FOR OFFICIAL USE

C

K&U	PS

3220/402

3220310

NATIONAL QUALIFICATIONS 2010

FRIDAY, 28 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

Town

Forename(s)

Surname

Date of birth

Day		Month		Year	

Scottish candidate number

Number of seat

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 If you use the additional space at the end of the answer book for answering any questions, you **must** write the correct question number beside each answer.

6 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.

7 Any necessary data will be found in the **data sheet** on page three.

8 Care should be taken to give an appropriate number of significant figures in the final answers to questions.

Use **blue** or **black ink**. Pencil may be used for graphs and diagrams only.

[BLANK PAGE]

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
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

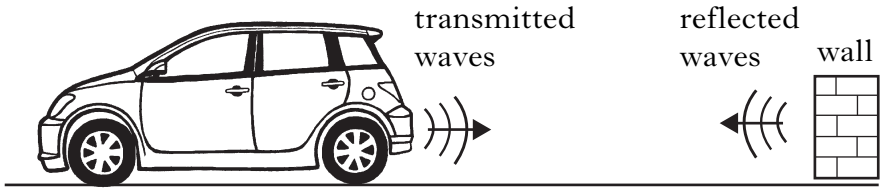
Prefix	*Symbol*	*Factor*
giga	G	$1\,000\,000\,000 = 10^9$
mega	M	$1\,000\,000 = 10^6$
kilo	k	$1000 = 10^3$
milli	m	$0{\cdot}001 = 10^{-3}$
micro	μ	$0{\cdot}000\,001 = 10^{-6}$
nano	n	$0{\cdot}000\,000\,001 = 10^{-9}$

DO NOT WRITE IN THIS MARGIN

K&U	PS

Marks

1. A car is fitted with a parking system. This warns the driver how close objects are behind the car. Equipment on the rear bumper of the car transmits ultrasound waves and receives the reflected waves.



(*a*) (i) Use the data sheet to find the speed of ultrasound waves in air.

..... **1**

(ii) The ultrasound waves have a frequency of 40 kHz.

Calculate the wavelength of these waves.

Space for working and answer

2

(*b*) The car stops 1·7 m from a wall.

Calculate the time for a transmitted wave to return to the car.

Space for working and answer

3

(*c*) The car is moved closer to the wall.

State what happens to the time for a transmitted wave to return to the car.

.....

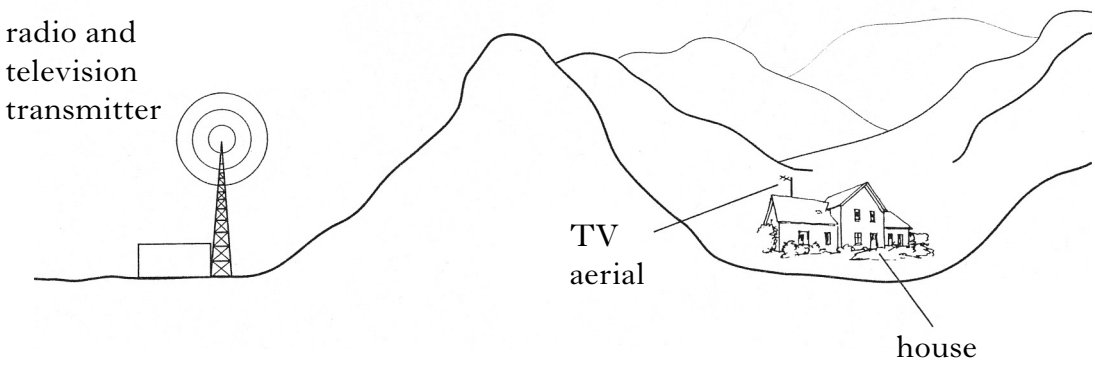
..... **1**

DO NOT WRITE IN THIS MARGIN

	K&U	PS

Marks

2. A hill lies between a radio and television transmitter and a house.



The house is within the range of both the radio and television signals from the transmitter.

(*a*) In the house, a radio has good reception but a TV has poor reception from this transmitter.

Suggest an explanation for this.

.....

.....

.....

