FOR OFFICIAL USE

C

K & U	PS

Total Marks

3220/402

NATIONAL QUALIFICATIONS 2001

MONDAY, 4 JUNE
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

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.

SCOTTISH QUALIFICATIONS AUTHORITY

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	$22{\cdot}6 \times 10^5$

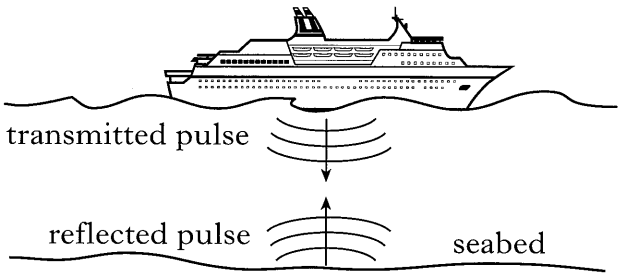
SI Prefixes and Multiplication Factors

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	$0{\cdot}001 = 10^{-3}$
micro	μ	$0{\cdot}000\,001 = 10^{-6}$
nano	n	$0{\cdot}000\,000\,001 = 10^{-9}$

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

1. The depth of the seabed is measured using pulses of ultrasound waves. The ultrasound waves are transmitted from a stationary ship. The waves are reflected from the seabed as shown and are detected by equipment on the ship. The transmitted ultrasound waves have a frequency of 30 kHz.



(*a*) One pulse of ultrasound waves is received back at the ship 0·2 s after being sent out.

(i) Use the data sheet to find the speed of the ultrasound waves in the water.

..... **1**

(ii) Calculate the depth of the seabed.

Space for working and answer

3

(iii) Calculate the wavelength of the ultrasound waves in the water.

Space for working and answer

2

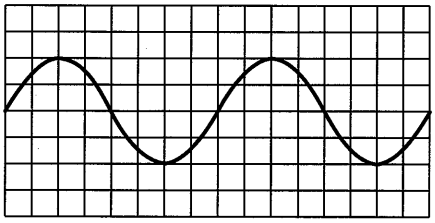
[Turn over

DO NOT WRITE IN THIS MARGIN

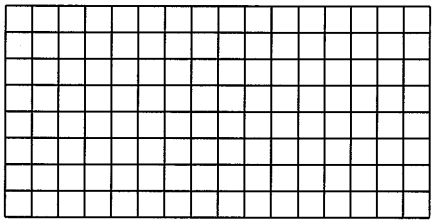
Marks	K&U	PS

1. (continued)

(*b*) The ultrasound waves lose energy as they travel through the water. The transmitted wave is displayed on an oscilloscope screen as shown.



Transmitted



Reflected

On the bottom part of the diagram, sketch the trace produced by the reflected wave. 2

(*c*) The frequency of the transmitted wave is increased to 60 kHz.

What happens to the time interval between the transmitted pulse and the reflected pulse?

Explain your answer.

.....

.....

.....

..... 2

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

2. A mobile phone has a power of 75 mW and operates using a 3 V battery.

(*a*) Calculate the current taken from the battery when the mobile phone is being used.

Space for working and answer

2

(*b*) Which of the following fuses should be connected in series with the battery of the mobile phone?

20 mA **100 mA** **2 A** **3 A**

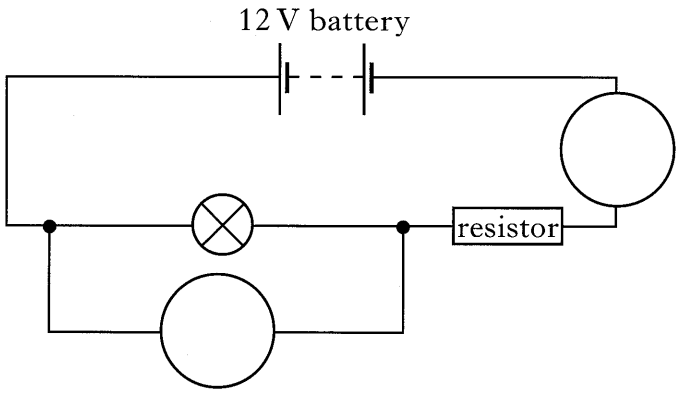
..... **1**

[Turn over

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

3. A 2·5 V, 100 mA lamp is operated at its correct power rating from a 12 V battery by using the circuit shown.



(*a*) A voltmeter and an ammeter included in the circuit show that the lamp is operating at its correct rating.

