C

K & U   PS

Total Marks

3220/402

NATIONAL	FRIDAY, 28 MAY	**PHYSICS**
QUALIFICATIONS	10.50 AM – 12.35 PM	STANDARD GRADE
2004		Credit Level

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Date of birth
Day Month Year   Scottish candidate number   Number of seat

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.

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	$3{\cdot}0 \times 10^8$
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	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
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

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	
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	$= 10^{-9}$

1. A mobile phone can send signals on 3 different frequencies, 900 MHz, 1800 MHz and 1900 MHz.

   (a) (i) Which signal has the longest wavelength?

   .... **1**

   (ii) Calculate the wavelength of the 1800 MHz signal.

   Space for working and answer

   3

   (b) At a base station, microwave signals from the mobile phone are converted into light signals for transmission along an optical fibre.

   (i) State two advantages of sending light signals along an optical fibre compared to sending electrical signals along a wire.

   ....

   .... **2**

   (ii) The time taken for light to travel along a glass optical fibre is 1·2 ms.

   (A) State the speed at which signals travel along the optical fibre.

   .... **1**

   (B) Calculate the length of the optical fibre.

   Space for working and answer

   2

Marks

2. A colour television receiver displays 25 images on the screen every second.

(*a*) Calculate the number of images displayed on the screen in one minute.

> *Space for working and answer*

1

(*b*) The television receiver contains decoders.

State the function of a decoder.

....

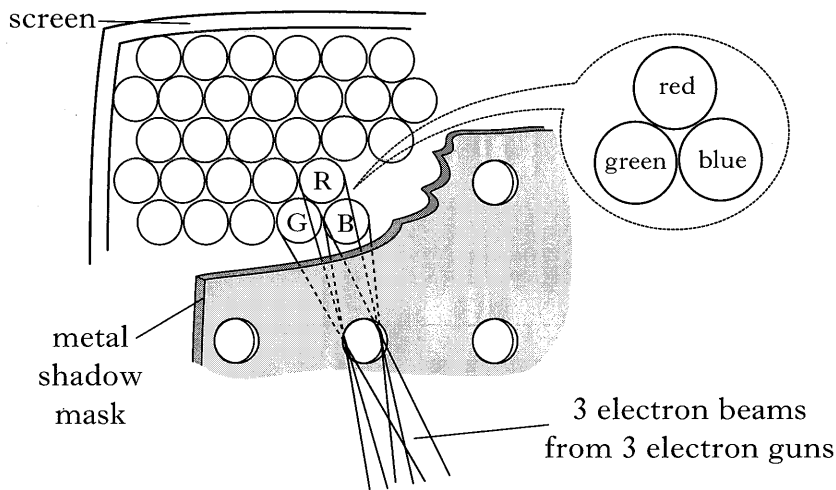.. 1

(*c*) In the colour television tube, three electron guns each send a beam of electrons to the screen.

(i) Why are **three** electron guns needed in a **colour** television tube?

....

.... 1

(ii) The diagram below shows the screen and the shadow mask in a colour television tube.

Use information from the diagram to explain why a shadow mask is needed.

....

....

.... 2

3. A portable radio contains a rechargeable battery and a generator. The battery is charged by turning the handle of the generator.

Marks
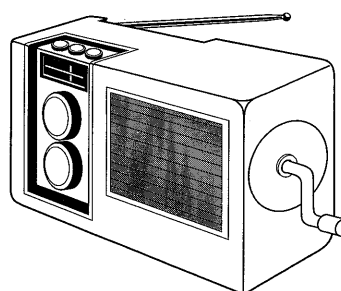
(*a*) State the purpose of the battery.

....   **1**

(*b*) The battery is fully discharged. The handle of the generator is turned 500 times by a constant force of 9·0 N. For each turn of the handle, the force moves through a distance of 400 mm.

  (i) Show that the work done in charging the battery is 1800 J.