..... **2**

(*b*) The house is also fitted with a dish aerial to receive TV signals from a geostationary satellite. The TV signals are carried by microwaves with a frequency of 12 GHz.

(i) State the speed of microwave signals in air.

..... **1**

(ii) What is meant by the term geostationary?

.....

..... **1**

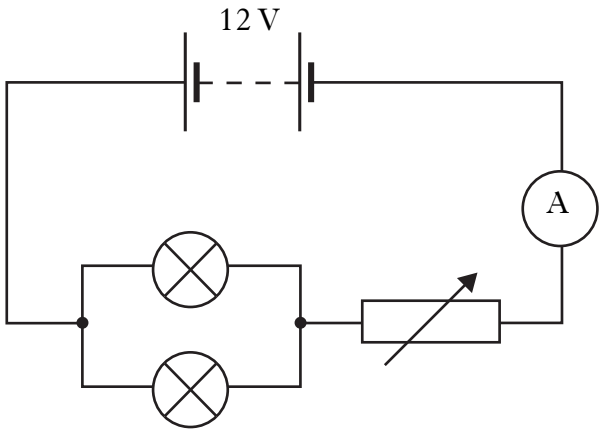
[Turn over

DO NOT WRITE IN THIS MARGIN

K&U	PS

Marks

3. The circuit shown is used to control the brightness of two **identical** lamps. The variable resistor is adjusted until the lamps operate at their correct voltage of 3·0 V.



(*a*) When the lamps operate at the correct voltage, the reading on the ammeter is 1·2 A.

Calculate the current in one lamp.

Space for working and answer

1

(*b*) Calculate the resistance of one lamp.

Space for working and answer

2

DO NOT WRITE IN THIS MARGIN

K&U	PS

Marks

3. (continued)

(*c*) Calculate the combined resistance of the two lamps in this circuit.

Space for working and answer

2

(*d*) When the lamps operate at their correct voltage the resistance of the variable resistor is 7·5 Ω.

Calculate the total resistance in the circuit.

Space for working and answer

2

(*e*) One of the lamps is removed.

(i) What happens to the reading on the ammeter?

..... **1**

(ii) Justify your answer.

..... **1**

[Turn over

DO NOT WRITE IN THIS MARGIN

K&U	PS

Marks

4. A washing machine contains a commercial electric motor. The rating plate on the washing machine shows the following information.

2530 W
230 V ac
50 Hz

The plug connected to the washing machine contains a 13 A fuse.

(*a*) (i) State the purpose of the fuse.

..... **1**

(ii) Show by calculation that a 3 A fuse is unsuitable.

Space for working and answer

2

DO NOT WRITE IN THIS MARGIN

K&U	PS

Marks

4. (continued)

(*b*) A student builds a simple dc electric motor. Some differences between a commercial motor and a simple dc motor are shown in the table.

Commercial motor	*Simple dc motor*
field coils	permanent magnets
multi-section commutator	commutator
carbon brushes	brushes

State a reason for a commercial motor using:

(i) field coils instead of permanent magnets;

..... **1**

(ii) a multi-section commutator instead of a single commutator.

..... **1**

(*c*) The electrical energy used by a commercial motor is measured in kilowatt-hours.

Calculate how many joules are equivalent to one kilowatt-hour.

Space for working and answer

2

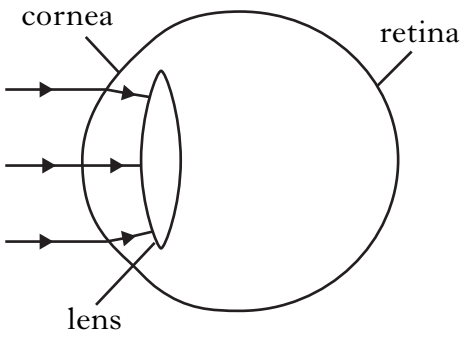
[Turn over

DO NOT WRITE IN THIS MARGIN

K&U	PS

Marks

5. In the eye, refraction of light occurs at both the cornea and the lens.



(*a*) The focal length of an eye lens system (the cornea and the lens together) is 22 mm.

Calculate the power of this eye lens system.

