[3220/257] 1990

C

SCOTTISH CERTIFICATE OF EDUCATION

PHYSICS

Standard Grade—CREDIT LEVEL

Friday, 27th April—1.30 p.m. to 3.15 p.m.

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 ink in the answer book provided.**
3. **Any necessary data will be found in the DATA SHEET on page two.**

UCP 3220/257 6/3/10910

DATA SHEET

Speed of light in materials

Material	*Speed in* $m\,s^{-1}$
Air	$3{\cdot}0 \times 10^8$
Water	$2{\cdot}3 \times 10^8$
Glass	$2{\cdot}0 \times 10^8$

Gravitational field strengths on the surface of planets

Planet	*Gravitational Field Strength in* $N\,kg^{-1}$
Venus	9·0
Earth	10·0
Mars	4·0
Jupiter	26·0

Properties of some radioactive substances

Substance	*Half-life*	*Radiation emitted*
Paladium – 100	86·4 hours	gamma
Antimony – 127	93·6 hours	beta and gamma
Radon – 220	55·6 seconds	alpha
Radon – 222	91·8 hours	alpha
Radium – 224	88·1 hours	alpha and gamma
Radium – 230	93·0 minutes	beta and gamma
Fermium – 247	9·0 seconds	alpha

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1. On a visit to the optician to have her eyes tested, Susan was told that each lens in her new spectacles would have a power of + 1·5 D.

(*a*) Calculate the focal length of each lens. **2**

(*b*) Is Susan long sighted or short sighted? **1**

(*c*) Describe an experiment Susan could carry out to check the focal length of one of the lenses. **3**

2. A party of astronauts has carried out a scientific survey on the planet Mars. They are preparing to return to Earth in their spaceship. The on-board computer provides them with the following information about their lift-off.

Constant thrust exerted by rocket motors = 160 000 N

Mass of spaceship = 25 000 kg

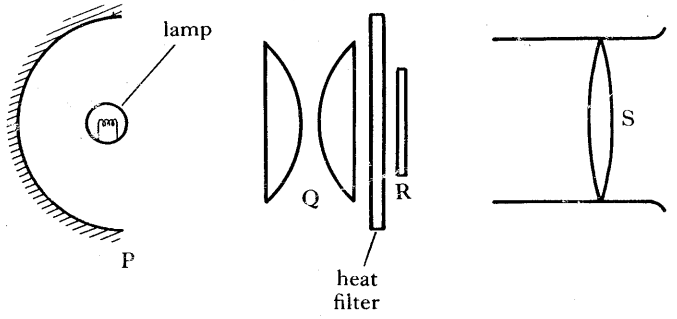
(*a*) What is the weight of the spaceship on Mars? **2**
(Data you require will be found in the Data Sheet on page two.)

(*b*) (i) Draw a diagram showing the forces acting on the spaceship just as it lifts off. **1**

(ii) Assuming that the mass of the spaceship remains constant, what is the acceleration during lift-off? **3**

(*c*) If the same values for thrust and mass had been provided by the on-board computer on Earth, explain why the spaceship would not be able to lift off. **1**

3. The diagram shows parts of a slide projector.



(*a*) Name the parts labelled P, Q, R and S in the diagram. **2**

(*b*) What is the purpose of each of the parts P, Q and S? **3**

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4. Figure 2 is a simplified diagram of how the compact disc player shown in figure 1 works.

