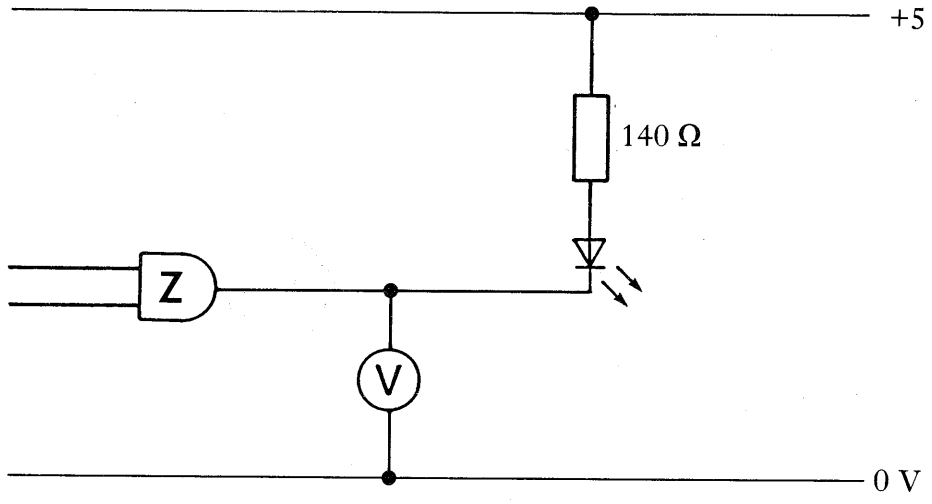


figure 3

When the output from gate Z is at logic level 0, the voltmeter reads 0 volt.
When the output from gate Z is at logic level 1, the voltmeter reads 5 volts.

(i) What is the logic level of the output from gate Z when the LED is lit?

..... **1**

(ii) When lit, the current in the LED is 20 mA.
Calculate the voltage across the LED.

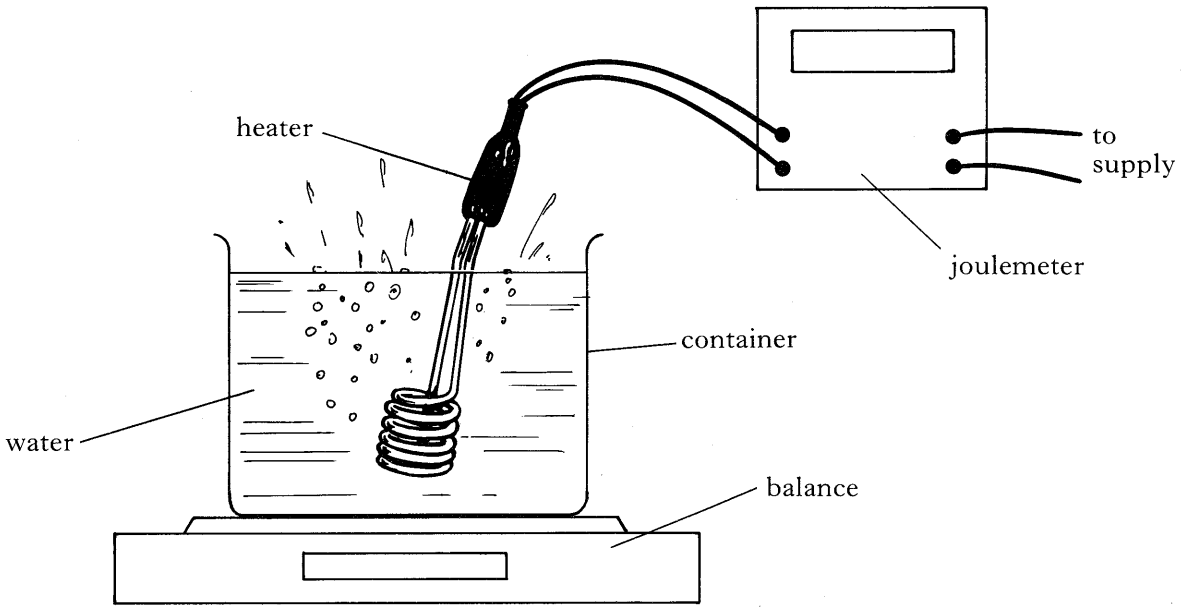
Space for working and answer

3

[Turn over

K&U	PS

6. A pupil sets up the apparatus shown below in an experiment to calculate a value for the specific latent heat of vaporisation of water.