Space for working and answer

2

DO NOT WRITE IN THIS MARGIN

K&U	PS

Marks

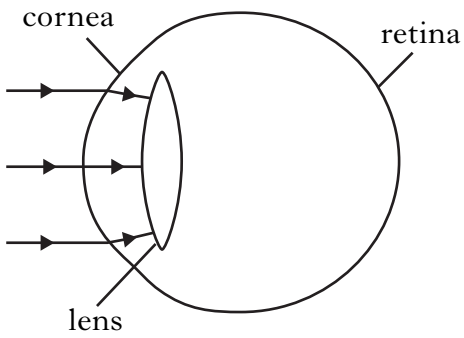
5. (continued)

(*b*) A student has an eye defect. An object close to the student's eye appears focused but a distant object appears blurred.

(i) What name is given to this eye defect?

..... **1**

(ii) The diagram shows rays of light, from a distant object, entering the student's eye.



Complete the diagram to show how the light rays reach the retina of the student's eye. **1**

(iii) By referring to your completed diagram, explain why the image on the retina of the student's eye is blurred.

..... **1**

(iv) A lens is used to correct this eye defect.

Draw the shape of this lens.

Space for drawing

1

DO NOT WRITE IN THIS MARGIN

K&U	PS

Marks

6. The table gives information about radioactive substances used in medicine.

Radioactive substance	*Type of ionising radiation emitted*	*Half-life*
iodine-131	beta and gamma	8 days
technetium-99 m	gamma	6 hours
cobalt-60	beta and gamma	5·3 years

(*a*) (i) State what is meant by the term ionisation.

.....

..... **1**

(ii) State a type of ionising radiation **not** given in the table above.

..... **1**

(*b*) A sample of iodine-131 is delivered to a hospital 24 days before it is given to a patient. The activity of the iodine-131 when it is given to the patient is 6 MBq.

Calculate the initial activity, in MBq, of the sample when it was delivered to the hospital.

Space for working and answer

2

DO NOT WRITE IN THIS MARGIN

K&U	PS

Marks

6. (continued)

(*c*) (i) Equivalent dose measures the biological effect of radiation.

State the unit of equivalent dose.

..... **1**

(ii) For living material the biological effect of radiation depends on a number of factors.

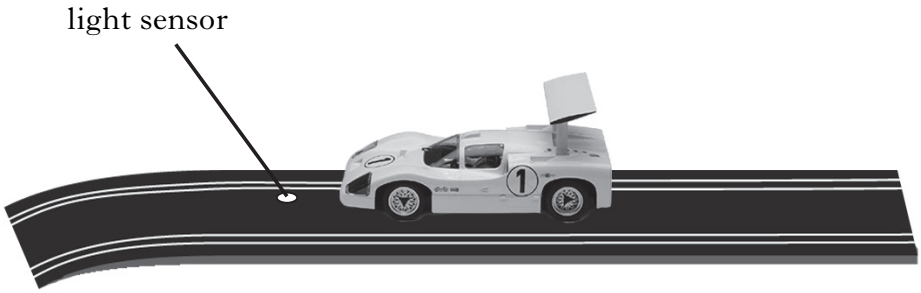
State **two** of these factors.

1 .....

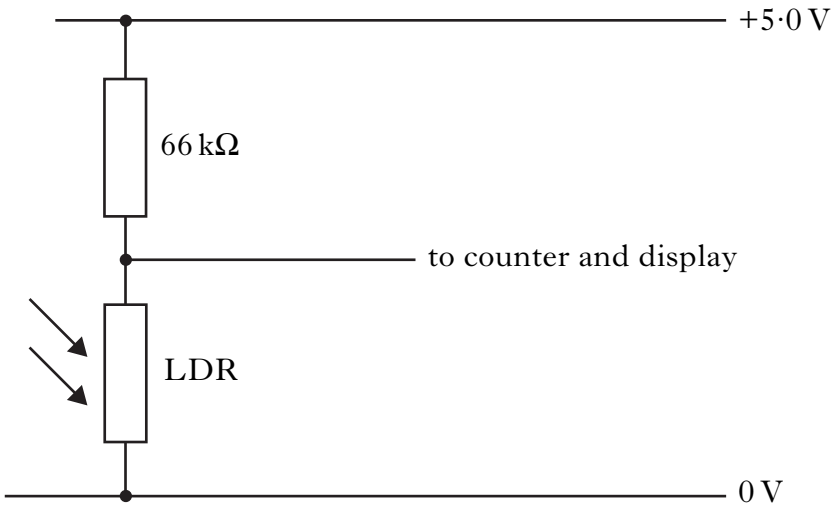
2 ..... **2**

[Turn over

7. A physics student builds a lap counter for a toy racing car set. The lap is counted when the car passes over the light sensor.