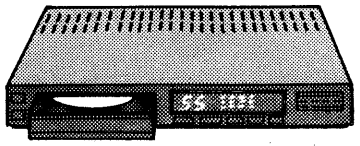


figure 1

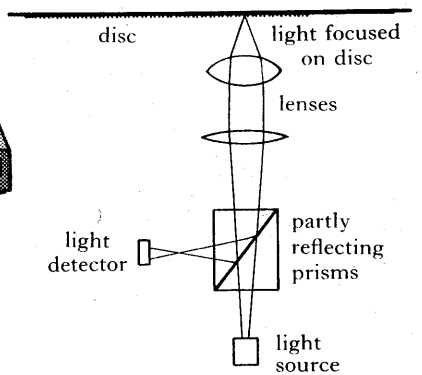


figure 2

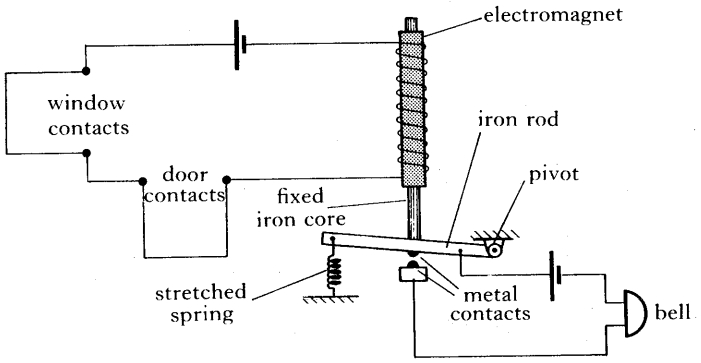
(*a*) (i) What type of light source is used in a compact disc system? **1**

(ii) What is used as the light detector? **1**

(iii) Into what type of signal does the detector change the light? **1**

(*b*) State **two** advantages of a compact disc system over a stereo record system. **2**

5. The diagram shows a circuit, designed by a pupil, to be used as a burglar alarm in a house.
The iron rod can turn about the pivot.



Explain how this alarm operates. **3**

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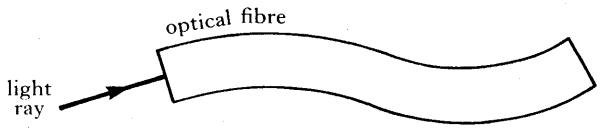
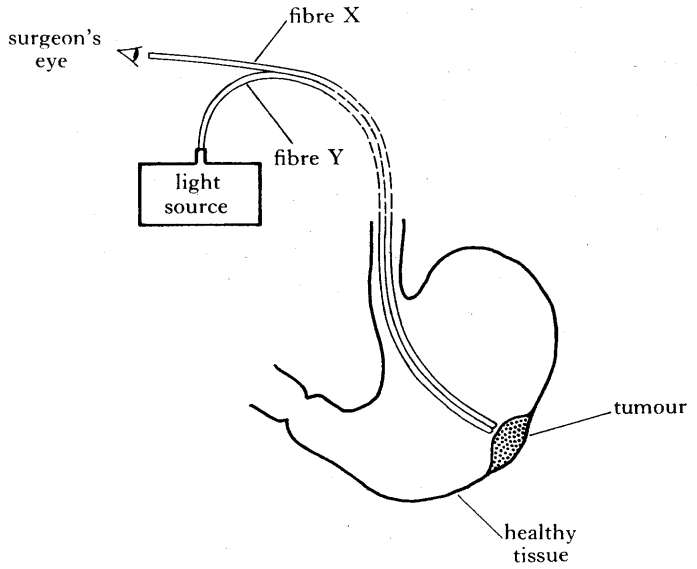
6. (*a*) The diagram below shows part of an optical fibre.



Copy the diagram and draw the path of the light ray through the fibre. **2**

(*b*) Surgeons use optical fibres.



(i) Explain how the fibres X and Y shown above allow a surgeon to see a tumour in a patient's stomach. **3**

(ii) Describe how the surgeon would use a laser to destroy the tumour. **2**

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7. Figure 1 shows a 240 V mains operated hair drier. The circuit diagram for the hair drier is shown in figure 2. In the drier, air can be heated by two elements and can be blown out at slow or fast speeds by a fan driven by a motor. The resistances of the heating elements are indicated on the diagram.

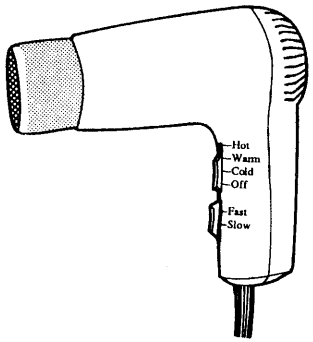

figure 1

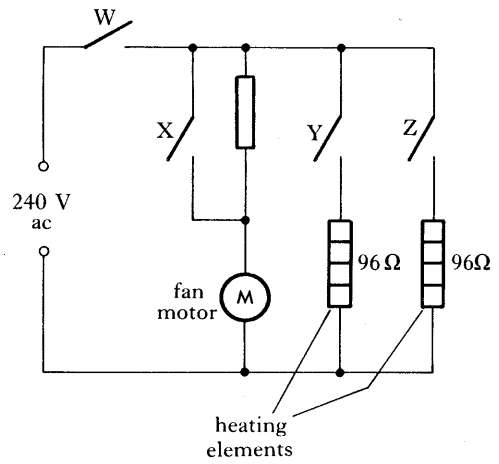

figure 2

Switches on the hair drier can be operated to produce:

1. three heat settings: *COLD, WARM* or *HOT* air
2. two fan speeds: *SLOW* or *FAST*.

