C

[3220/286] 1992

SCOTTISH CERTIFICATE OF EDUCATION

PHYSICS

Standard Grade—CREDIT LEVEL

Thursday, 14th May—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.**

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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	3000
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

Materials	*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*
mega	M	$1\,000\,000 = 10^6$
kilo	k	$1000 = 10^3$
milli	m	$0{\cdot}001 = 10^{-3}$
micro	μ	$0{\cdot}000\,001 = 10^{-6}$

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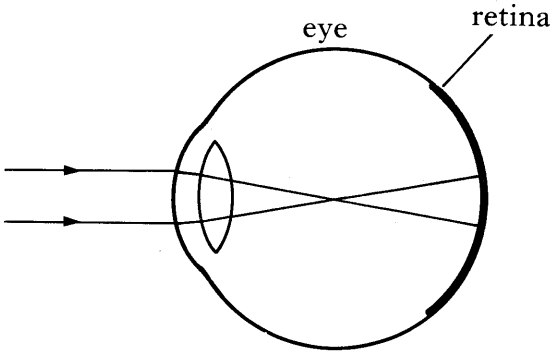
1. Ultrasound is used to obtain information about the growth of unborn babies. Ultrasound of frequency 6·0 MHz is transmitted through the mother's body at a speed of 1500 m/s.		
(*a*) What is the wavelength of the ultrasound in the mother's body?	2	
(*b*) Why is ultrasound, rather than X-rays, used to obtain information about the unborn baby?		1
2. The diagram below shows rays of light from a distant object entering the eye of a short-sighted person.		



Draw a diagram to show how a lens would correct the problem.	3	
3. The diagram below shows some of the radiations which make up the electromagnetic spectrum in order of wavelength. Two radiations Y and Z have not been named.		

Gamma rays	*X-rays*	*Y*	*Visible light*	*Infra red*	*Z*	*Radio and TV waves*

(*a*) Name:		
(i) radiation Y;		
(ii) radiation Z.	2	
(*b*) Name a detector for any one of the radiations in the diagram. You must indicate which radiation you have chosen.	1	
(*c*) How does the speed of gamma rays compare with the speed of visible light?	1	

[Turn over

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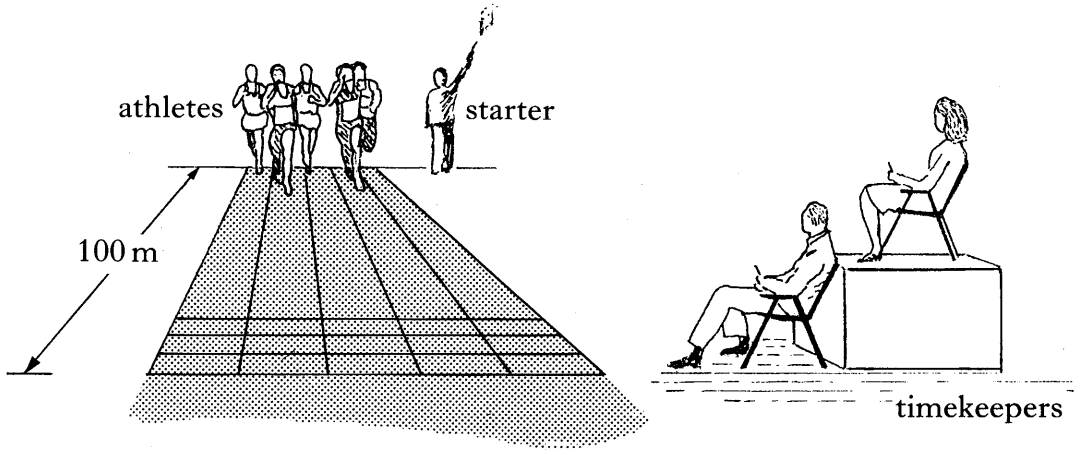
4. Two timekeepers Smith and Jones are timing a 100 m sprint.



Smith starts her stopwatch when she sees the smoke from the starter's gun. Jones starts his watch when he hears the bang from the gun. Both stop their watches at the instant the winner reaches the finishing line. Both timekeepers are 100 m from the starter.