(*a*) The circuit for the light sensor contains an LDR as shown.



The resistance of the LDR for different conditions is shown in the table.

Light Sensor	*Resistance of LDR* (kΩ)
covered	22
uncovered	2

DO NOT WRITE IN THIS MARGIN

K&U	PS

Marks

7. (*a*) (continued)

Calculate the voltage across the LDR when the light sensor is covered.

Space for working and answer

3

(*b*) (i) The system contains a counter and display. The output of the counter is **binary**. This is then converted to **decimal** and shown on the display. What decimal number is shown when the counter output is 1001?

..... **1**

(ii) The system also contains a buzzer. The buzzer emits a sound when a car completes a lap. The buzzer has a resistance of 120 Ω and a power of 147 mW.

Calculate the voltage across the buzzer when it sounds.

Space for working and answer

2

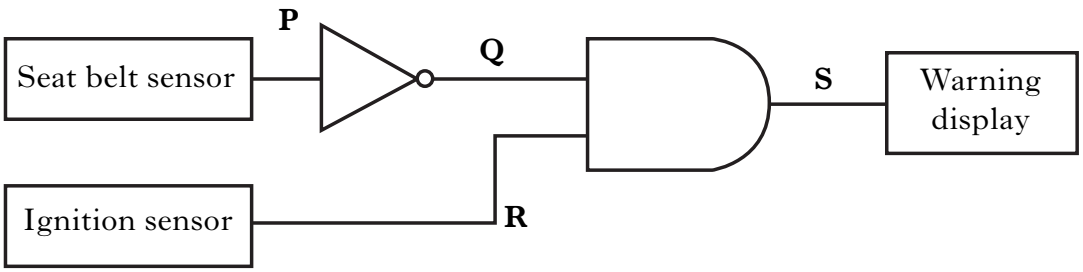
[Turn over

DO NOT WRITE IN THIS MARGIN

K&U	PS

Marks

8. An electronic device warns a car driver when the seat belt has not been fastened. The device only operates when the ignition is switched on. The device contains the logic circuit shown.



The seat belt sensor produces logic 1 when the seat belt is fastened and logic 0 when the seat belt is unfastened.

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

(*a*) (i) Suggest a suitable output device that will illuminate the warning display.

..... **1**

(ii) Complete the truth table for the logic levels **P**, **Q** and **S** in the circuit.

Seat belt	Ignition	**P**	**Q**	**R**	**S**
unfastened	off			**0**	
unfastened	on			**1**	
fastened	off			**0**	
fastened	on			**1**	

3

(*b*) Explain in terms of forces, why seat belts are used in cars.

.....

.....

..... **2**

DO NOT WRITE IN THIS MARGIN

K&U | PS

Marks

8. (continued)

(*c*) The car has another electronic device that also contains a logic gate. The truth table for **this** logic gate is shown below.

Input 1	Input 2	Output
0	0	0
0	1	1
1	0	1
1	1	1

(i) Name this logic gate.

..... **1**

(ii) Draw the symbol for this logic gate.

Space for symbol

1

(*d*) The temperature outside the car is measured with an electronic thermometer and displayed on a screen.

What input device could be used in the electronic thermometer?

