C

K & U   PS

Total Marks

3220/402

NATIONAL
QUALIFICATIONS
2006

WEDNESDAY, 17 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 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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AUTHORITY
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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	$1 \cdot 6$
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 computer is connected to the Internet by means of a copper wire and a glass optical fibre as shown.

computer
copper wire
optical fibre junction
optical fibre
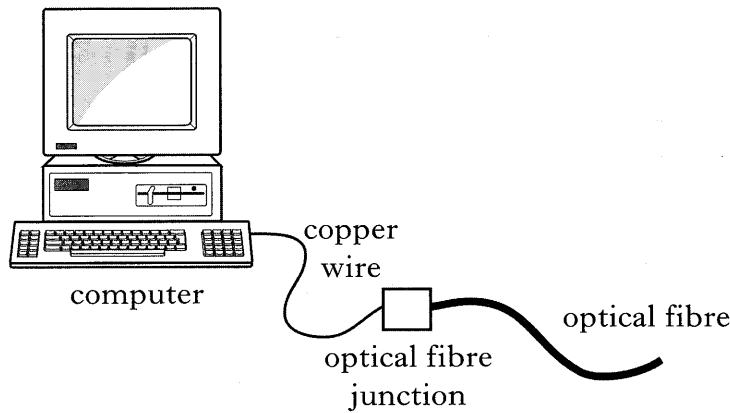
(a) In the table below, enter:

(i) the speed of the signal in each material;

(ii) the type of signal in each material.

	Copper wire	*Glass optical fibre*
Speed of signal		
Type of signal		

2

2

(b) Complete the diagram to show how the signal travels along the optical fibre.

optical fibre junction
optical fibre

2
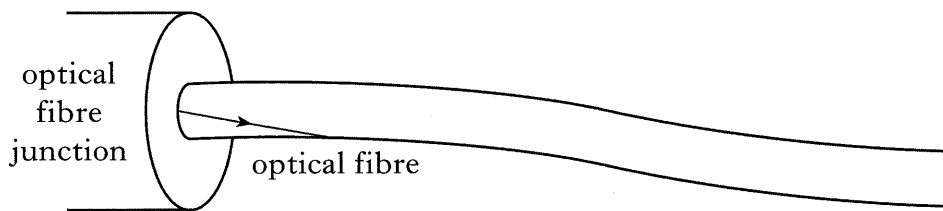
(c) Copper wire or glass optical fibre can be used in telecommunication systems.

(i) Explain which material, copper or glass, would need less repeater amplifiers over a long distance.

....

....

2

(ii) A broadband communication system carries 100 television channels and 200 phone channels.

Explain which material, copper or glass, should be used in this system.

....

....

2

2. A ship has a satellite navigation system. A receiver on the ship picks up signals from three global positioning satellites.

not to scale
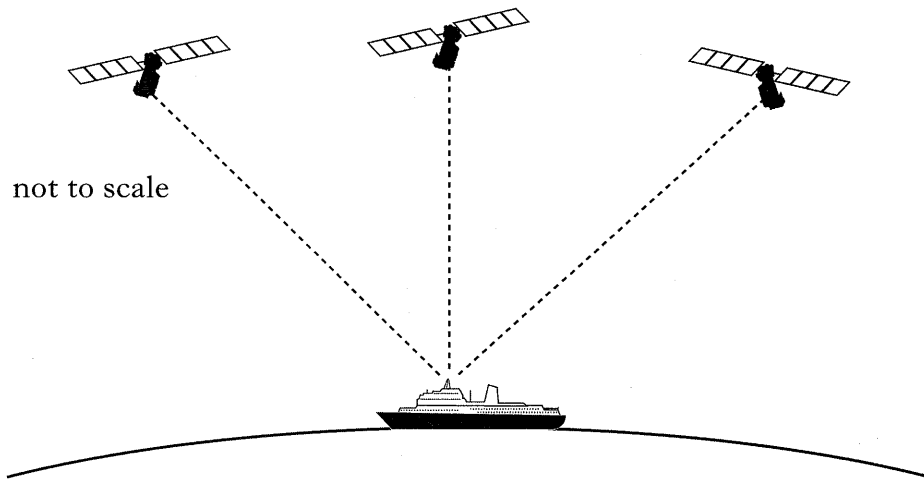
These satellites can transmit radio signals at three different frequencies, 1176 MHz, 1228 MHz and 1575 MHz. The satellites orbit at a height of 20 200 km above the Earth's surface.

(*a*) (i) State the speed of the radio signals.

.... **1**

(ii) One of the satellites is directly above the ship.

Calculate the time taken for the signal from this satellite to reach the ship.

Space for working and answer

2

(iii) Calculate the wavelength of the 1228 MHz signal.

Space for working and answer

2

Marks

2. (continued)

(b) State which of the three signals has the shortest wavelength.

.... 1

(c) One of the global positioning satellites is shown below.

curved reflector
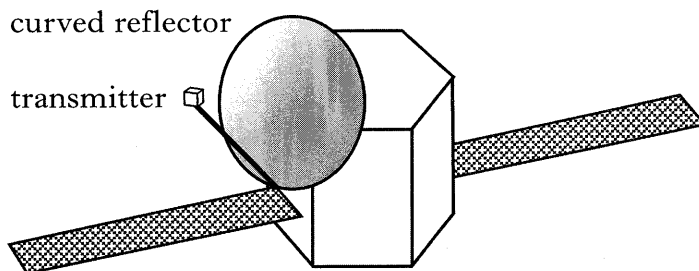
transmitter

(i) Complete the diagram below to show the effect of the curved reflector on the transmitted signals.