Enter the readings that are seen on the meters. Include the units for both readings. **2**

(*b*) (i) Calculate the voltage across the resistor.

Space for working and answer

1

(ii) Calculate the resistance of the resistor.

Space for working and answer

2

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

4. A simple d.c. motor is shown in Figure 1.

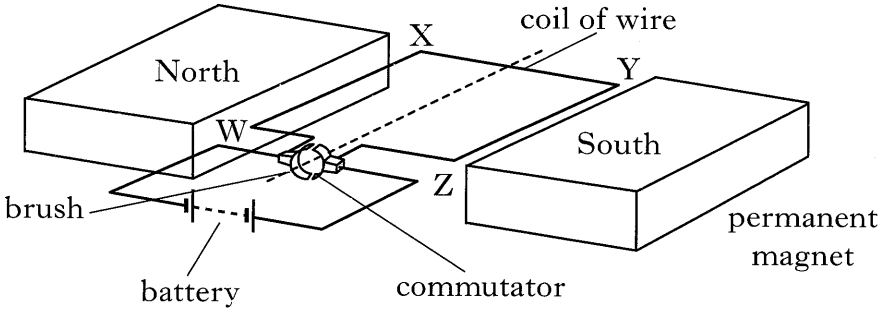


Figure 1

(*a*) The coil WXYZ rotates in a clockwise direction.

State **two** changes that could be made to make the coil rotate in the opposite direction.

Change 1 .....

.....

Change 2 .....

..... 2

[Turn over

DO NOT WRITE IN THIS MARGIN

Marks | K&U | PS

4. (continued)

(*b*) Part of a commercial electric motor is shown in Figure 2.

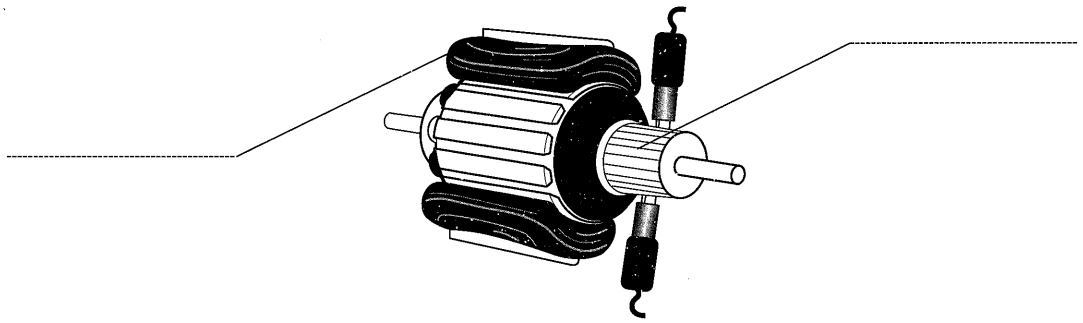


Figure 2

(i) Label the two parts indicated on the motor, using names from the list below.

brush **commutator** **field coil** **rotating coil** 2

(ii) In the commercial electric motor, state why

(A) more than one rotating coil is used

.....

..... 1

(B) field coils rather than permanent magnets are used.

.....

..... 1

DO NOT WRITE IN THIS MARGIN

	Marks	K&U	PS

5. (*a*) A long-sighted person is prescribed glasses that have lenses each with a power of 2·5 D.

(i) State what is meant by long-sight.

.....

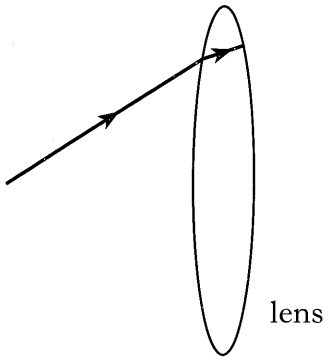
..... **1**

(ii) Calculate the focal length of each lens.

Space for working and answer

2

(*b*) Complete the diagram below to show the path of the ray of light after it emerges from the lens.



1

[Turn over

DO NOT WRITE IN THIS MARGIN

	Marks	K&U	PS

6. Carbon dating is used by scientists to tell the age of organic (formerly living) material. This method is based on knowing that the half-life of radioactive carbon is 5730 years.

(*a*) Explain what is meant by the statement "the half-life of radioactive carbon is 5730 years".