..... **1**

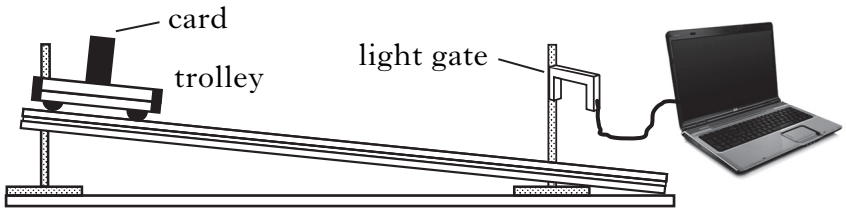
[Turn over

DO NOT WRITE IN THIS MARGIN

K&U	PS

Marks

9. A student releases a trolley from rest near the top of a track. The trolley moves down the track. A card attached to the trolley passes through a light gate near the bottom of the track.



(*a*) The student records the following information.

Length of the card = 60 mm
Distance travelled by the trolley down the track = 1·2 m
Time for the card to pass through the light gate = 0·075 s

Calculate the instantaneous speed of the trolley as it passes through the light gate.

Space for working and answer

2

(*b*) The mass of the trolley is 0·55 kg.

Calculate its kinetic energy as it passes through the light gate.

Space for working and answer

2

(*c*) Suggest a possible value for the average speed of the trolley over the 1·2 m distance travelled by the trolley down the track.

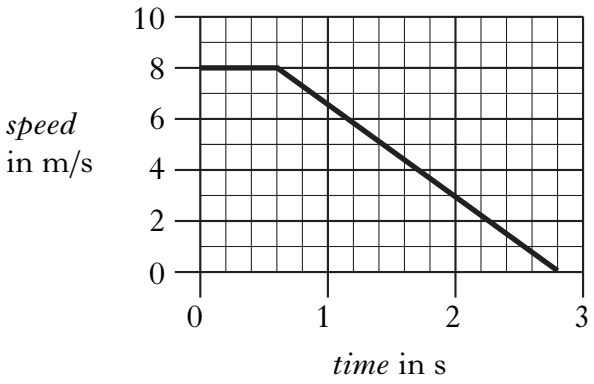
..... **1**

DO NOT WRITE IN THIS MARGIN

	K&U	PS

Marks

10. A cyclist is approaching traffic lights at a constant speed. The cyclist sees the lights change to red. The graph shows how the speed of the cyclist varies with time from the instant the cyclist sees the lights change to red.



(*a*) (i) How long did it take for the cyclist to react before applying the brakes?

..... **1**

(ii) Calculate the distance travelled from the instant the cyclist sees the traffic lights change to red until stationary.

Space for working and answer

2

(*b*) The cyclist now sees the traffic lights change to green and accelerates away from the lights. The combined mass of the cycle and cyclist is 75 kg. An unbalanced force of 150 N acts on this combined mass.

Calculate the acceleration.

Space for working and answer

2

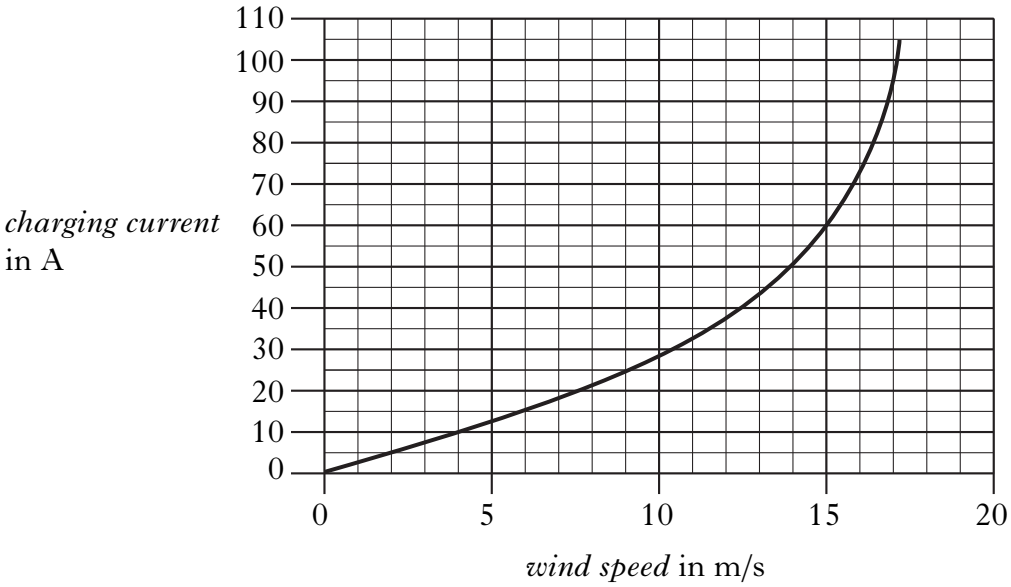
DO NOT WRITE IN THIS MARGIN

K&U	PS

Marks

11. A wind generator is used to charge a 12 V battery. The charging current depends on the wind speed.

The graph shows the charging current at different wind speeds.