(*a*) Which switch or switches, in figure 2, should be closed to produce a *FAST* flow of *HOT* air?

Explain your answer. **3**

(*b*) (i) What is the combined resistance of the two heating elements when switches Y and Z are closed? **2**

(ii) What is the power produced by the two heating elements if switch W is now closed? **2**

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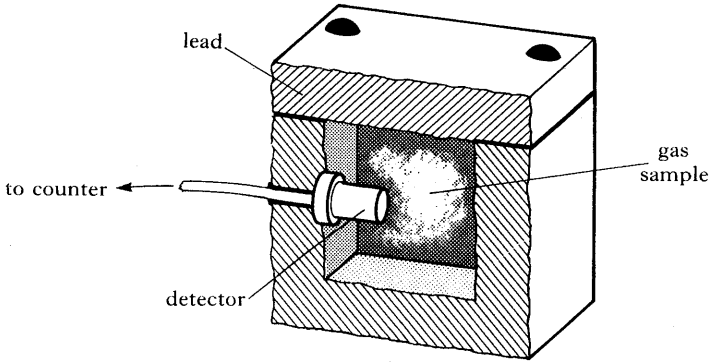
8. A sample of air containing a radioactive gas was collected from a house in Cornwall. The sample and a detector were put into a sealed lead container. A cutaway section of the container is shown below. The count rate for the sample was found at various times.



(*a*) (i) Why were the sample and detector enclosed in a thick lead container? **1**

(ii) The measurements of count rate for the sample as time passed were as follows:

Time in h	0	30	60	90	120	150	180
Count rate in counts min^{-1}	42·0	33·5	26·7	21·3	17·0	13·6	10·8

Use these figures to give an **estimate** of the half-life of the radioactive gas. **1**

(*b*) Such gas samples from Cornwall emit radiation which gives a high density of ionisation compared with the other two types of radiation emitted by natural substances.

(i) What does *ionisation* mean? **2**

(ii) What kind of radiation is the sample emitting? **1**

(iii) Explain why this gas is dangerous if it is breathed in. **2**

(*c*) Using the Data Sheet, on page two, state which radioactive element is present in the sample. **1**