> *Space for working and answer*

  2

  (ii) Only 90% of the work done in charging the battery is available as output energy from the battery.

    (A) Calculate the output energy available.

> *Space for working and answer*

  2

    (B) When operating, the radio takes a current of 250 mA. The voltage of the battery is 3 V.

    Calculate the maximum time for which the radio operates.
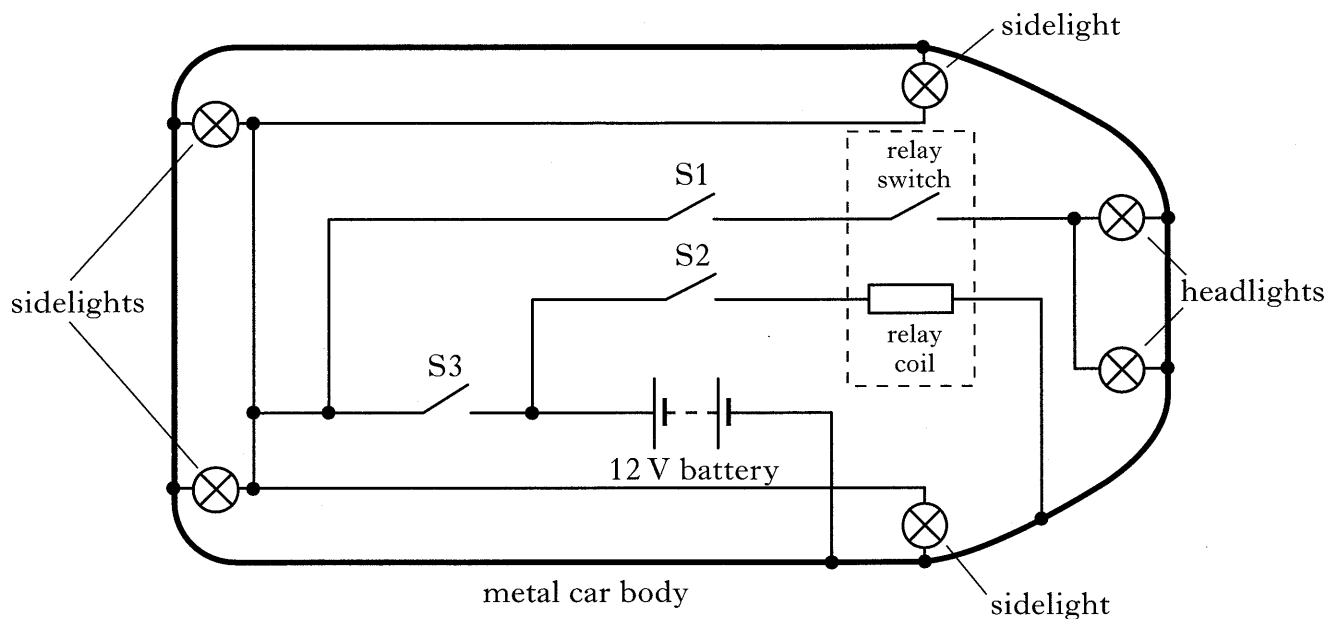
> *Space for working and answer*

  2

4. The circuit diagram of the wiring of a car's sidelights and headlights is shown.

S1 is the headlight switch. S2 is the ignition switch.

When there is a current in the relay coil, the relay switch closes.

(*a*) Which lights are on when switch S3 **only** is closed?

.... 1

(*b*) At night the car has the sidelights on and the headlights on. The driver switches off the ignition. This opens the ignition switch.

Explain why **only** the headlights go out.

....

....

.... 2

4. (continued)

(c) **Each** sidelight is rated at 12 V, 6 W, and **each** headlight is rated at 12 V, 55 W.

(i) Calculate the current in the battery when **only** the sidelights are on.

> *Space for working and answer*

3

(ii) The driver leaves the car for 10 minutes with **only** the sidelights on.