.....

..... **2**

(*b*) The proportion of radioactive carbon in the organic material is found by measuring its activity using a scintillation counter.

(i) State the **unit** that is used for the activity of a radioactive source.

..... **1**

(ii) Describe how a scintillation counter is used as a detector of radiation.

.....

.....

..... **2**

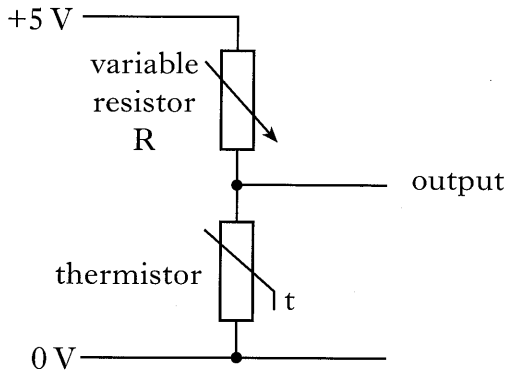
(iii) State an example of the effect of radiation other than scintillations.

..... **1**

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

7. A thermistor is used as a temperature sensor in the voltage divider circuit shown below. The circuit is used to sense the temperature of water in a tank. When the temperature of the water in the tank falls below a certain value, the output of the voltage divider causes a switching circuit to operate a heater.



(*a*) When the voltage across the thermistor reaches 0·7 V, the circuit causes the heater to be switched on.

(i) The variable resistor R is set to a resistance of 4300 Ω.

Calculate the resistance of the thermistor when the voltage across the thermistor is 0·7 V.

Space for working and answer

2

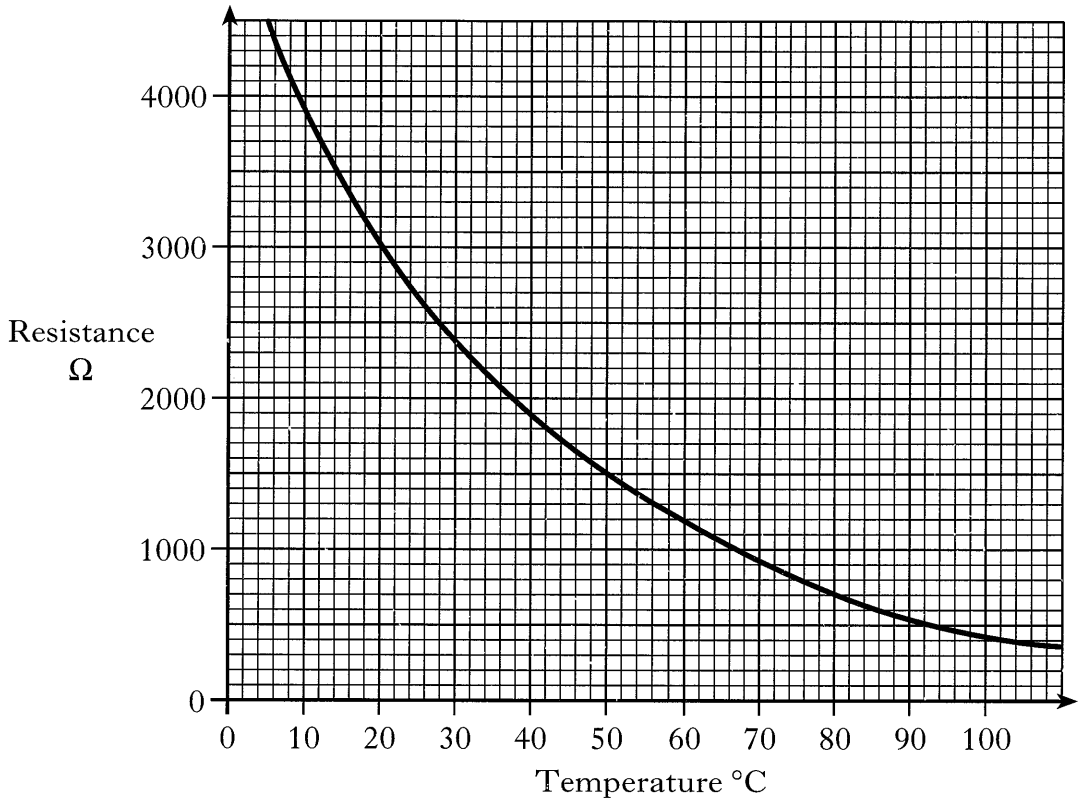
[Turn over

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

7. (*a*) (continued)

(ii) The graph shows how the resistance of the thermistor changes with temperature.