The reading on the balance remains steady as the water is brought to the boil.

The pupil then observes that the reading on the balance gradually decreases.

The energy supplied during the time taken for the reading on the balance to drop by 0·15 kg is measured by the pupil to be $3{\cdot}15 \times 10^5$ J.

(*a*) Calculate a value for the specific latent heat of vaporisation of water from the pupil's experiment.

Space for working and answer

2

(*b*) During the experiment, the pupil noticed that water splashes out of the container due to the vigorous boiling.

(i) Explain why the splashing is likely to cause a lower value than expected for the specific latent heat of vaporisation of water.

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..... 1

(ii) How could this splashing be reduced?

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..... 1

K&U	PS

7. A car is travelling along a straight road. An electronic timer is used to time how long the car takes to pass through an infrared beam. The car has a mass of 1100 kg and a length of 4·5 m.

(*a*) The time taken to pass through the beam is measured to be 0·34 s.

Calculate the average speed of the car as it passes through the beam.

(Use an appropriate number of figures in your answer.)

Space for working and answer

2

(*b*) A graph of the car's speed against time is shown in figure 1.

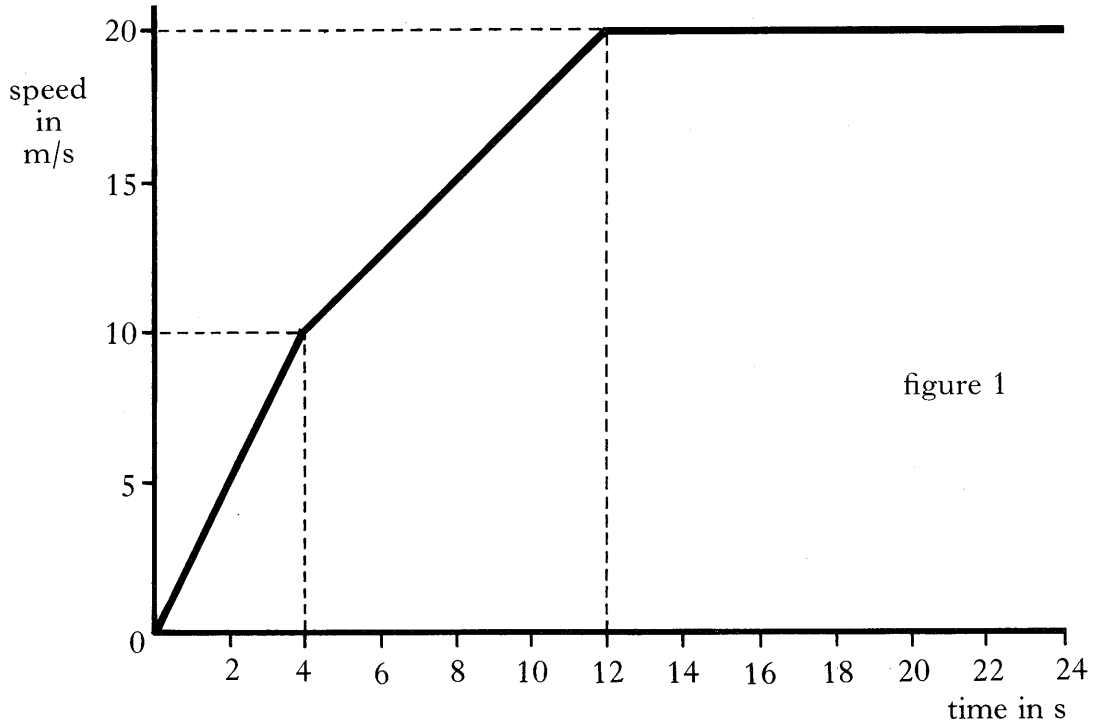

figure 1

Calculate the unbalanced force on the car between 4 s and 12 s.