Calculate the charge that flows through the battery in this time.

> *Space for working and answer*

2

(iii) Each headlight gives out more light energy than each sidelight when on for the same time.

Explain why this happens.

....

....

....

2

[Turn over

5. An entry system for a block of flats lets residents speak to callers before unlocking the outside door.

(*a*) A microphone at the outside door is connected through an amplifier to a loudspeaker in a flat.

microphone ○— [amplifier] —◁ loudspeaker
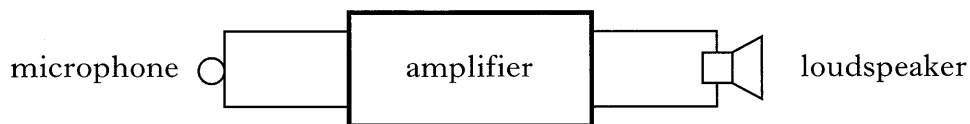
The input power to the amplifier from the microphone is 5 mW and the output power from the amplifier is 2 W.

(i) Calculate the power gain of the amplifier.

Space for working and answer

2

(ii) The voltage across the loudspeaker is 4 V.

Calculate the resistance (impedance) of the loudspeaker.

Space for working and answer

2

5.   (continued)

(*b*) The entry system allows a resident to unlock the outside door from the flat. The diagram below shows this part of this system.

push switch

battery

electro-
magnet

spring

door

door
frame

iron bar

spring
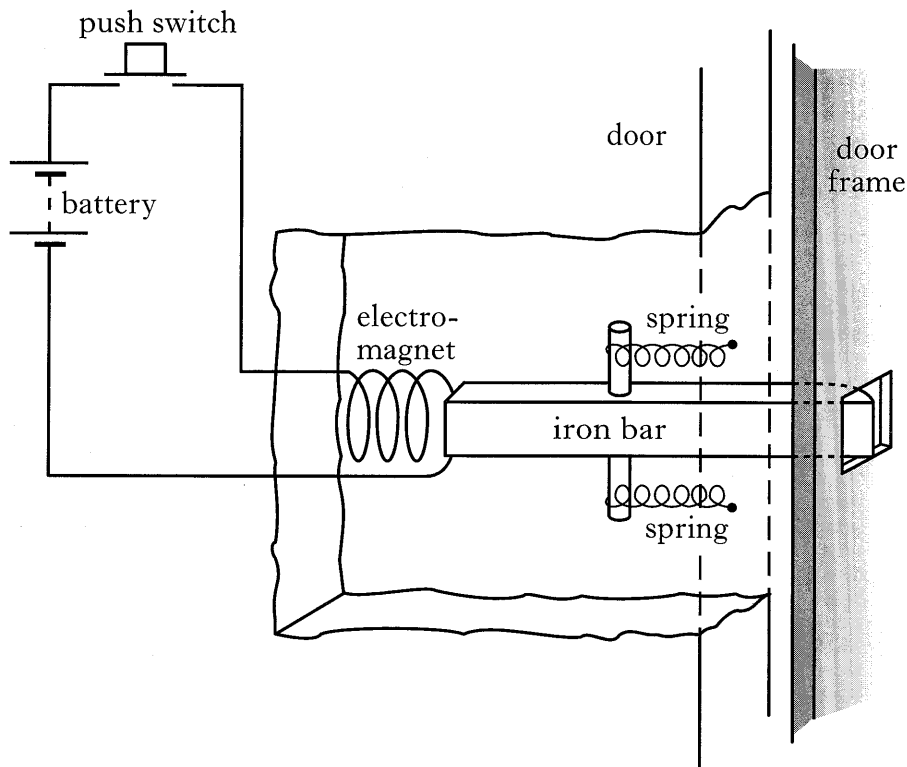
Explain how this part of the system operates to unlock the door.

....

....

....

....   2

[Turn over

6. A person visits an optician for an eye test and is found to be long sighted in both eyes. The optician issues the following prescription for lenses.