(A) Use the graph to decide the temperature at which the heater is switched on.

..... **1**

(B) The resistance of the variable resistor R is increased to a value **greater than** 4300 Ω.

What effect does this have on the temperature at which the heater is switched on?

Explain your answer.

.....

.....

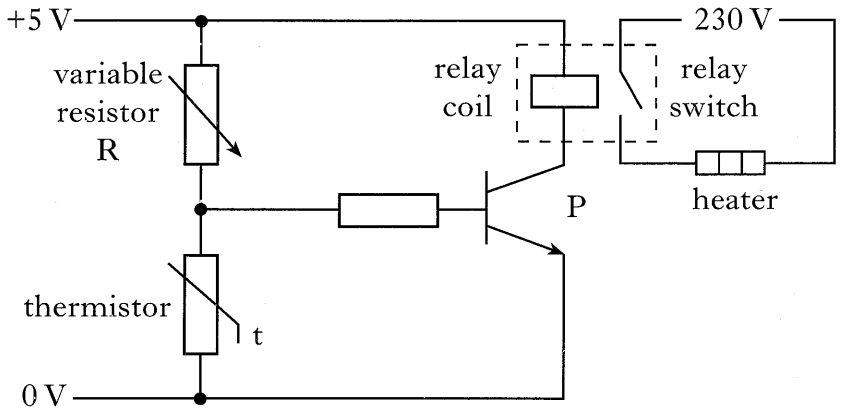
..... **2**

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

7. (continued)

(*b*) The voltage divider circuit is connected to the switching circuit, as shown, to operate the heater. When there is a current in the relay coil, the relay switch closes.



(i) Name component P.

..... **1**

(ii) Explain why the heater switches on as the temperature falls below a selected value.

.....

.....

.....

.....

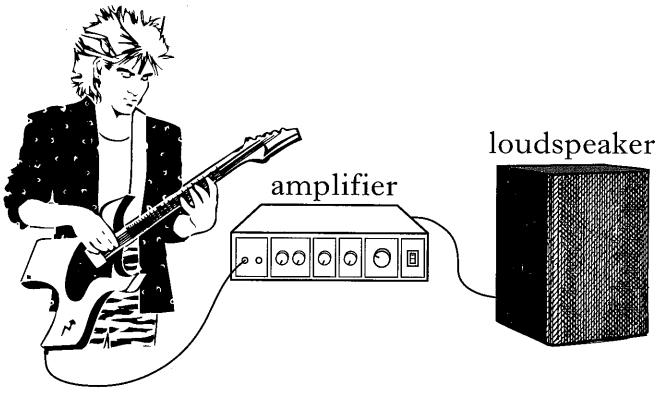
..... **3**

[Turn over

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

8. An electric guitar is connected to an amplifier.



The input power to the amplifier from the guitar is 16 mW. The output of the amplifier is connected to a loudspeaker. The loudspeaker has a resistance of 9 Ω.

(*a*) The amplifier delivers an output power of 64 W to the loudspeaker.

(i) Calculate the power gain of the amplifier.

Space for working and answer

2

(ii) Calculate the voltage across the loudspeaker.

Space for working and answer

2

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

8. (continued)

(*b*) A second, identical loudspeaker is connected in parallel with the first. Calculate the combined resistance of the two loudspeakers in parallel.

Space for working and answer

2

(*c*) The guitarist plays a note of frequency 256 Hz.
What is the frequency of the output signal from the amplifier?