(*a*) Which timekeeper records the shorter time for the winner? Explain your answer. **2**

(*b*) The reading on Jones' watch is 11·3 s.
What is the reading on Smith's watch?
(Data you require will be found in the Data Sheet on page 2.) **3**

5. A tail and brake lamp on a car has two filaments in the same glass bulb as shown in figure 1. One filament has a resistance of 7 Ω and the other a resistance of 28 Ω. Figure 2 shows the circuit containing the two filaments.

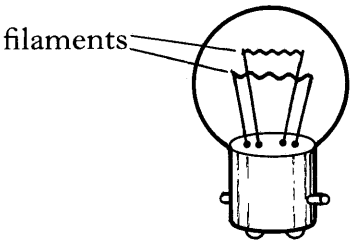


figure 1

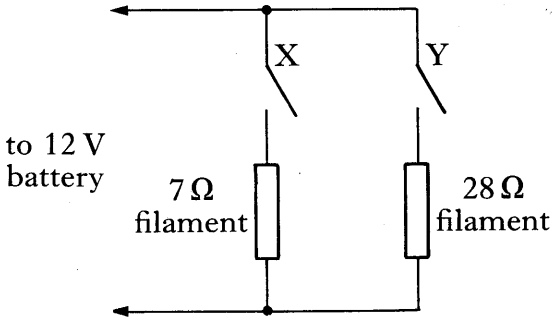


figure 2

(*a*) What is the resistance of the two filaments when connected in parallel by closing switches X and Y? **2**

(*b*) For safety reasons, the brake light has a higher power than the tail light.
Explain which filament acts as the brake light. **2**

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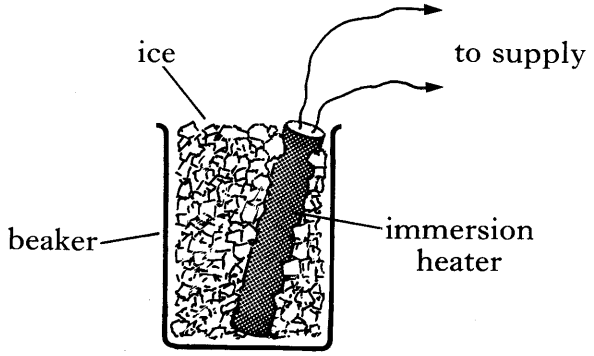
6. A pupil, working in a laboratory, sets up the apparatus shown below to measure the specific latent heat of fusion of ice.



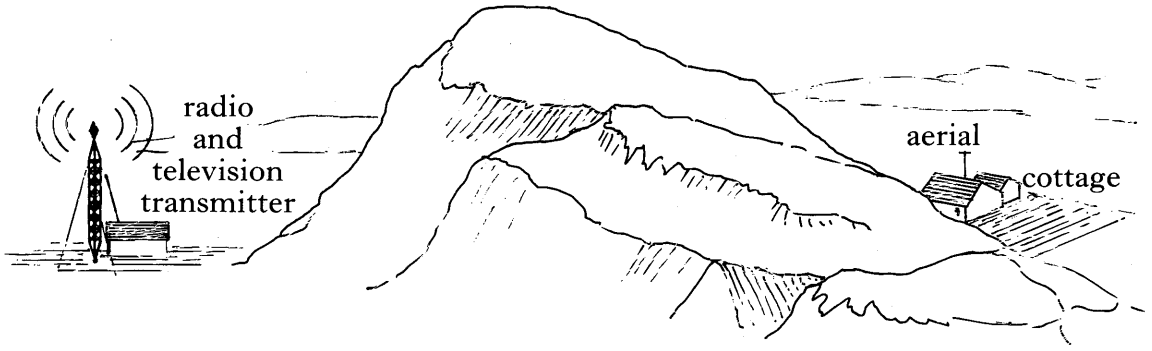
He places the ice around the immersion heater and switches the heater on for 5 minutes. He then pours off the melted ice and measures its mass. The immersion heater is rated at 50 W and the mass of melted ice is 0·05 kg.

(*a*) Calculate the value of the specific latent heat of fusion of ice given by the above measurements. **3**

(*b*) Why will the above method not give an accurate value for the specific latent heat of fusion of ice? **1**

(*c*) Suggest a way in which the experiment could be improved to give a more accurate result. **1**

7. While on holiday in the Highlands with her family, Kirsty notices that a radio and television transmitter is situated on the other side of the hill from the cottage where she is staying.