Space for working and answer

4

7. (continued)

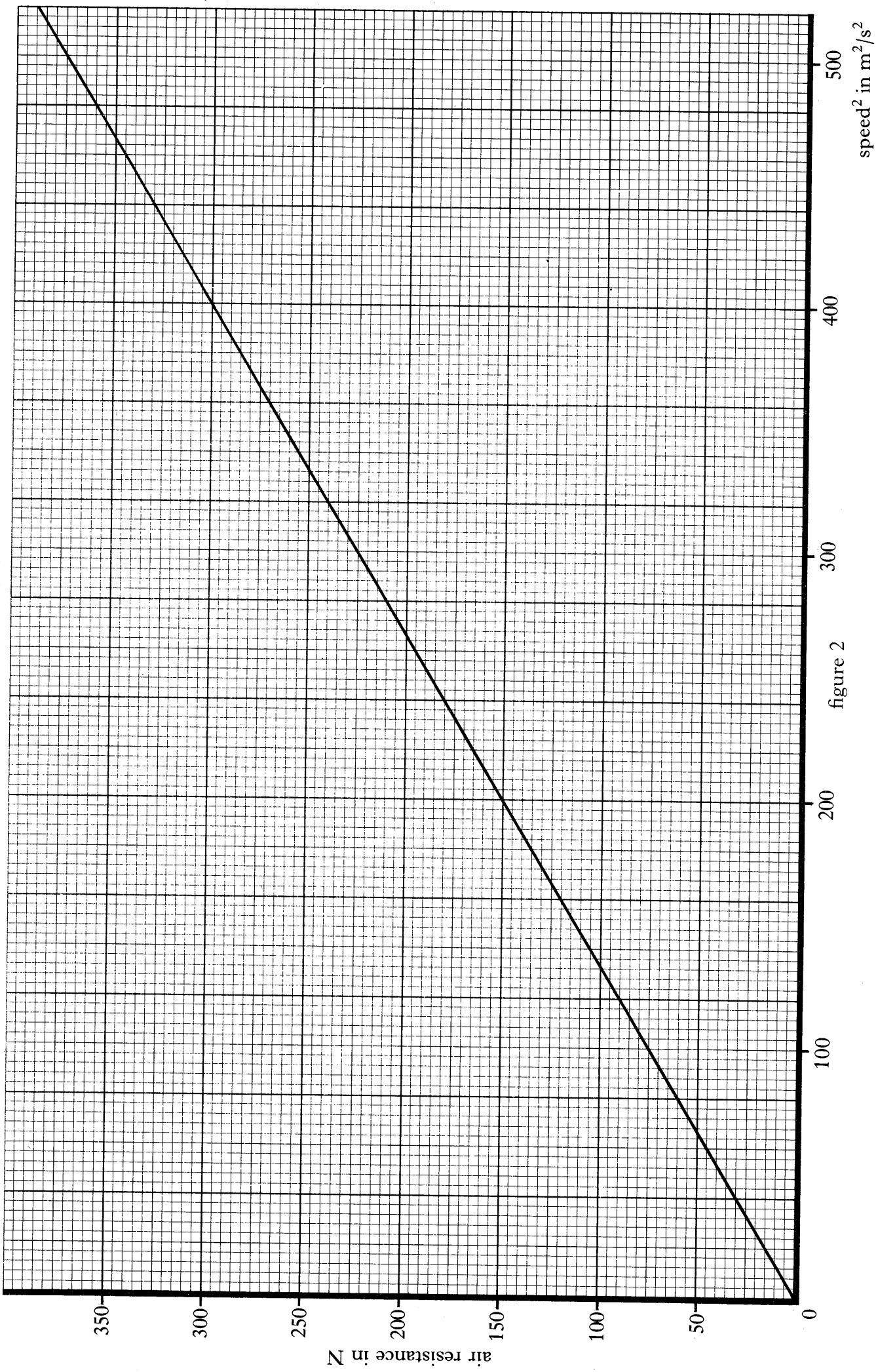

figure 2

K&U	PS

7. (continued)

(*c*) Air resistance acts on the car while it is moving. Figure 2, on the page opposite, shows how the air resistance varies when plotted against the speed squared.