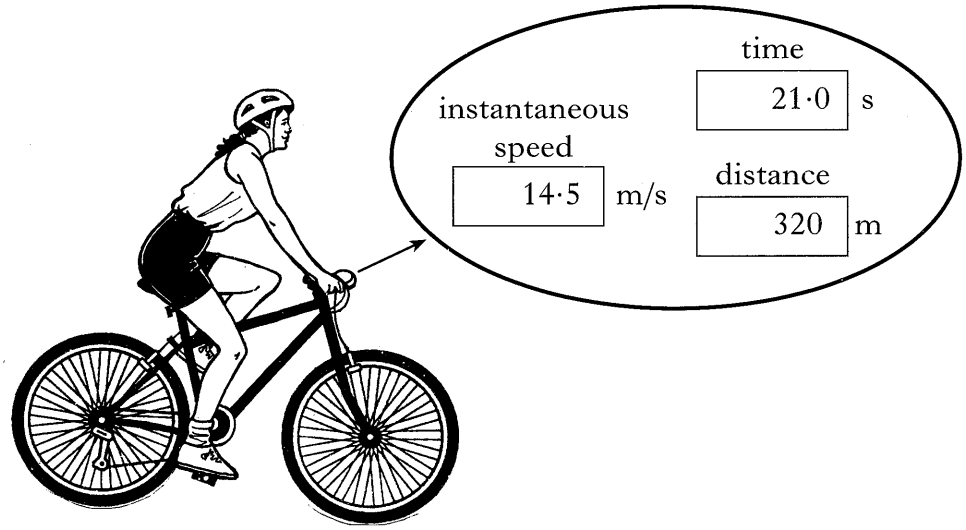
..... **1**

[Turn over

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

9. A cyclist has a small computer attached to her bike. The computer gives information on the cyclist's instantaneous speed, distance travelled and time taken.



At a point during a journey, the readings on the display are as shown above.

(*a*) (i) Calculate the average speed of the cyclist up to this point.

(You must use an appropriate number of significant figures in your answer to this question.)

Space for working and answer

3

(ii) Why is the average speed of the cyclist not always the same as the instantaneous speed displayed on the computer?

.....

.....

.....

2

DO NOT WRITE IN THIS MARGIN

Marks | K&U | PS

9. (continued)

(*b*) (i) The total mass of the cyclist and bike is 80 kg.

Calculate the total kinetic energy of the cyclist and the bike at this point during the journey.

Space for working and answer

2

(ii) The cyclist brakes to a halt in a distance of 50 m.

Calculate the braking force used.

Space for working and answer

2

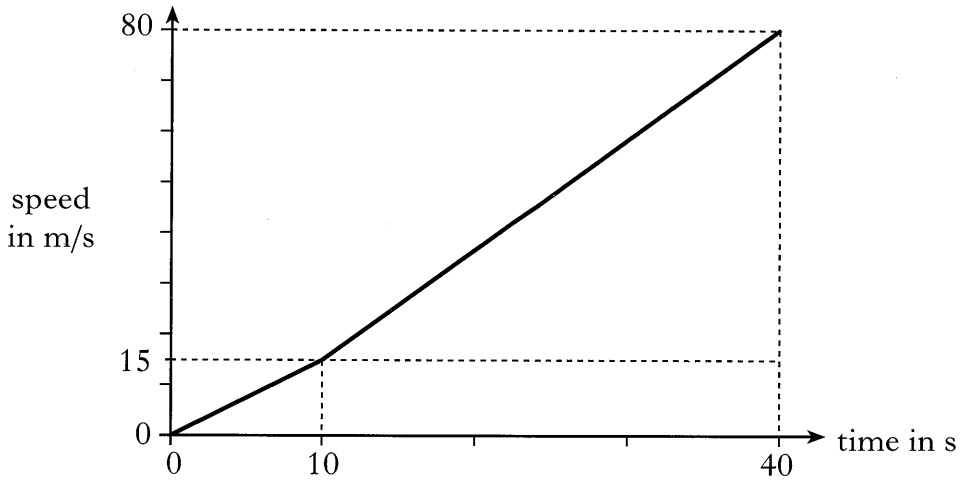
[Turn over

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

10. An aircraft has a mass of 268 000 kg. The aircraft accelerates from rest along a straight runway. It takes 40 s for the aircraft to reach its take-off speed of 80 m/s.

(*a*) The speed-time graph of the aircraft is shown.



(i) Calculate the acceleration of the aircraft **during the first 10 s**.

Space for working and answer

2

(ii) Calculate the unbalanced force acting on the aircraft **during the first 10 s**.

Space for working and answer

2

DO NOT WRITE IN THIS MARGIN

Marks | K&U | PS

10. (*a*) (continued)

(iii) By using information **from the graph**, explain whether the unbalanced force on the aircraft is greater during the time period 0–10 s or 10 s–40 s.

.....

.....