	Power of lens required (D)
Left eye	+2·5
Right eye	+1·0

(*a*) State what is meant by long sight.

....

.... **1**

(*b*) Draw the shape of the lenses used to correct the defect in each eye.

Your drawings must show how the two lenses are different.

Shape of lens for left eye	
Shape of lens for right eye	

3

(*c*) Calculate the focal length of the lens prescribed for the left eye.

Space for working and answer

2

7. A smoke detector contains two metal electrodes, a battery and an alarm circuit. Alpha radiation from a radioactive source ionises air between the two electrodes.
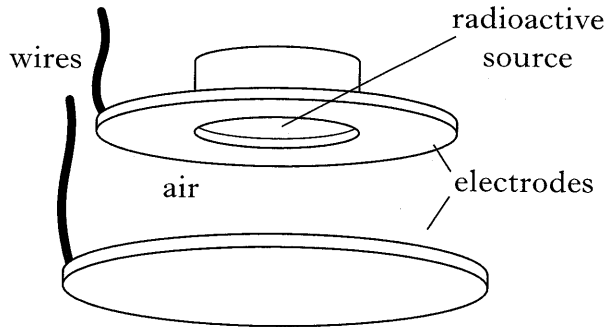
A voltage is applied across the electrodes. Although there is a gap between the two electrodes, there is a current between the electrodes. When there are smoke particles between the electrodes, this current is reduced. This sets off the alarm.

(a) (i) What is meant by ionisation?

....

.... **1**

(ii) Explain how the current is produced in the gap between the electrodes.

....

.... **1**

(b) Apart from safety reasons, why is a source that emits alpha radiation more suitable in a smoke detector than a source that emits gamma radiation?

....

.... **1**

(c) State the unit of activity of a radioactive source.

.... **1**

8. At a bottling plant, shampoo bottles on a conveyor pass a liquid level detector. Bottles filled to an acceptable level continue along the conveyor for packing. Bottles that are overfilled or underfilled are rejected.
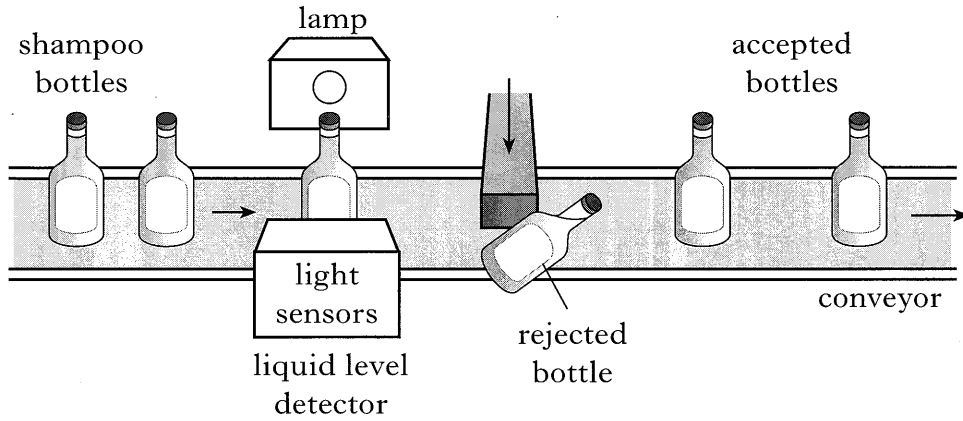
The liquid level detector consists of a lamp and two identical light sensors. The sensors are placed as shown in the diagram below. Light from the lamp can reach a sensor only when there is no shampoo between the lamp and the sensor.
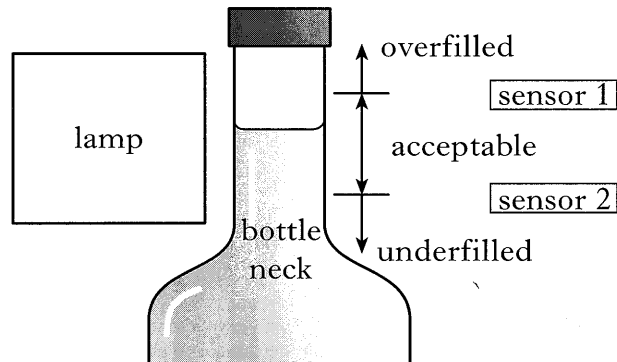
Part of the logic circuit of the liquid level detector is shown below.