(*a*) On checking the local paper, Kirsty finds that the radio programme she wishes to listen to is transmitted at a frequency of 1089 kHz and that the television programme she wishes to see is transmitted at a frequency of 623 MHz.

Which of these two transmissions has the longer wavelength? **1**

(*b*) Kirsty notices that, although she can get good reception on her radio, the television reception is very poor.

Use your answer to part (*a*) to explain this difference in reception. **2**

(*c*) Kirsty tries playing a video cassette and finds that she gets a perfect picture on the television screen.

Explain why this can happen when the television reception is so poor. **1**

[Turn over

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8. Two types of battery are available for use in the slide viewer shown in figure 1. A pupil is trying to find out which is the better type. Using the lamp from his viewer, he sets up the circuit shown in figure 1 to measure how long the first battery Y will last.

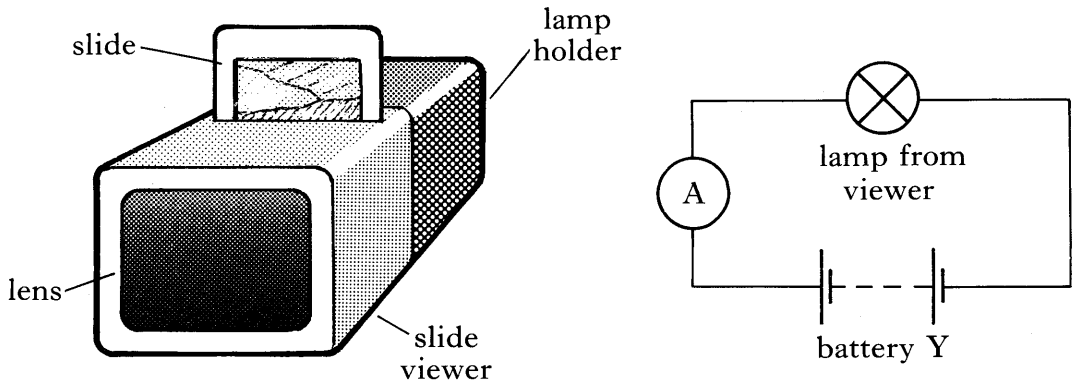


figure 1

He repeats the experiment with the second battery Z.

The results of the pupil's experiments are shown as graphs in figure 2 and figure 3 opposite.

(*a*) Re-draw the above circuit diagram and complete it to show how the voltmeter would be connected to obtain the results in figure 2. **1**

(*b*) Using the data given in the graphs, find:

(i) the maximum power delivered to the lamp by battery Z; **3**

(ii) the voltage across the lamp when battery Z delivers a current of 200 mA; **1**

(iii) the resistance of the lamp when the current from battery Z is 200 mA. **2**

(*c*) A slide in the viewer becomes difficult to see when the current in the lamp falls below 200 mA.

(i) Compared to battery Y, how many more hours of viewing can be obtained from battery Z before the picture becomes difficult to see? **1**

(ii) Battery Y costs 80p and battery Z costs 96p.
Which battery is the better value for money? You **must** justify your answer. **2**

8. (continued)