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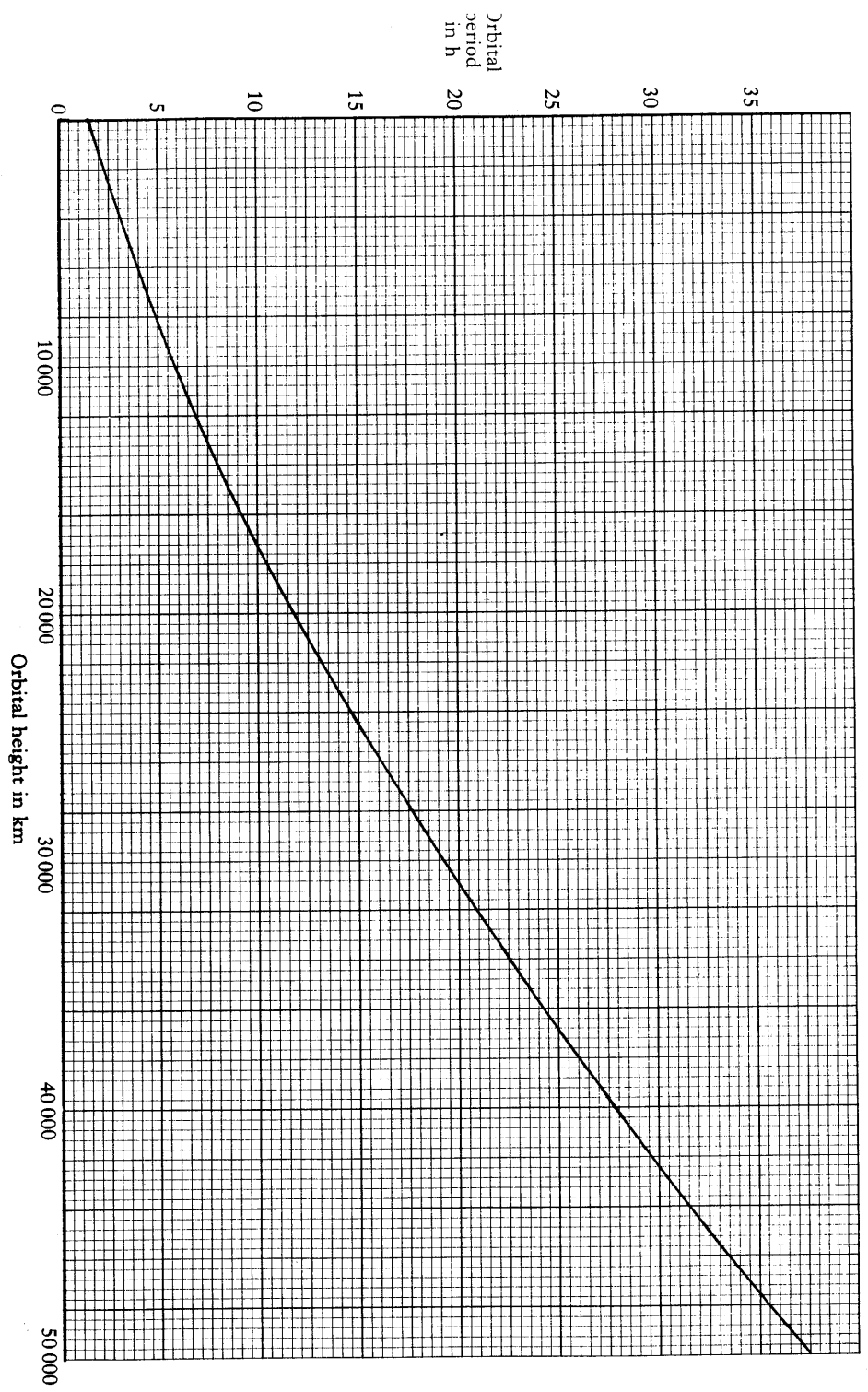
9. (*a*) A TV signal is transmitted from an aerial in Aberdeen at a frequency of 480 MHz.		
(i) Calculate the wavelength of the signal. (Data you require will be found in the Data Sheet, on page two.)	2	
(ii) How long would it take this signal to travel directly from Aberdeen to Dundee, a distance of 88 km?	2	
(iii) Such a signal from Aberdeen cannot usually be received in New York, USA. Give **two** reasons for this.		2
(*b*) One way to get TV signals from Aberdeen to New York is to use a geostationary satellite. The graph opposite shows how the orbital period of any Earth satellite varies with its orbital height.		
(i) Use the graph to find the orbital period for one of the *Explorer* satellites with an orbital height of 4000 km.		1
(ii) *Early Bird* was the first geostationary satellite. Use the graph to find its orbital height.		1
(iii) Explain, with the aid of a suitable diagram, how a geostationary satellite could be used to send a TV signal from Aberdeen to New York.	2	
(iv) A system consisting of a small aerial and a large curved dish is used to transmit the TV signal to the satellite. With the aid of a diagram, explain the purpose of the curved dish.	2	



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10. (*a*) The resistance of a light dependent resistor (LDR) in light and in dark is given below.

Resistance of LDR in light = 1·0 kΩ
Resistance of LDR in dark = 1·0 MΩ

A 49 kΩ resistor and a LDR are connected to a 5 V d.c. supply as shown in figure 1.

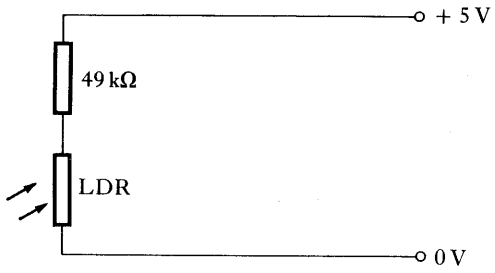

figure 1

What is the voltage across the LDR when in light? | 2 |

(*b*) Figure 2 shows a circuit which can switch on a light emitting diode (LED) on a control panel to indicate that the lights in a tunnel have failed.