2
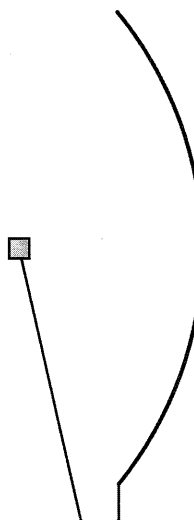
(ii) A satellite in orbit a few hundred kilometres above Earth has a period of one hour. A geostationary satellite orbits 36 000 km above Earth.

Suggest the period of the global positioning satellite.

.... 1

[Turn over

3. Two students are investigating voltage, current and resistance.

(a) The first student builds the circuit shown.
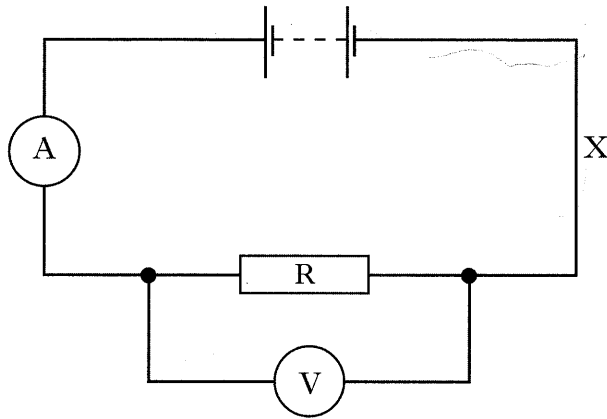
The ammeter displays a current of 0·10 A and the voltmeter displays a voltage of 3·0 V.

(i) Calculate the resistance of R when the current is 0·10 A.

Space for working and answer

2

(ii) The student inserts another ammeter at position X.

What is the reading on this ammeter?

.... 1

(b) The second student uses the **same** resistor in the circuit below.

Page six
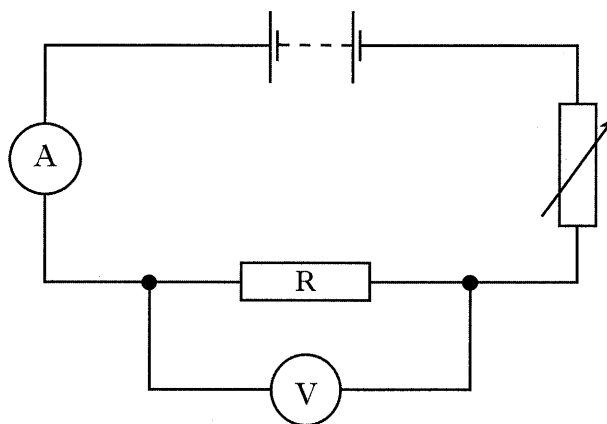
3. (b) (continued)

This student obtains the following set of results.

Result number	Voltage across R (V)	Current through R (A)
1	6·0	0·20
2	7·5	0·25
3	9·0	0·30
4	10·0	0·35
5	12·0	0·40

  (i) Describe how these different values of voltage and current are obtained.

....

....   **2**

  (ii) Explain which result should be retaken.

....

....   **2**

(c) What additional information about resistance does the second student's experiment give compared to the first student's experiment?

....

....

....   **1**

[Turn over

4. A circuit breaker as shown below is used in a circuit.

fixed   moveable
contact   contact

N ////////////// S

iron

terminal   terminal
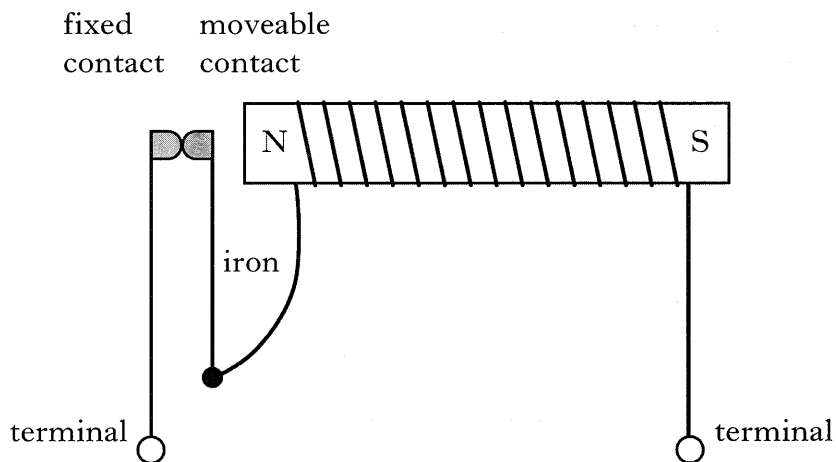
(a) (i) State **one** advantage of a circuit breaker compared to a fuse.

....