8. **(continued)**

The logic level outputs of a light sensor are as shown.

Light level at sensor	Logic level output
dark	0
light	1

(a) Name gate X.

.... 1

(b) Complete the table to show the logic levels at P, Q and R when bottles filled to different levels are at the detector.

Liquid level	P	Q	R
Overfilled			
Acceptable			
Underfilled			

3

(c) The rejector circuit requires a logic level 1 to operate.

What type of gate at Y gives a logic 1 output only when a bottle is not filled to an acceptable level?

.... 1

[Turn over

9. Land speed records are calculated by timing a vehicle as it travels a measured distance of 2·0 km.

   (a) Explain whether the average speed or the instantaneous speed of the vehicle can be calculated from these measurements.

   ....

   ....

   2

   (b) A vehicle travels the measured distance at a constant speed of 220 m/s.

   Calculate the time taken.

   Space for working and answer

   2

   (c) At the end of the measured distance, the driver switches off the engine and opens a parachute to brake.

   The speed-time graph shows the motion of the vehicle from this time.

   The mass of the vehicle is 3000 kg.
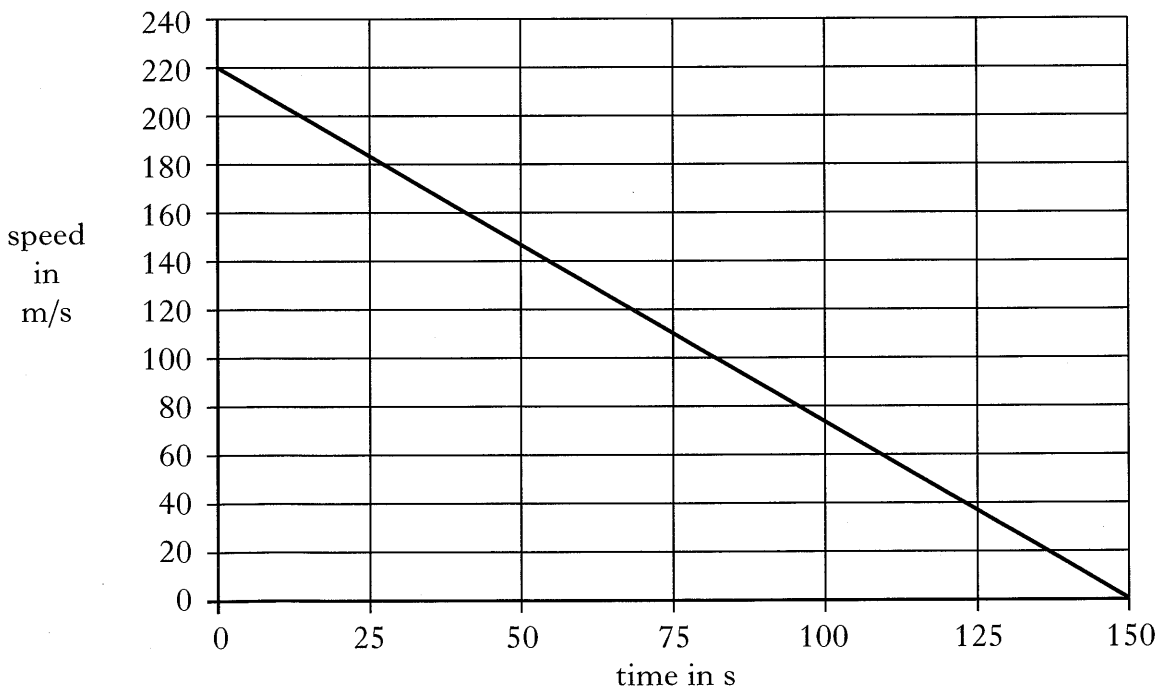
9. (*c*) **(continued)**

    (i)   Explain how the parachute helps to reduce the speed of the vehicle.