figure 2

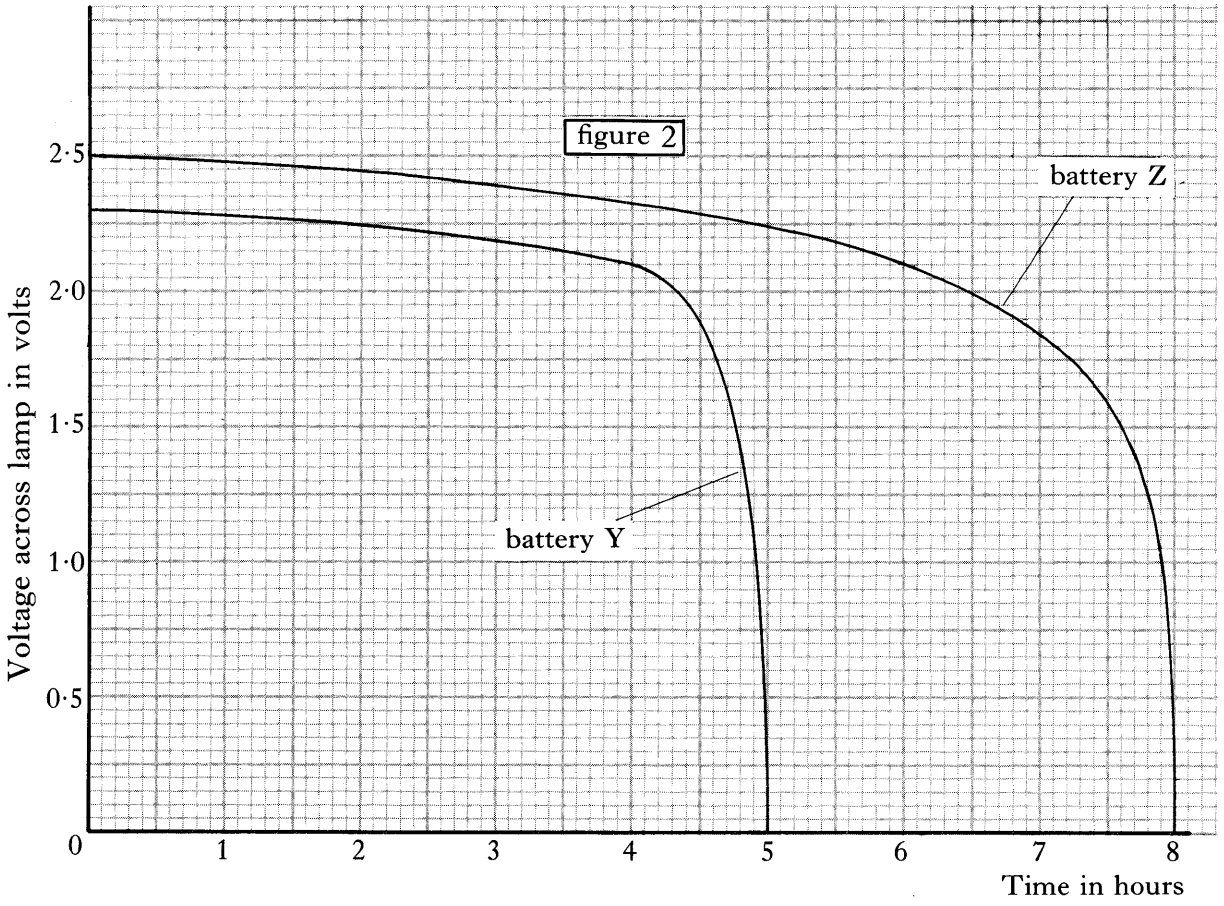
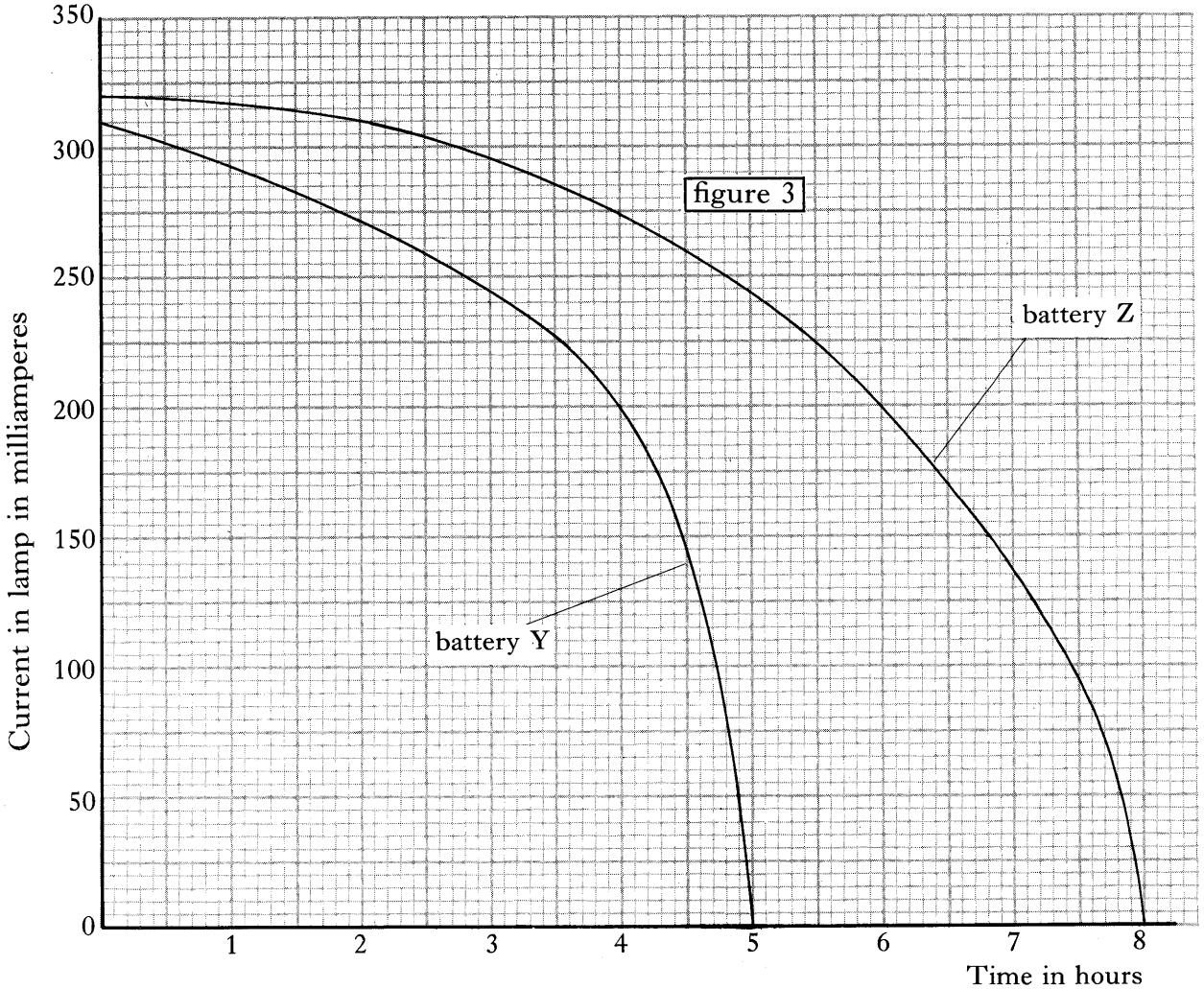