.... **1**

(ii) The circuit breaker breaks the circuit when the current becomes too high.

fixed   moveable
contact   contact

N ////////////// S

iron

terminal   terminal
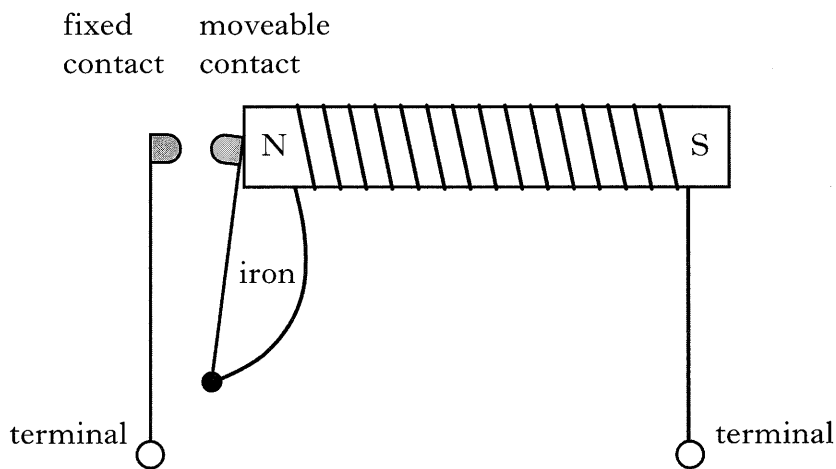
Explain how the circuit breaker operates when the current becomes too high.

....

....

.... **2**

4. (continued)

(*b*) A 5 ampere circuit breaker is used in a household lighting circuit which has three 60 W lamps as shown below.
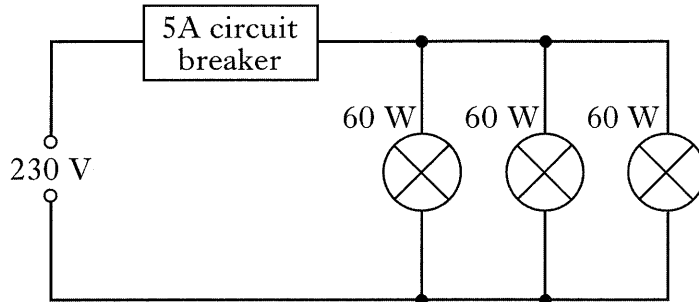
(i) Show that the resistance of **one** lamp is 882 Ω.

> *Space for working and answer*

2

(ii) Calculate the combined resistance of the three lamps in this circuit.

> *Space for working and answer*

2

(iii) Show by calculation whether the circuit breaker will switch off the lamps when all three are lit.

> *Space for working and answer*

3

5. A radioactive source is used for medical treatment. The graph shows the activity of this source over a period of time.

(*a*) Use information from the graph to calculate the half-life of this source.

> *Space for working and answer*

1

5. (continued)

(b) Describe a method that could be used to measure the half-life of this radioactive source, using the apparatus shown. You can ignore background radiation.

clock

detector

stopclock

counter

source

....

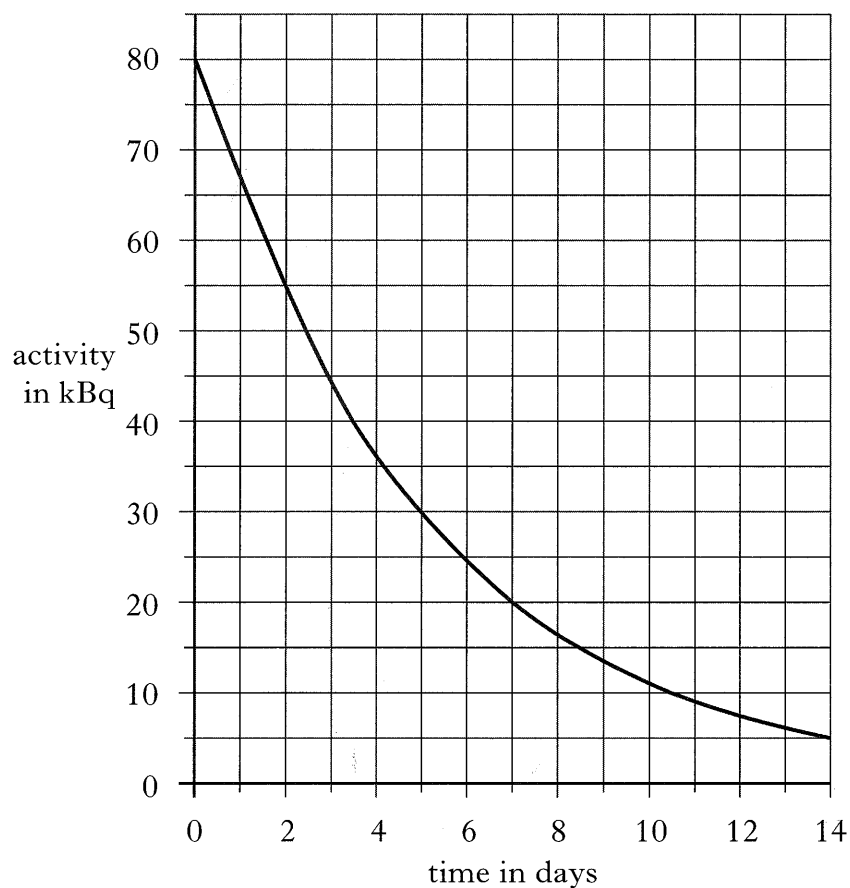...

....

....

....