..... **2**

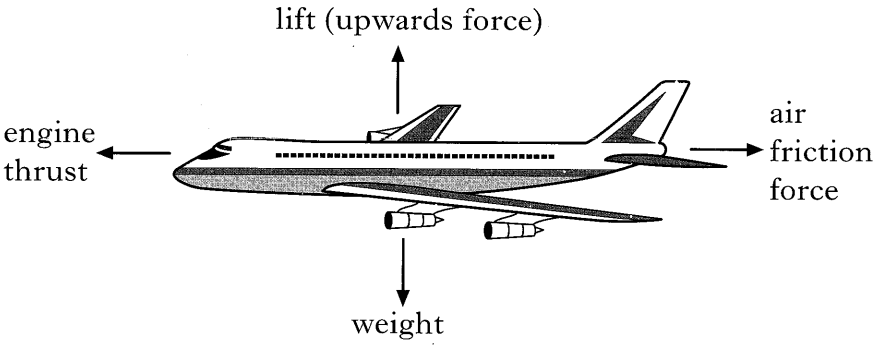
(iv) Calculate the length of runway required to allow the aircraft to reach its take-off speed.

Space for working and answer

3

(*b*) After take-off, the aircraft flies at a constant height of 10 000 m. The pilot increases the speed of the aircraft at this height.

The diagram shows the forces acting on the aircraft at this height.



Complete the statements about the sizes of the forces acting on the aircraft by using phrases from the following list.

equal to **greater than** **less than**

(i) The engine thrust is ..... the air friction force. **1**

(ii) The lift is ..... the weight. **1**

DO NOT WRITE IN THIS MARGIN

Marks | K&U | PS

11. (*a*) The following information relates to two power stations, a fossil fuel power station and a nuclear power station.

Fossil Fuel Power Station	
Heat energy produced per kilogram of fuel	$4{\cdot}5 \times 10^7$ J
Waste produced per year —not radioactive	100 000 kg
Cooling water required	550 kg/s

Nuclear Power Station	
Heat energy produced per kilogram of fuel	$4{\cdot}4 \times 10^{11}$ J
Waste produced per year —radioactive	5 kg
Cooling water required	550 kg/s

(i) Compare the information given for the two types of power station. State **one** advantage of generating electricity using each type of power station.

Fossil fuel .....

.....

Nuclear.....

..... 2

(ii) Using information given, state where both types of power station are likely to be located.

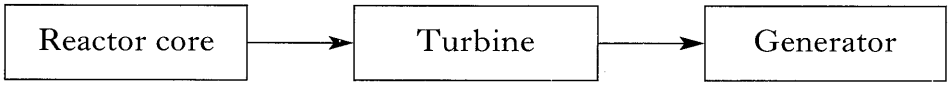
Explain why they are built in these locations.

.....

.....

..... 2

(*b*) A simple block diagram of a nuclear power station is shown below.



State the energy transformation that takes place in

(i) the reactor core

..... 1

(ii) the generator.

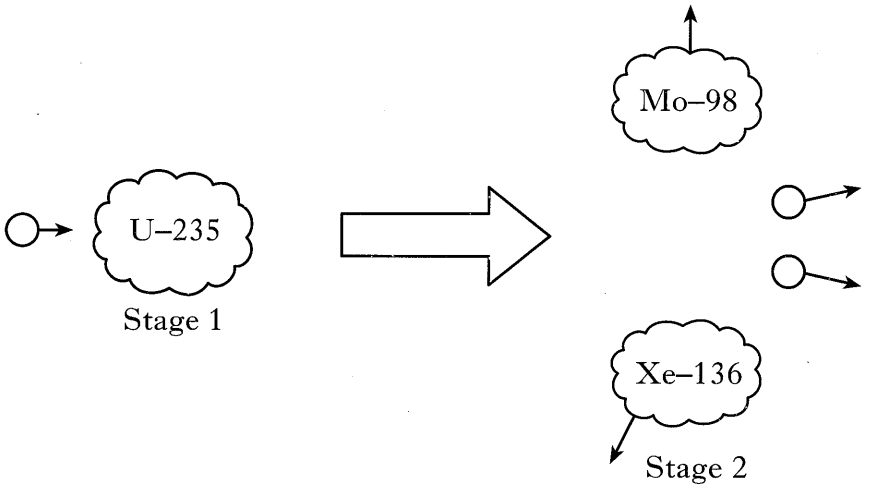
..... 1

DO NOT WRITE IN THIS MARGIN

Marks | K&U | PS

11. (continued)

(*c*) The diagram shows what happens when a uranium nucleus undergoes fission in a nuclear reaction.