Using data from the graphs, find the air resistance acting on the car between 12 s and 20 s.

Space for working and answer

2

(*d*) The car's average fuel consumption increases when a very light unladen roof rack is placed on the car. Explain why this happens.

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[Turn over

K&U	PS

8. (*a*) A 25 kΩ resistor is connected in series with a thermistor and a 12 V supply as shown in figure 1.

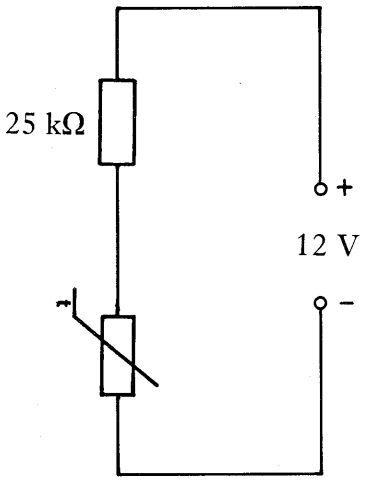

figure 1

At a particular temperature the voltage across the thermistor is 2 V.

(i) Calculate the voltage across the resistor.

Space for working and answer

1

(ii) Calculate the resistance of the thermistor.

Space for working and answer

2

K&U	PS

8. (continued)

(*b*) A graph of resistance of the thermistor against temperature is shown in figure 2.

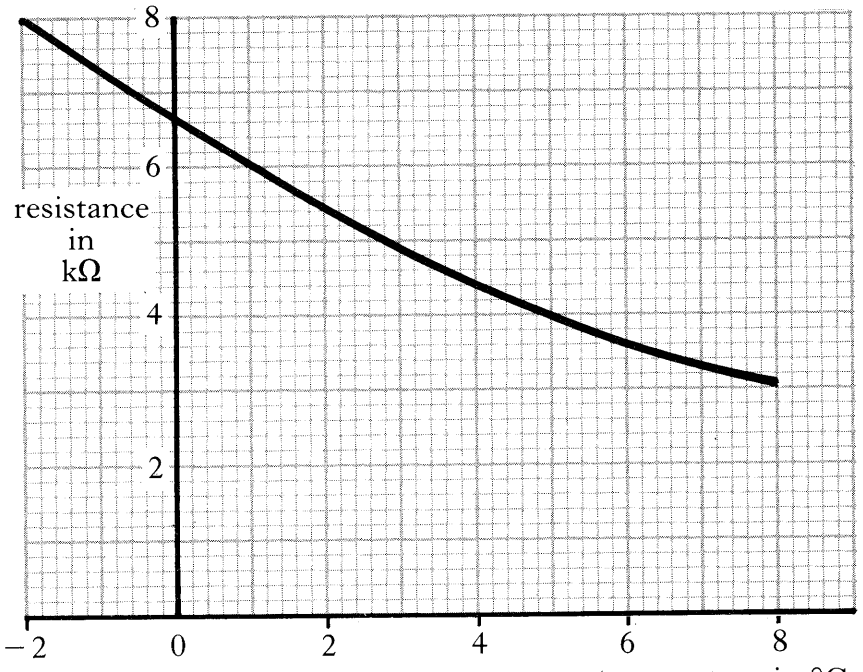

figure 2

Use the graph to estimate the temperature of the thermistor.

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1

(*c*) Some cars are fitted with a warning device as shown in figure 3. The circuit alerts the driver when there is a risk of ice on the road.