.... **2**
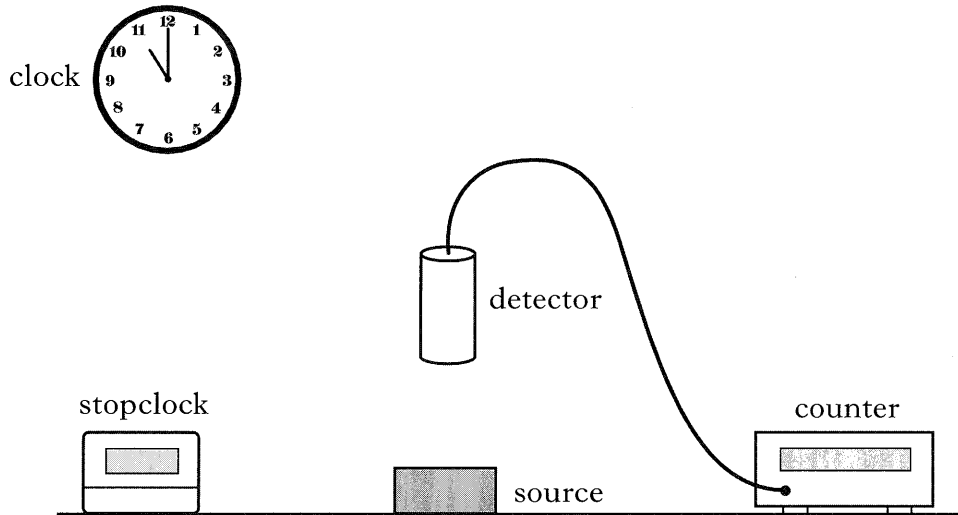
(c) A sample of this source is to be given to a patient at 9.30 am on May 17. When the sample is prepared, its initial activity is 200 kBq. The activity of the sample when given to the patient must be 12·5 kBq.

Calculate at what time and on what date the sample should be prepared.

Space for working and answer

2

6. The table below gives information about some types of laser.

Type of laser	Wavelength (nm)	Output power (W)
Krypton fluoride	248	1·0
Argon	488	2·0
Helium neon	633	0·005
Rhodamine	570 to 650	50·0
Carbon dioxide	10 600	200·0

(a) The visible spectrum has wavelengths ranging from 400 nm to 700 nm.

   (i) Name one type of laser **from the table** that emits visible radiation.

     ....

   (ii) Name one type of laser **from the table** that emits ultraviolet radiation.

     ....

   (iii) Give **one** medical use of ultraviolet radiation.

     ....

(b) A rhodamine laser can be adjusted to emit a range of wavelengths.

What difference is observed in the light from this laser beam as the wavelength changes?

....

....

(c) The beam from the carbon dioxide laser is used to cut steel. A section of steel is cut in 10 minutes.

Using information from the table, calculate the energy given out by the laser during this cutting process.
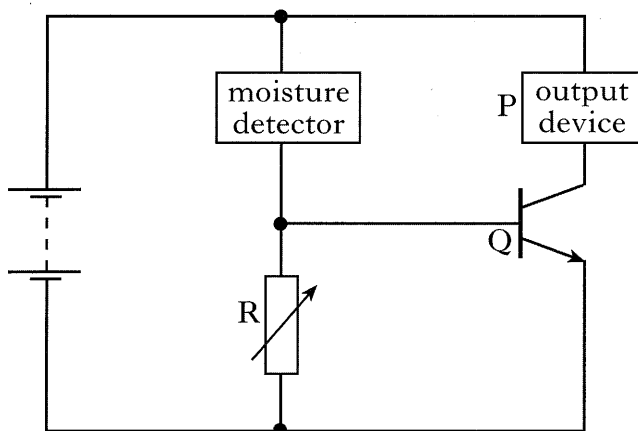
Space for working and answer

Marks

1

1

1

1

2

7. A student designs a lie detector using the following circuit.

Moisture detector:

high resistance when dry
low resistance when wet

(*a*) Name component Q.

.... 1

(*b*) Suggest a suitable output device that could be used at P to produce an audible output.

.... 1

(*c*) This lie detector is based on the fact that when a person tells a lie, the moisture on their skin increases. Initially, the person holds the moisture detector in dry hands and component R is adjusted until the output device is silent.

(i) What happens to the resistance of the moisture detector when the person holding it tells a lie?

....

.... 1

(ii) Explain how the circuit operates as a lie detector.

....

....

....

.... 2

[Turn over

8. An automatic vending machine accepts 1p, 2p and 5p coins. Four light sensors P, Q, R and S are arranged as shown in the coin slot.
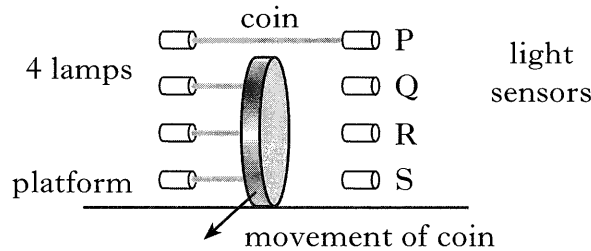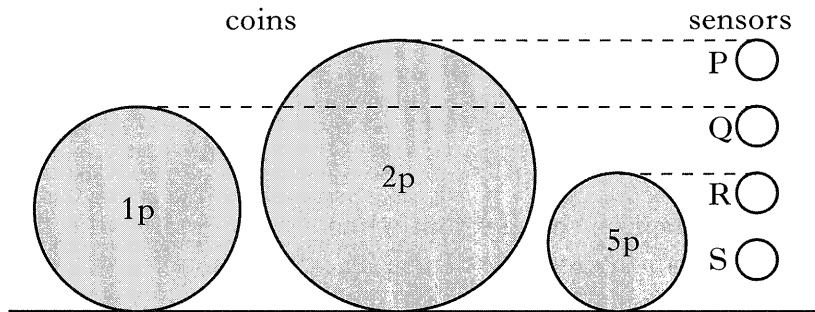

When a coin passes between a lamp and its sensor, the light is blocked. Coins of different diameters block the light from different lamps.