(i) Circle **one** word in each set of brackets to describe what happens at each stage.

Stage 1: A uranium nucleus is bombarded by a {proton / neutron / electron}.

Stage 2: The uranium nucleus disintegrates, producing fission fragments, two {protons / neutrons / electrons} and {plutonium / heat / electricity}. **3**

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

.....

.....

..... **3**

[Turn over

DO NOT WRITE IN THIS MARGIN

Marks | K&U | PS

12. Ice cubes are used to cool down water for drinking. Each ice cube has a mass of 12 g and is initially at a temperature of 0 °C.

(*a*) Calculate how much heat is needed to melt an ice cube.

(Any additional information needed can be found in the data sheet on page 2.)

Space for working and answer

3

(*b*) When an ice cube is added to water, where does most of the energy come from to melt the ice?

.....

1

(*c*) (i) An ice cube is added to a glass containing 200 g of water.

The initial temperature of the water is 18 °C. The final temperature when all of the ice has melted is 15 °C.

Calculate the heat removed from the water.

(Any additional information needed can be found in the data sheet on page 2.)

Space for working and answer

3

(ii) Suggest a final temperature when an ice cube is added to an insulated bottle of water. The bottle has a lid and contains an equal mass of water as above, and is at the same initial temperature.

Explain your answer.

.....

.....

.....

2

DO NOT WRITE IN THIS MARGIN

Marks | K&U | PS

13. Read the following passage about the launching of a space observatory using the Space Shuttle Columbia.

In July 1999, NASA used the Space Shuttle Columbia to launch a space-based observatory, called the Chandra X-ray Observatory.

This observatory is designed to detect X-rays emitted by objects in our solar system and beyond. X-rays are absorbed by the Earth's atmosphere, so a space-based observatory is necessary to detect them. Signals are sent from the observatory to Earth using radio waves.

There are now three observatories orbiting the Earth. The other two are the Hubble Space Telescope that detects visible light and the Compton Gamma Ray Observatory.

(*a*) Why is it necessary to site an observatory in space to detect X-rays?

.....

.....

1

(*b*) Four members of the electromagnetic spectrum are mentioned in the passage. Complete the diagram by placing these members in the correct order of wavelength.

		Ultraviolet		Infrared	Microwaves	

The electromagnetic spectrum

4

(*c*) Explain why different kinds of observatory are used to detect signals from space.

.....

.....

.....

2

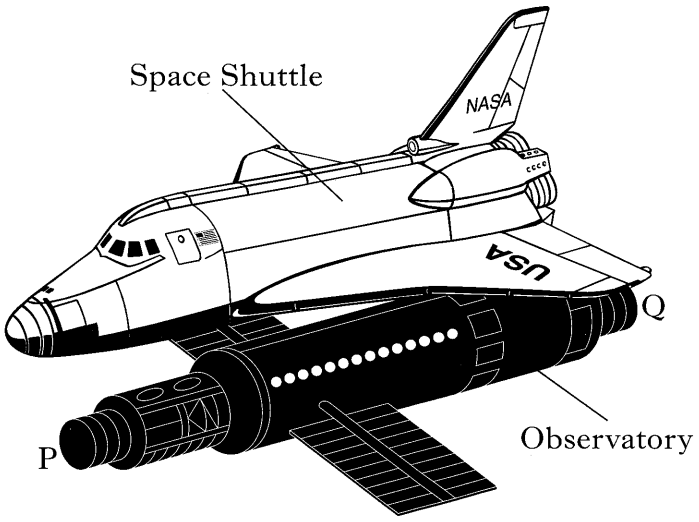
[Turn over

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

13. (continued)

(*d*) When the Space Shuttle reached the correct height above Earth, the observatory was separated from it.



Two rocket motors P and Q on the observatory, as shown, were used during the separation. The observatory accelerated away from the space shuttle for a short time. It then remained at a fixed distance ahead of the space shuttle. Describe how the rockets P and Q were used during this separation.

.....

.....

.....

..... 2

[*END OF QUESTION PAPER*]

DO NOT WRITE IN THIS MARGIN

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.

DO NOT WRITE IN THIS MARGIN

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.

DO NOT WRITE IN THIS MARGIN

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.

[BLANK PAGE]