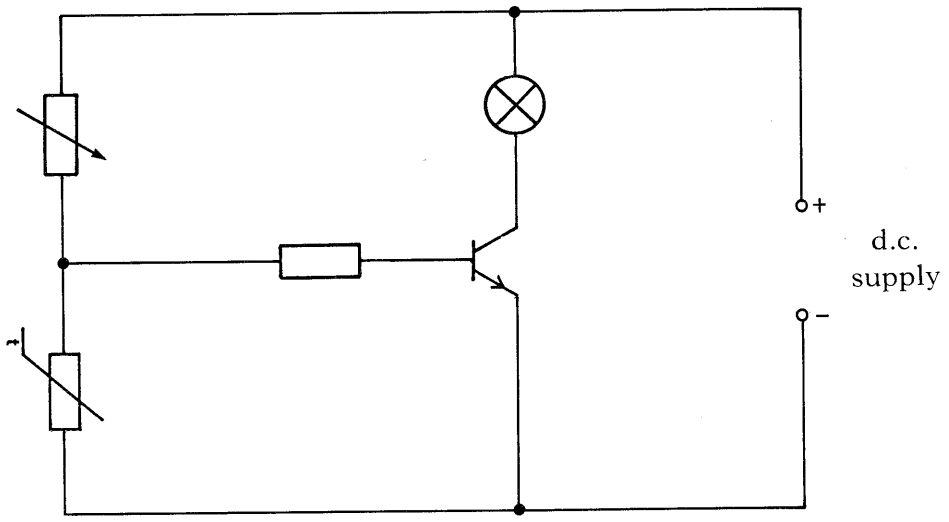

figure 3

Describe how the circuit works.

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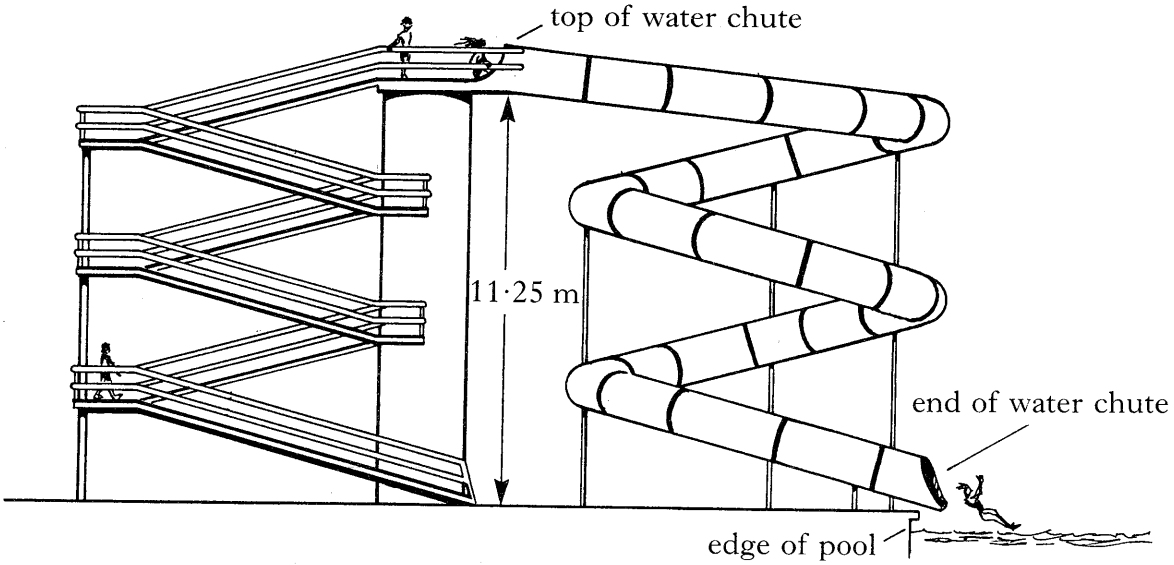
9. The diagram shows a water chute at a leisure pool. The top of the chute is 11·25 m above the edge of the pool. A girl, of mass 50 kg, climbs from the edge of the pool to the top of the water chute.



(*a*) Calculate the potential energy gained by the girl in climbing from the edge of the pool to the top of the chute.

Space for working and answer

2

(*b*) The girl slides from rest to the bottom of the chute. Assuming that her potential energy is all transferred to kinetic energy, show that her speed at the bottom of the chute is 15 m/s.