The position of the sensors in relation to the diameters of coins is shown below.

The logic output of the sensors is as follows:

    light blocked   – logic output 1
    light not blocked – logic output 0

(*a*) (i) Name a suitable input device to be used as a sensor.

.... **1**

    (ii) Complete the truth table for the outputs of the sensors when each of the coins passes between the lamps and the sensors.

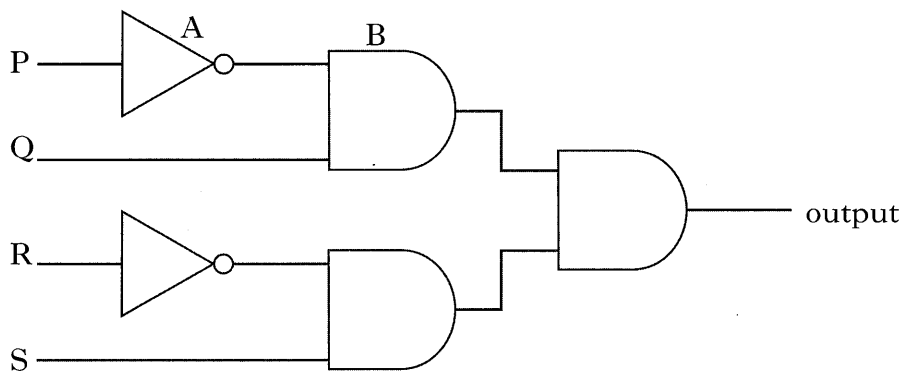|	*1p coin*	*2p coin*	*5p coin*
Sensor P			
Sensor Q			
Sensor R			
Sensor S			

3

8. (continued)

(*b*) A washer is a metal disc with a hole in the middle. The machine is able to reject washers, when they are inserted instead of coins. A washer the same diameter as a 1p coin blocks the light from reaching sensors Q and S only.

washer

4 lamps

light sensors

platform
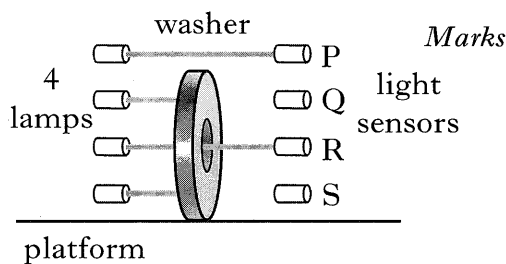
Part of the circuit used is shown below.

(i) Name gate A.

.... **1**

(ii) Name gate B.

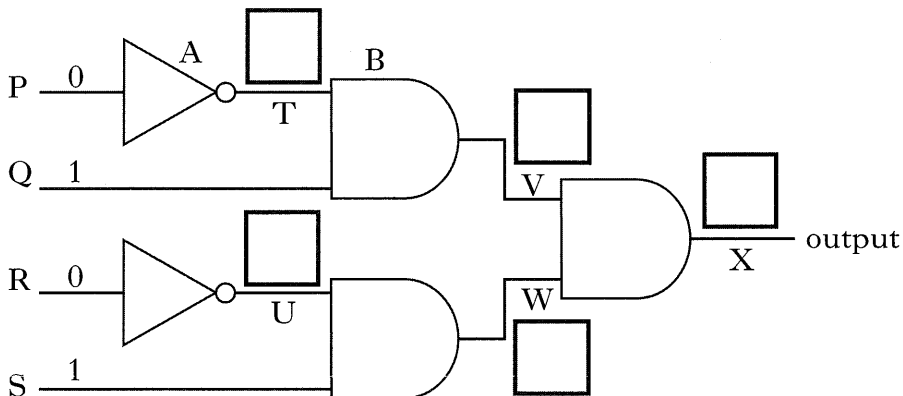.. **1**

(iii) When a washer is inserted, the logic levels at P, Q, R and S are as shown below.

In the boxes on the diagram above, enter the logic levels at each position T, U, V, W and X. **2**

(iv) When a washer is detected, this circuit activates an output device that pushes the washer to reject it.

Name a suitable device to be used as the output device.

.... **1**

9. A table from the Highway Code giving overall stopping distances for vehicles is shown.

The overall stopping distance is made up of:

the **thinking distance** – the distance travelled while the driver "thinks" about braking. This distance depends on the driver's reaction time.
plus
the **braking distance** – the distance travelled while braking.

Speed of vehicle (m/s)	Overall stopping distance (m)
8·9	6 6
13·4	9 14
17·8	12 24
26·7	18 55
thinking distance	braking distance

(*a*) (i) How far does a vehicle travelling at 13·4 m/s travel while the driver thinks about braking?