figure 3



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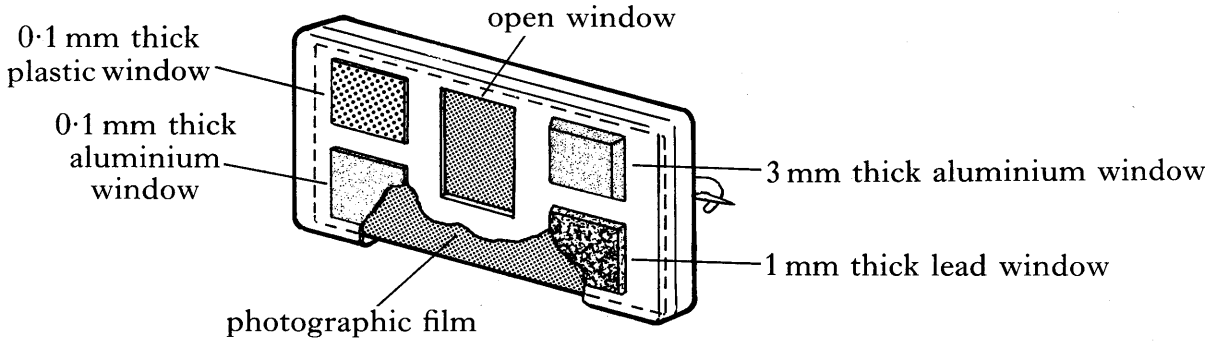
9. A hospital technician measures the half-life of a radioactive element which emits beta radiation and finds this to be 20 minutes.		
(*a*) The sample of radioactive element she is working with has an activity of 2000 Bq at the start of her measurement. What will be the activity of the sample after 1 hour?	2	
(*b*) Describe a method which she could use to measure the half-life of the element. Your description should include:		
(i) a labelled diagram of the apparatus she could use;		
(ii) the measurements which she should take.	4	
(*c*) While working with radioactive substances, the technician wears a film badge similar to that shown in the diagram below. A photographic film, protected from light, is placed behind the windows in the badge.		



If the technician was exposed accidentally to too much beta radiation, which part or parts of the film would **not** be affected?
Explain your answer. | | 2

10. (*a*) Figure 1 shows two logic gates X and Y.