....

....   **1**

    (ii)   Calculate the distance travelled by the vehicle from the time the parachute opens until the vehicle stops.

Space for working and answer

                                               2

    (iii)   Calculate the acceleration of the vehicle while it is slowing down.

Space for working and answer

                                               2

    (iv)   Calculate the unbalanced force on the vehicle while it is slowing down.

Space for working and answer

                                               2

[Turn over

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

(v) Calculate the kinetic energy of the vehicle at the instant the parachute opens.

> *Space for working and answer*

2

10. A metal guitar string, fixed to a wooden base, is connected to an oscilloscope. A magnet is placed so that the string is between the poles of the magnet, as shown.
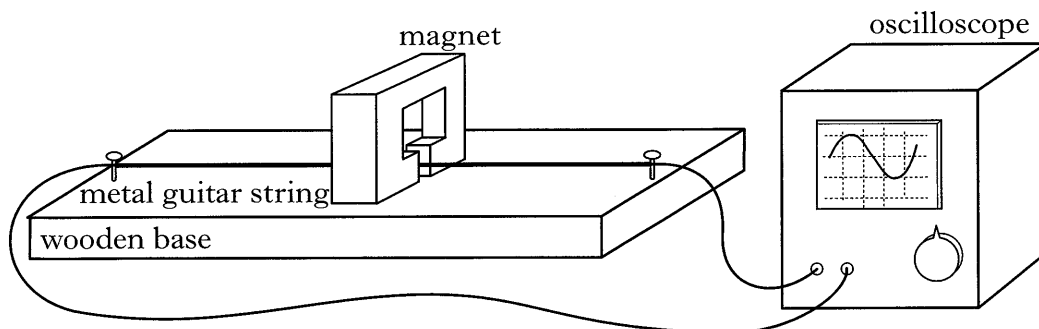
When the string is plucked, a sound is produced and a voltage is induced in the string. The induced voltage is displayed on the screen of the oscilloscope.

(a) (i) Why is a voltage induced when the string is plucked?

....

.... 1

(ii) State one change that can be made so that a larger voltage is induced.

.... 1

10. **(continued)**

   (*b*) The oscilloscope gain setting and trace are shown.

1 cm $\updownarrow$

GAIN

2·0   1·0

5·0   0·5

10   0·2

mV/cm

1 cm

Calculate the peak voltage.

Space for working and answer

2

   (*c*) A different metal string is used to produce a louder sound of higher frequency. No other changes are made to the equipment.

Draw a possible new trace on the blank screen below.