.... **1**

(ii) Use information **from the table** to calculate the reaction time.
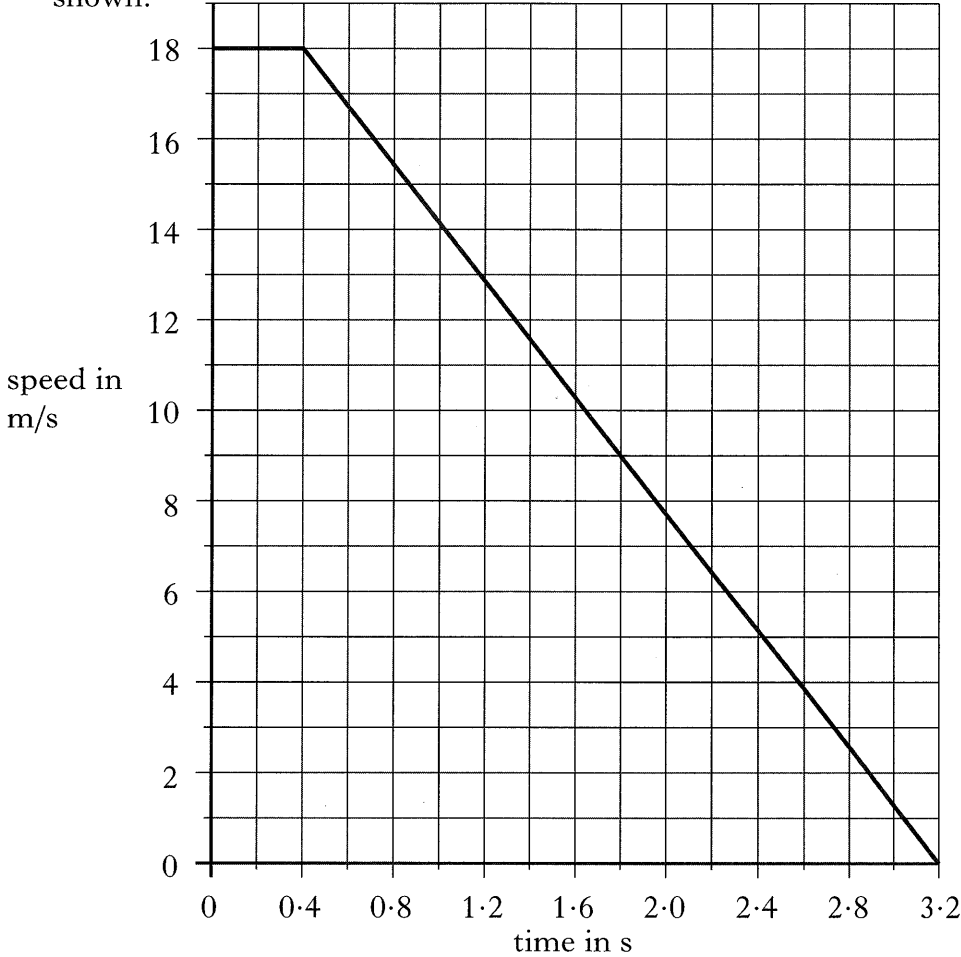
> *Space for working and answer*

2

9. (continued)

(b) A car travels along a road. The driver sees traffic lights ahead change from green and starts to brake as soon as possible. A graph of the car's motion, from the moment the driver sees the traffic lights change, is shown.

(i) What is **this** driver's reaction time?

.... **1**

(ii) Calculate the overall stopping distance.

Space for working and answer

3
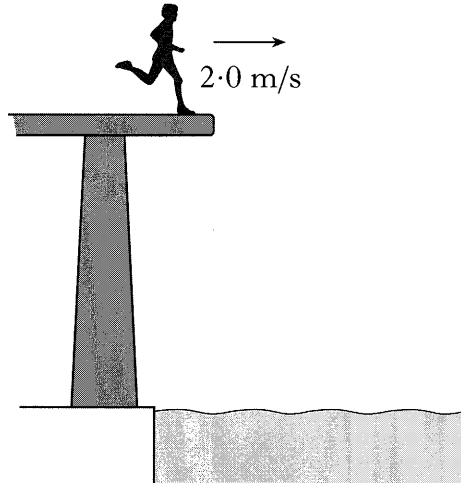
(iii) Calculate the acceleration of the car from the time the driver applies the brakes.

Space for working and answer

2

10. A student runs along a diving platform and leaves the platform *Marks* horizontally with a speed of 2·0 m/s. The student lands in the water 0·3 s later. Air resistance is negligible.

$2 \cdot 0$ m/s

(*a*) (i) Calculate the horizontal distance travelled by the student before landing in the water.

> *Space for working and answer*

2

(ii) The student has a vertical acceleration of 10 m/s^2.

Calculate the vertical speed as the student enters the water.

> *Space for working and answer*

2

(*b*) Later the student runs off the end of the same platform with a horizontal speed of 3·0 m/s.

How long does the student take to reach the water this time? Explain your answer.

....

....

....

2

10. (continued)

(c) The student climbs from the water level to a higher platform. This platform is 5·0 m above the water. The student has a mass of 50 kg.