(*a*) During one charge of the battery, the wind speed is constant at 15 m/s. During this time a charge of 4500 C is transferred to the battery.

Calculate the time taken to transfer this charge to the battery.

Space for working and answer

3

DO NOT WRITE IN THIS MARGIN

K&U	PS

Marks

11. (continued)

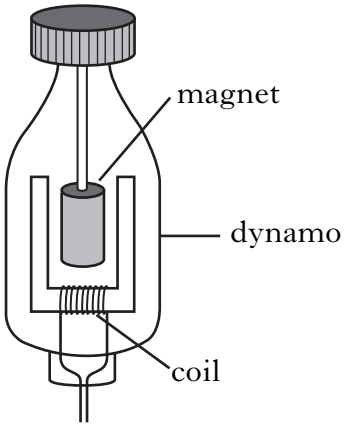
(*b*) At another wind speed the generator has an output power of 120 W and is 30% efficient.

Calculate the input power to the generator.

Space for working and answer

2

(*c*) A bicycle has a small generator called a dynamo. The dynamo contains a magnet which spins near a coil of wire.



When the magnet spins, a voltage is induced in the coil.

State **two** factors that affect the size of the induced voltage.

1 .....

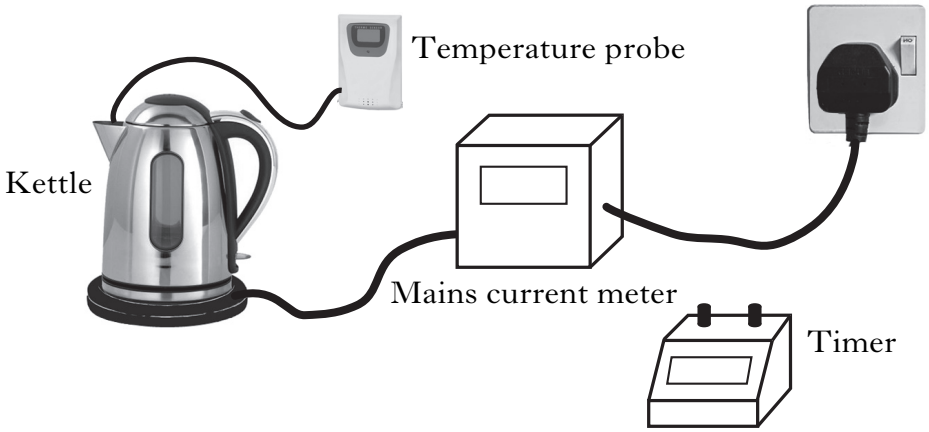
2 ..... **2**

[Turn over

K&U	PS

Marks

12. A technician tests an electric kettle. The kettle is filled with water and switched on for 3 minutes.



The technician records the following information.

Current = 12·5 A
Voltage = 230 V
Time = 3 minutes
Initial temperature = 18 °C
Final temperature = 90 °C

(*a*) (i) Show that 517 500 J of electrical energy is supplied to the kettle in 3 minutes.

Space for working and answer

2

DO NOT WRITE IN THIS MARGIN

K&U	PS

Marks

12. (*a*) (continued)

(ii) Calculate the mass of water in the kettle.

Space for working and answer

3

(iii) Explain why the mass of water will be less than calculated in (*a*)(ii).

.....

1

(*b*) The technician tests a second kettle. When the water boils this kettle does not switch off and continues to heat the water.

(i) State what happens to the temperature of the water when it boils.

.....

1

While the water is boiling, the kettle supplies 565 000 J of heat energy to the water.