trace produced
by original
string

trace produced
by second
string

2

11. A mass of 500 g of a substance is heated with a 30 W heater. A temperature probe is inserted into the substance.
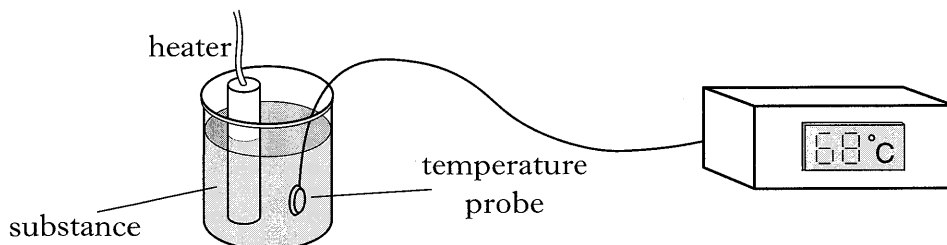
The substance is initially solid and at room temperature. The graph below shows the variation of the temperature of the substance from the time the heater is switched on.
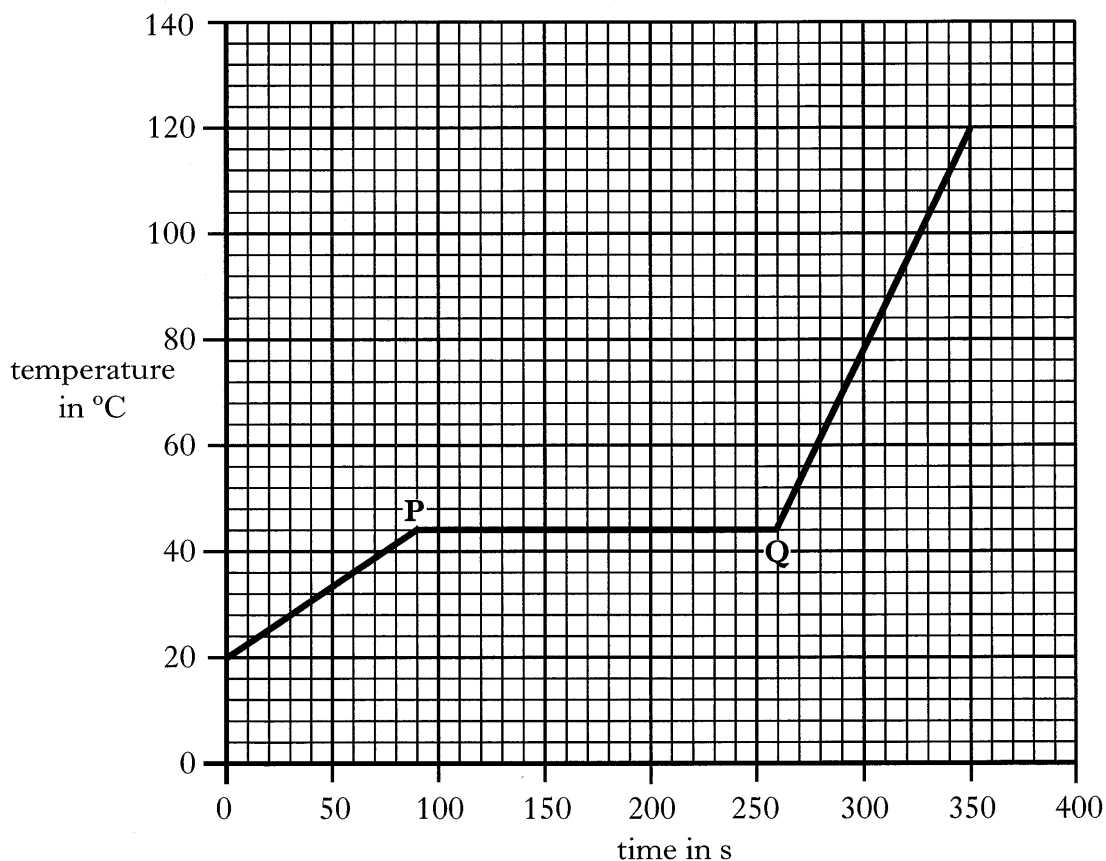
(*a*) State the value of room temperature.

.... 1

Marks | K&U | PS

11. **(continued)**

(*b*) (i) Why does the temperature of the substance remain constant between P and Q?

.... **1**

(ii) Calculate the energy transferred by the heater during the time interval PQ.

> *Space for working and answer*

3

(iii) Calculate the specific latent heat of fusion of the substance.