5·0 m
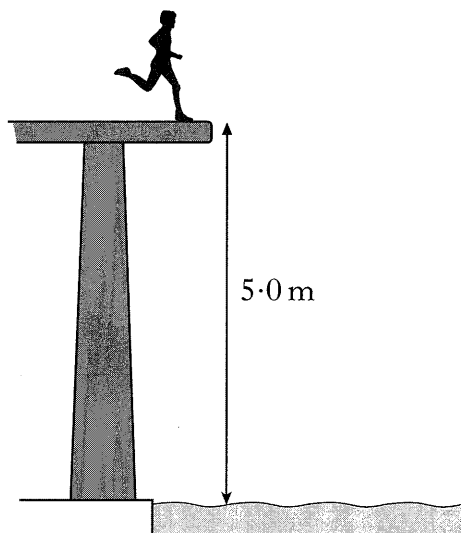
(i) Calculate the gain in gravitational potential energy of the student.

Space for working and answer

2

(ii) The student drops from the edge of the platform and lands in the water.

Calculate the vertical speed as the student enters the water.

Space for working and answer

2

[Turn over

11. A wind generator on a yacht is used to charge a battery at 12 V.
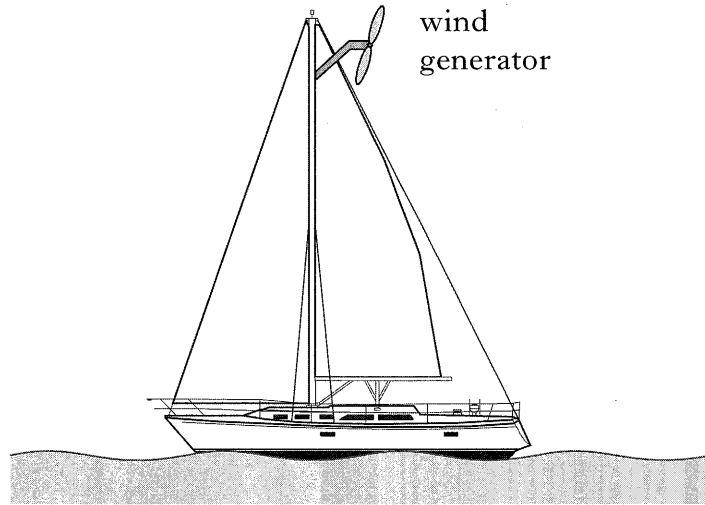
The graph shows the charging current at different wind speeds.
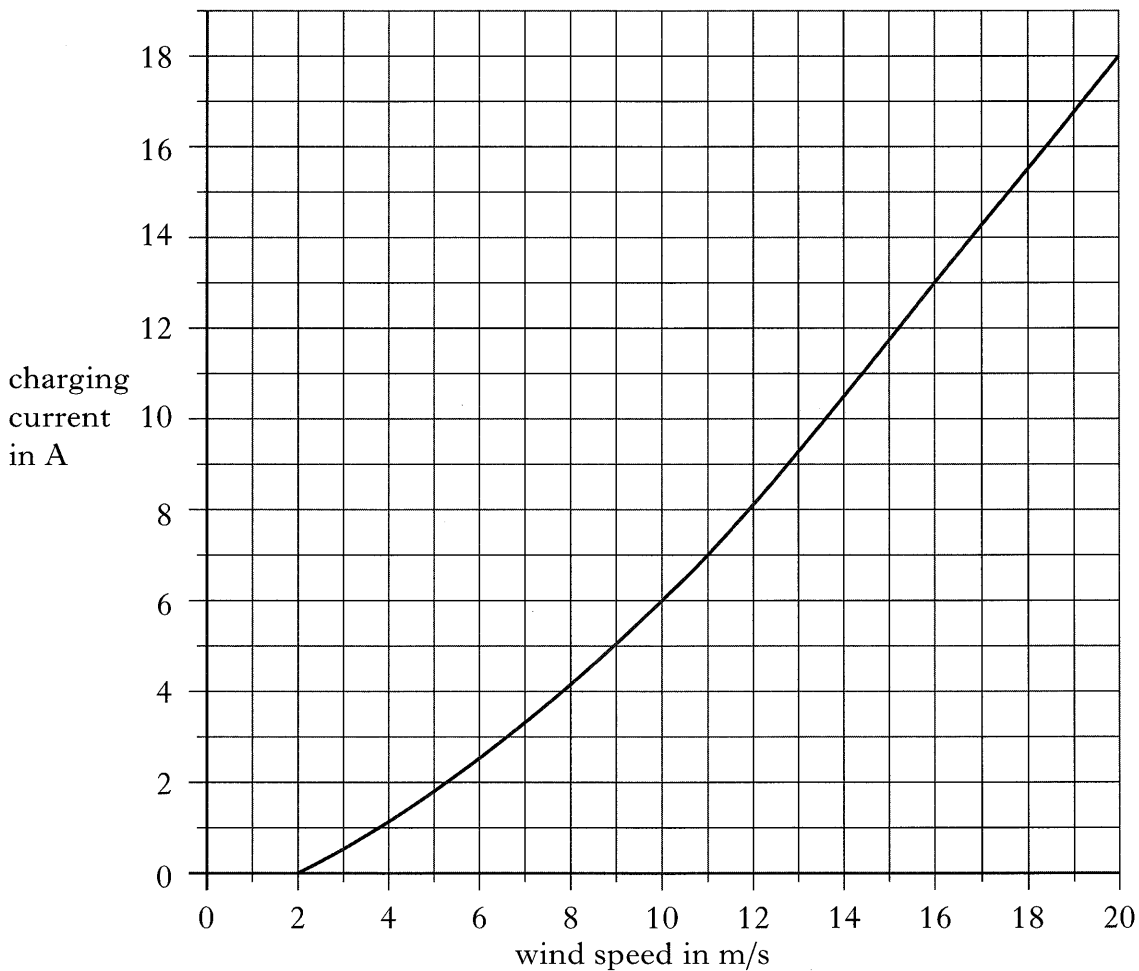
(*a*) The wind blows at a speed of 10 m/s.