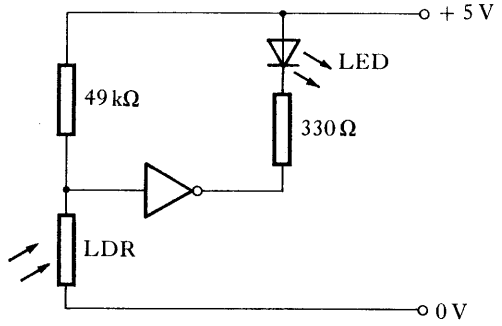

figure 2

State whether the input voltage to the NOT gate is *HIGH* or *LOW* when the tunnel lights are on. | | 1 |

(*c*) Due to a fault, the tunnel lights go out.

(i) What effect does this have on the resistance of the LDR? | 1 |

(ii) Is the input voltage to the NOT gate *HIGH* or *LOW*? | | 1 |

(iii) What is the output voltage from the NOT gate? | | 1 |

(*d*) When the LED is lit, the voltage across it is 1·7 V.
What is the current in the 330 Ω resistor? | | 3 |

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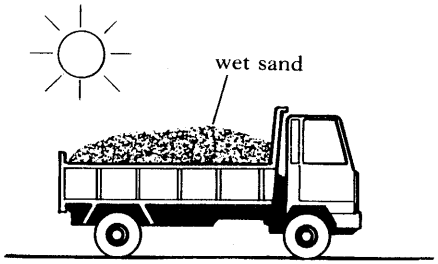
11. A small truck has a load of very wet sand on board.



(*a*) On a long trip the driver notices that the sand is drying out.
Explain the effect that this would have on the maximum acceleration of the truck. | 2 |

(*b*) Measurements of the air resistance on the truck are made at different speeds and the results shown below.

Speed v (ms^{-1})	5	10	15	20	25
Air resistance R (N)	200	800	1800	3200	5000

There is a relationship between the air resistance R and the speed v.
Three pupils, William, Mary and James, suggest the following relationships. In each case k is a constant.

William: $R = \frac{k}{v}$
Mary : $R = kv$
James : $R = kv^2$

(i) Explain why you would immediately reject William's suggestion. | | 1 |

(ii) Which pupil made the correct suggestion?
You **must** clearly show, using all of the measurements, the working which leads you to your answer. | | 3 |

(*c*) At a certain speed, the air resistance is 4050 N and other resistive forces amount to 350 N.
The total mass of the truck and sand is 1240 kg and the forward force produced by the engine is 4640 N.
What is the acceleration of the truck? | | 4 |

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12. Figure 1 shows the gas-fired central heating boiler for a house. The efficiency of the boiler is 65%. In an average year the boiler is supplied with 1500 therms of energy.

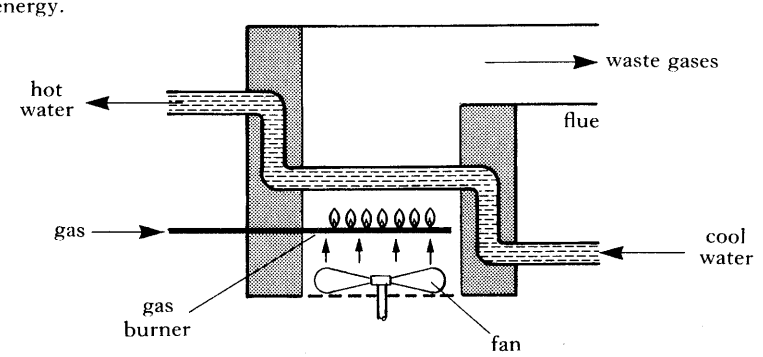

figure 1

(*a*) What is the energy output, in therms, from the boiler in a year? | 2 |

A new design of boiler with an efficiency of 80% is available. A householder wishes to see how much saving could be made on gas bills by installing this new boiler so that it gives the same yearly energy output as the boiler in figure 1.