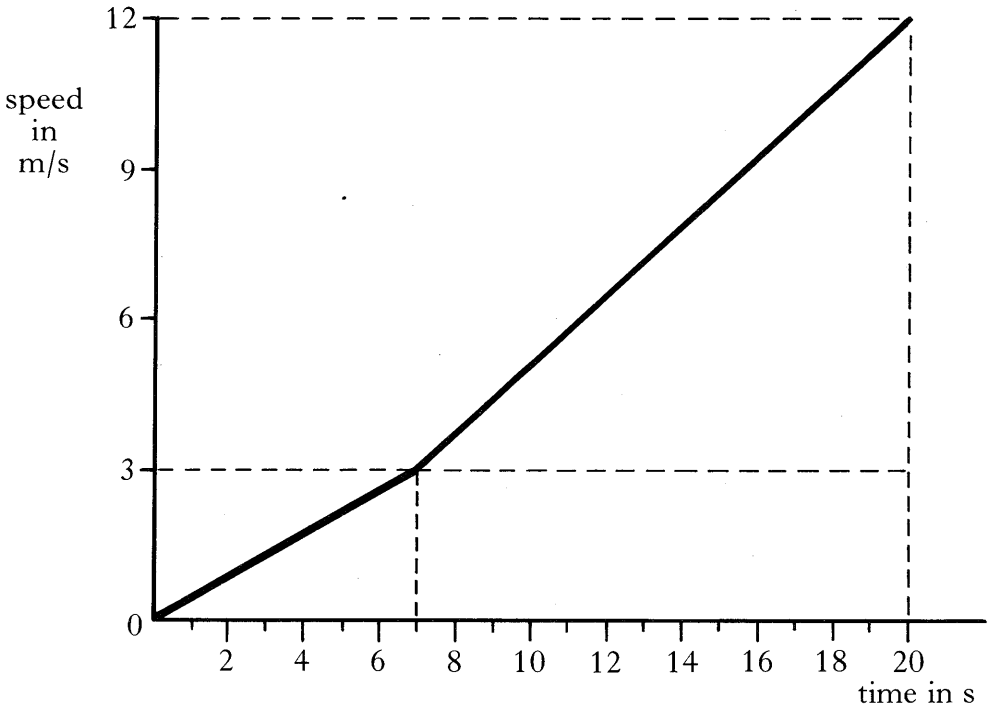
Space for working and answer

2

K&U	PS

9. (continued)

(*c*) Frictional forces act on the girl so that her actual speed at the bottom of the chute is 12 m/s. The graph below shows how the girl's speed varies with time as she slides down the chute.



(i) Calculate the distance travelled by the girl in sliding from the top to the bottom of the chute.

Space for working and answer

3

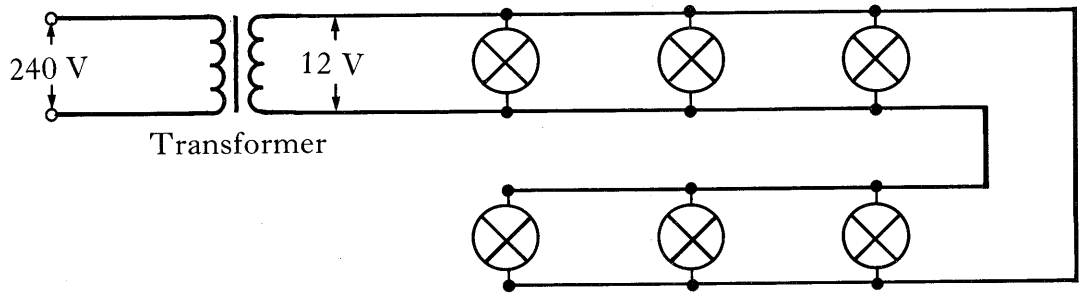
(ii) The energy transferred as heat in her journey down the chute is 2025 J. Calculate the average frictional force acting on the girl.