(ii) Calculate the mass of water changed into steam.

Space for working and answer

3

[Turn over

DO NOT WRITE IN THIS MARGIN

K&U	PS

Marks

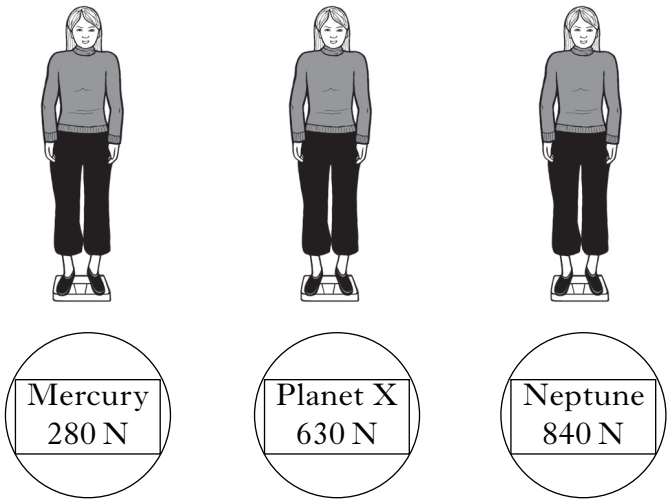
13. During a visit to a science centre a student learns more about gravitational field strength.

(*a*) State what is meant by gravitational field strength.

.....

..... **1**

(*b*) The science centre has a set of specially designed scales. The weight of the student on different planets in the solar system can be found by using these scales. The student stands on each of these scales in turn. The weight on each of these scales is shown.



(i) The student has a mass of 70 kg.

Calculate the gravitational field strength on Planet X.

Space for working and answer

2

(ii) Identify Planet X.

..... **1**

DO NOT WRITE IN THIS MARGIN

K&U	PS

Marks

13. (continued)

(*c*) The student watches a short film. This film shows an astronaut dropping a hammer onto the surface of the Moon. The hammer takes 1·2 s to fall to the Moon's surface. The gravitational field strength on the Moon is 1·6 N/kg.

(i) Calculate the vertical speed of the hammer just before it strikes the Moon's surface.

Space for working and answer

2

(ii) The film then shows the astronaut throwing the hammer horizontally from the same height.

How long does it take for the hammer to fall to the Moon's surface?

..... **1**

[Turn over

DO NOT WRITE IN THIS MARGIN

K&U | PS

Marks

14. The diagram represents the electromagnetic spectrum.

Some of the radiations have not been named.

gamma	X-rays	P	Visible light	Q	microwaves	Radio and TV

Electromagnetic spectrum

increasing frequency ←

(*a*) (i) Name radiations P and Q.

P .....

Q..... **2**

(ii) Which radiation in the electromagnetic spectrum has the shortest wavelength?

..... **1**

(iii) State **one** detector of radio waves.

..... **1**

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

..... **1**

(*b*) Yellow light is part of the visible spectrum. The wavelength of yellow light is $5{\cdot}9 \times 10^{-7}$ m.

The visible spectrum also contains red, blue and green light.

Use the information above to complete the following table.

Colour	*Wavelength* (m)
	7×10^{-7}
yellow	
	$5{\cdot}5 \times 10^{-7}$
	$4{\cdot}5 \times 10^{-7}$

2

DO NOT WRITE IN THIS MARGIN

K&U	PS

Marks

14. (continued)

(*c*) The table below gives information about planets that orbit the Sun.

Planet	*Distance from the Sun* (Gm)	*Period* (days)	*Mass* (Earth masses)
Earth	150	365	1
Jupiter	780		318
Mars	228	687	0·11
Mercury	58	88	0·06
Saturn	1430	10 760	95
Venus	110	225	0·82

(i) Give an approximate value, **in days**, for the period of Jupiter.

..... **1**

(ii) Calculate the time taken for light from the Sun to reach Saturn.

Space for working and answer

3

[*END OF QUESTION PAPER*]

DO NOT WRITE IN THIS MARGIN

K&U	PS

ADDITIONAL SPACE FOR ANSWERS

Make sure you write the correct question number beside each answer.