(*b*) How many therms of energy would need to be supplied to the new boiler to heat the house for a year? | 2 |

(*c*) British Gas Scotland charges 40 p per therm.
What would be the saving on gas bills in a year if the new boiler were installed? | | 2 |

The householder's boiler has broken down. He must decide whether to replace it with a similar one or with one of the new design. The new design of boiler costs £270 **more** to instal.

(*d*) How long would it take him to recover the extra cost of installing a boiler of the new design? | | 2 |

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12. (continued)

Figure 2 shows the new design of boiler which makes use of the steam in the waste gases produced by the burner.
In the old style boiler, this steam goes out through the flue. With the new design, the burner is inverted and the tube carrying the water is bent into a U-shape as shown. The steam is blown by the fan towards the secondary tube which carries cool water into the boiler.

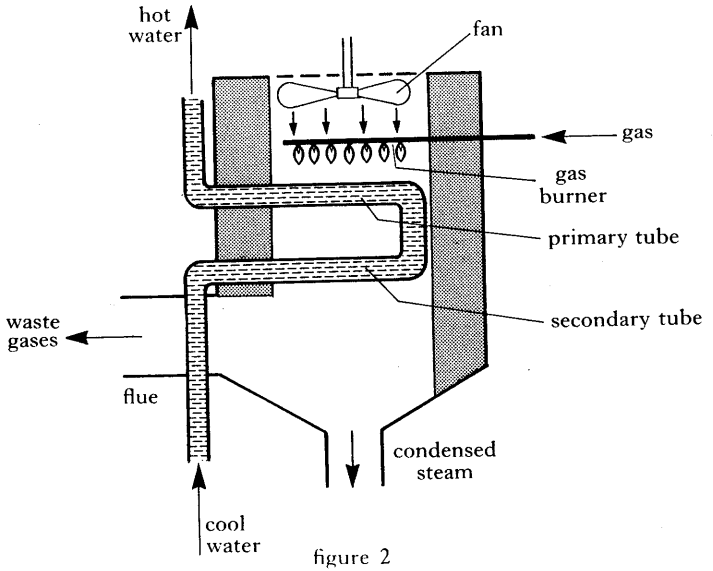

figure 2

(*e*) Explain why, by condensing the steam on the secondary tube, the new boiler is more efficient. | | 2 |

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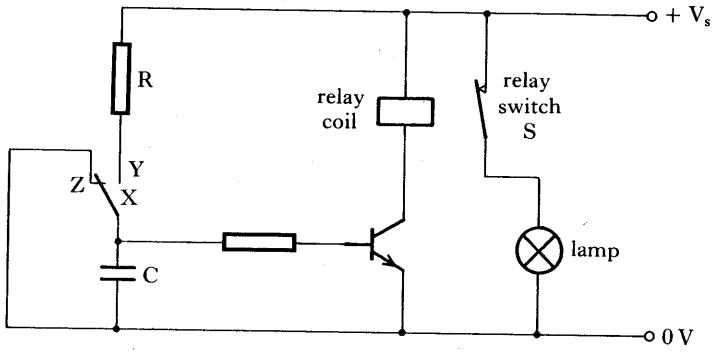
13. Imran and Alistair design the following circuit which will allow a lamp to stay on for a short time after the switch contact X in a lamp switch (XYZ) has been moved from Z to Y.



When there is no current in the relay coil, the switch S is closed and the lamp is on. When there is a current in the relay coil, the switch S opens and the lamp is switched off.

(*a*) (i) Capacitor C is uncharged and the switch contact X is moved from Z to Y. The lamp goes off after a few seconds.

(A) What happens to the voltage across the capacitor after the switch contact is moved to Y? **1**

(B) Explain why the transistor does not switch on immediately when X makes contact with Y. **2**

(C) When the transistor switches on, what effect does this have on the relay switch? **1**

(ii) When the switch contact X is moved from Y to Z, the lamp re-lights. Explain. **3**

(*b*) Alastair and Imran decide to investigate how the time taken for the lamp to go off, when X is moved from Z to Y, depends on the values of R and C.

Alastair increases the value of R and at the same time decreases the value of C. Imran disagrees with this procedure.

What advice should Imran give to Alastair so that he is able to carry out the investigation more scientifically? **2**

[END OF QUESTION PAPER]