    (i) What is the charging current at this wind speed?

....

1

Marks | K&U | PS

11. **(a)** **(continued)**

    (ii) Calculate the electrical power produced by the generator at this wind speed.

> *Space for working and answer*

                    2

    (iii) The wind speed does not change.

       Calculate the energy supplied to the battery in 3·5 hours.

> *Space for working and answer*

                    2

(b) The yacht has a stand-by petrol powered generator to charge the battery.

Why is the petrol generator necessary, in addition to the wind generator?
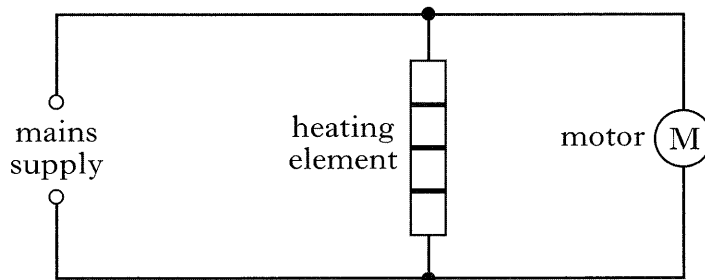
....

.... **1**

[Turn over

12. A mains operated air heater contains a fan, driven by a motor, and a heating element. Cold air is drawn into the heater by the fan. The air is heated as it passes the heating element.
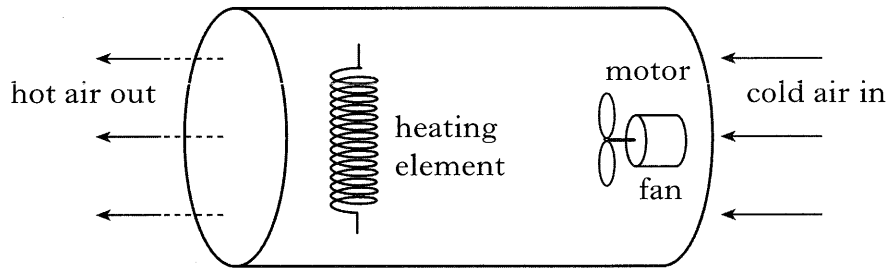
The circuit diagram for the air heater is shown.

(*a*) (i) What is the voltage across the heating element when the heater is operating?

.... **1**

(ii) What type of circuit is used for the air heater?

.... **1**

(*b*) The following data relates to the heater when the fan rotates at a particular speed.

mass of air passing through per second   0·2 kg
energy supplied to air per second   2000 J
specific heat capacity of air   1000 J/kg °C

(i) Calculate the increase in air temperature.

Space for working and answer

2

12. (*b*) **(continued)**

(ii) The motor is adjusted to rotate the fan at a higher speed. This draws a greater mass of air per second through the heater. Explain any difference this causes to the temperature of the hot air.

....

....

.... 2

[Turn over

13. Titan is the largest of Saturn's moons. The gravitational field strength on Titan is 1·35 N/kg.

(a) (i) What is a moon?

....

.... **1**

(ii) What is meant by gravitational field strength?

....

.... **1**

(b) Early in 2005, a probe was released from a spacecraft orbiting Titan. The probe, of mass 318 kg, travelled through the atmosphere of Titan.

(i) Calculate the weight of the probe on Titan.

> *Space for working and answer*

2

(ii) As the probe descended through the atmosphere, a parachute attached to it opened.

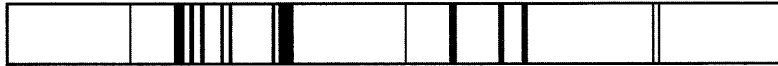State why the parachute was used.

....

....

.... **1**
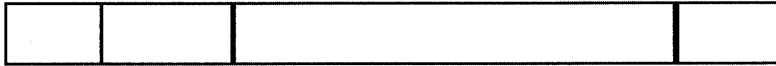
13. **(*b*)** **(continued)**

(iii) The probe carried equipment to analyse the spectral lines of radiation from gases in the atmosphere of Titan. These lines are shown. The spectral lines of a number of elements are also shown.
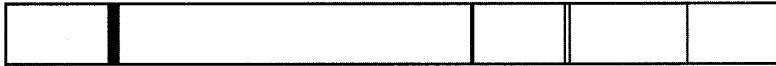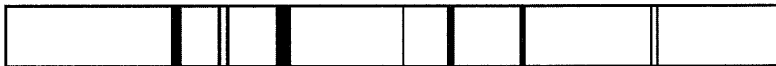
Spectral lines from gases in Titan's atmosphere

Helium

Hydrogen

Mercury

Nitrogen

Use the spectral lines of the elements to identify which elements are present in the atmosphere of Titan.

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....

.... 2

[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.**

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