Space for working and answer

2

K&U	PS

10. A shop window display area is illuminated using a low voltage lighting circuit. The circuit consists of a transformer and six lamps each rated at 12 V, 50 W connected as shown below.



The transformer converts the 240 V mains voltage to the 12 V required to operate the lamps.

(*a*) Assume that the lamps are operating at their correct rating and the transformer is 100% efficient.

(i) Calculate the current in **one** of the lamps.

Space for working and answer

2

(ii) Calculate the current drawn from the transformer.

Space for working and answer

1

(iii) Calculate the current drawn from the mains supply.

Space for working and answer

2

(*b*) Give **one** reason why transformers are not 100% efficient.

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1

	K&U	PS

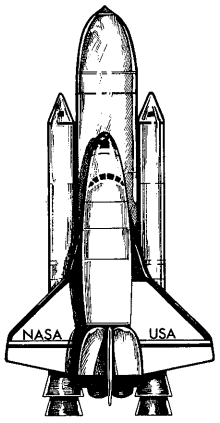
11. (*a*) A space shuttle of mass $2{\cdot}1 \times 10^6$ kg lifts off from Earth. At lift-off, the force on the shuttle due to air resistance is zero.

(i) Calculate the weight of the shuttle at lift-off.

Space for working and answer

2

(ii) On the diagram below, label the forces acting on the shuttle at lift-off and show their direction.



2

(iii) Explain why the speed of a spacecraft, travelling in outer space, is constant although its engines are switched off.

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(*b*) A space shuttle is used to launch a satellite.

(i) The period of the satellite's orbit is 12 hours.

State what would have to happen to the height of the orbit to make it geostationary.

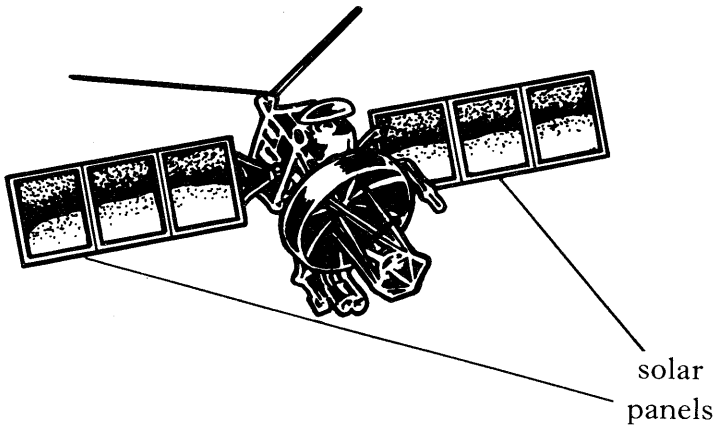
..... 1

[Turn over

	K&U	PS

11. (continued)

(*b*) (ii) The satellite has solar panels, as shown below, which use solar power to produce electricity.



The solar power received on each square metre of panel is 1·5 kW.

The total area of the panels is 12 m^2 and their efficiency is 10%.

Calculate the electrical power from the panels.

Space for working and answer

3

(*c*) During re-entry to the Earth's atmosphere, the temperature of the heat shield of the shuttle rises by 1300 °C. The heat shield has a mass of 3500 kg and gains $4{\cdot}7 \times 10^9$ J of heat.

(i) Calculate the specific heat capacity of the heat shield.

Space for working and answer

2

(ii) Using the Data sheet, identify the material of which the shield is made.

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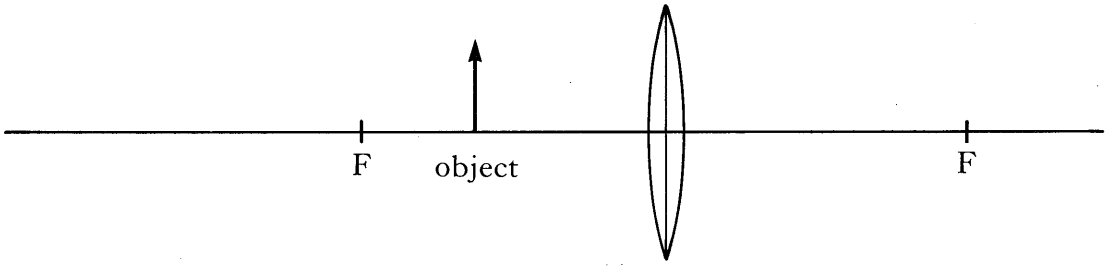
1

K&U	PS

12. (*a*) The diagram shows a refracting telescope.