> *Space for working and answer*

2

[Turn over

12. A bicycle lamp contains four LEDs W, X, Y and Z and a 3 V battery. The lamp uses a pulse generator to make two of the LEDs flash. A simplified circuit diagram of the bicycle lamp is shown.
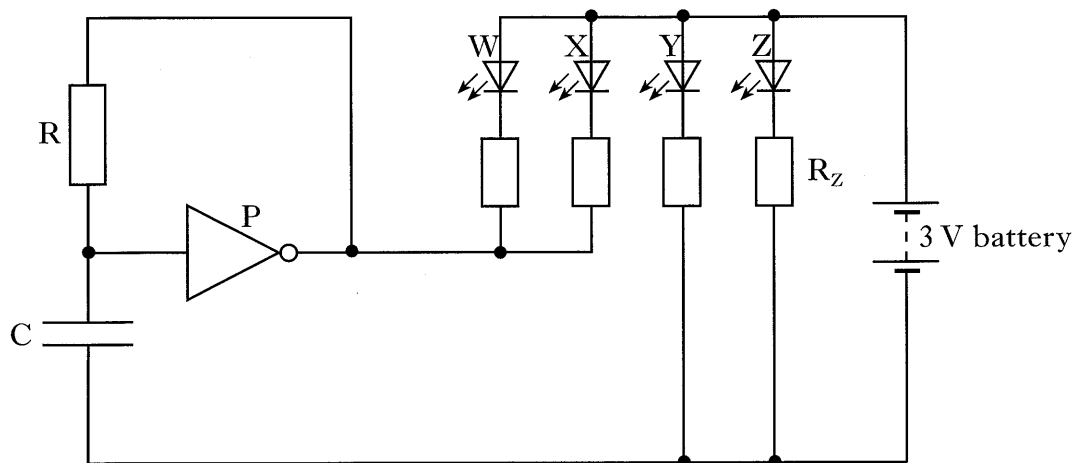
(a) (i) Which LEDs flash when the lamp is operating?

.... **1**

(ii) State two changes that could be made to the circuit to increase the frequency at which the LEDs flash.

....

.... **2**

(b) When LED Z is lit, the current in it is 15 mA and the voltage across it is 1·8 V.

Calculate the resistance of R_Z.

Space for working and answer

3

13. The table below has information about three telescopes used to detect radiation from space.

objective lens	Refracting telescope in Edinburgh, with 150 mm diameter objective lens.
detector curved reflector	Radio telescope at Jodrell Bank, with a curved reflector of diameter 76 m.
detector curved reflector	Radio telescope at Arecibo, Puerto Rico, with a curved reflector of diameter 300 m.

(a) What type of radiation is detected by a refracting telescope?

.... **1**

(b) Why are different types of telescope used to detect radiation from space?

....

.... **1**

(c) In a radio telescope, where is the detector placed in relation to the curved reflector?

....

.... **1**

(d) Explain which of the three telescopes shown above is best for detecting very weak radio signals from deep space.

....

....

....

.... **2**

14. A space vehicle consists of a rocket engine, fuel and a probe. When sitting on the launch pad, the total mass of the space vehicle is 150 000 kg.

(a) Calculate the weight of the space vehicle on the launch pad.

Space for working and answer

2

(b) The space vehicle is launched. Shortly after lift-off, it is at a height of 650 km above the surface of the Earth. At this time, 80 000 kg of fuel have been used.

Give **two** reasons why the weight of the space vehicle is now less than it was on the launch pad.

Reason one...

....

Reason two ....

.... 2

(c) The space vehicle travels into a region of space where the gravitational field strength is zero. The engine is now switched off.

Describe and explain the motion of the vehicle.

....

....

.... 2

15. Some members of the electromagnetic spectrum are named below.

TV and Radio		Infrared	Visible light		X-rays	Gamma rays

(a) Write the names of the missing radiations in the correct spaces in the diagram above.

2

(b) State **one** radiation that has a lower frequency than visible light.

....

1

(c) State **one** detector of X-rays.

....

1

(d) State **one** medical use of infrared radiation.

....

1

[END OF QUESTION PAPER]

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.