(i) The eyepiece lens can be used as a magnifying glass.

Complete the diagram below to show how a magnified image of an object is formed. The points marked F are one focal length from the centre of the lens.



3

(ii) How could the design of the telescope be altered to increase the brightness of the image when viewing a star?

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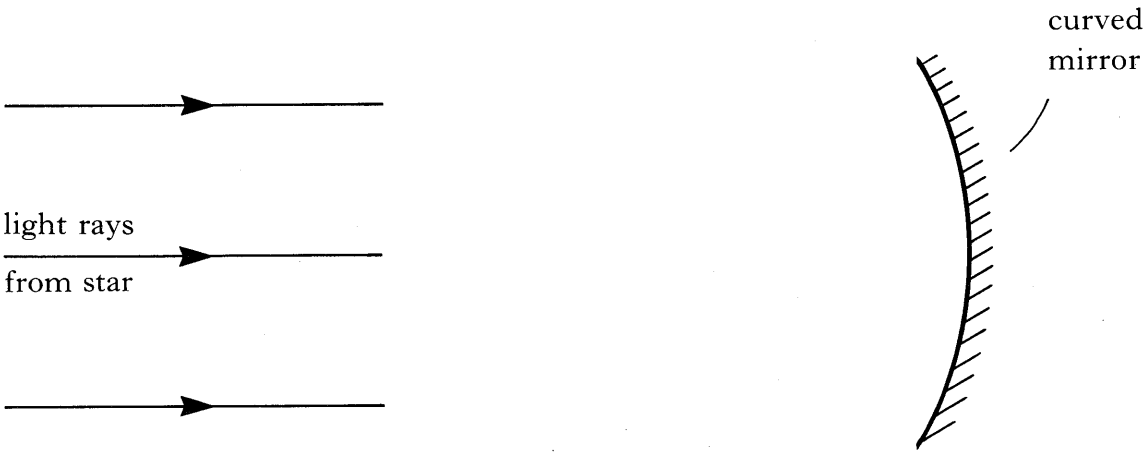
1

(*b*) The Hubble telescope was put in orbit around the Earth in 1990.

(i) The telescope uses a curved mirror to collect light rays from a star as shown below.



Complete the diagram to show what happens to the rays of light after they reach the mirror.

2

12. (continued)

(*b*) (ii) The telescope has detectors for various radiations.

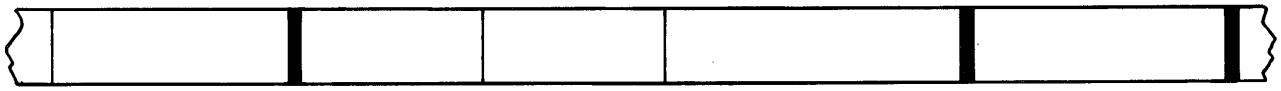
Name a possible detector for ultraviolet radiation.

..... **1**

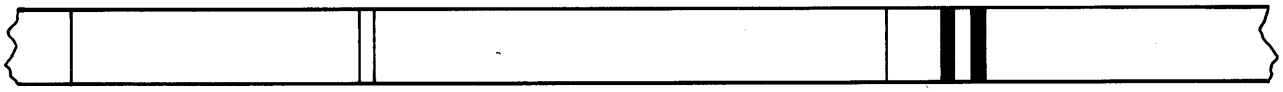
(iii) The spectral lines of radiation from a distant star are shown in figure 1. Figure 2 shows the spectral lines of a number of elements.

figure 1

Hydrogen



Helium



Sodium

Mercury

figure 2

Use the spectral lines of the elements in figure 2 to identify which elements are present in the star.

..... **2**

[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

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