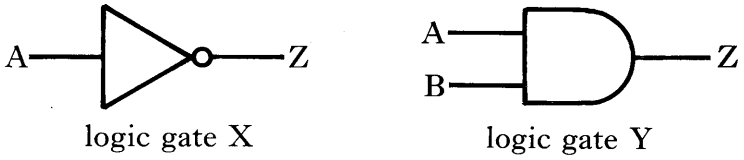


figure 1

(i) Name logic gate X and draw its truth table.	2	
(ii) Name logic gate Y and draw its truth table.	2	

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10. (continued)

(*b*) A pupil uses the logic gates, shown in figure 1, when designing an electronic lock system. The system contains six light detectors illuminated by a light source. When a card with holes in it is inserted between the light source and detectors, as shown in figure 2, it can act as a "key" by allowing light to reach only some of the detectors.

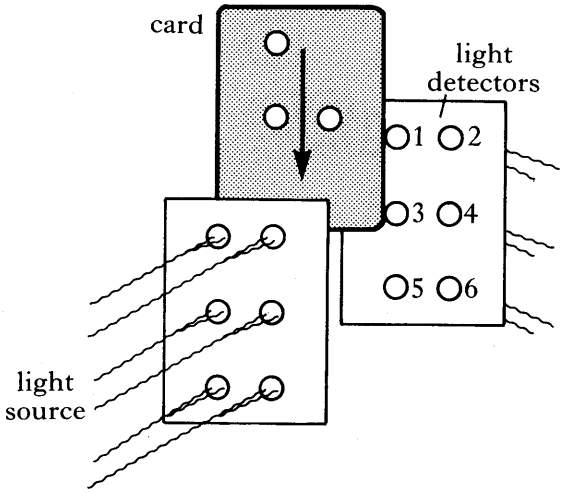

figure 2

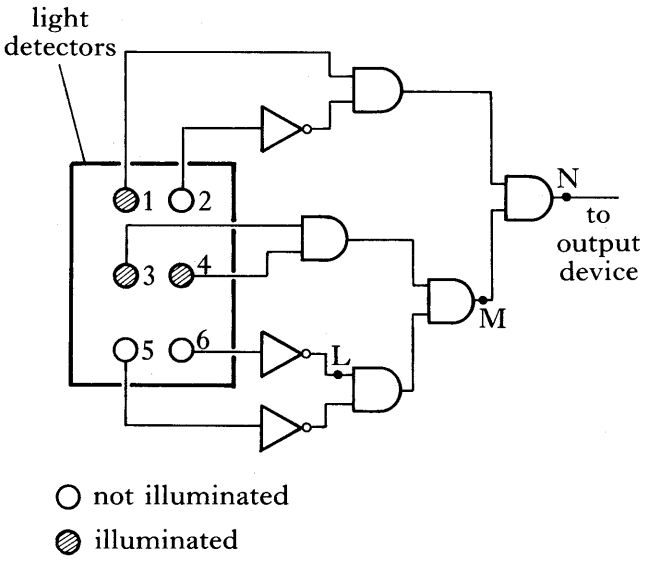

figure 3

A set of logic gates connected to the detectors can provide the correct output voltage to open the lock.

The logic gates are connected as shown in figure 3.

Each detector gives a "high" logic output when light shines on it.

The effect of using the card is shown in figure 3.

(i) What are the logic levels at points L and M? **2**

(ii) What is the logic level at point N? **1**

(iii) Name a suitable output device which could be connected to the system at N. **1**

(*c*) The pupil wishes to use a different card as the "key". This card is shown in figure 4.

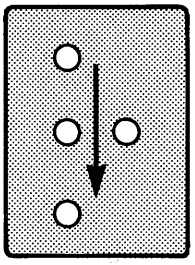

figure 4

What change would have to be made to the circuit shown in figure 3 before this card would open the "lock"? **2**

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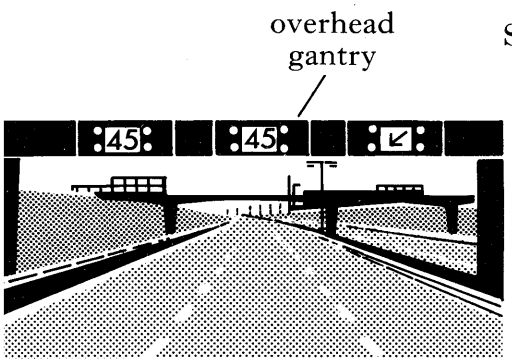
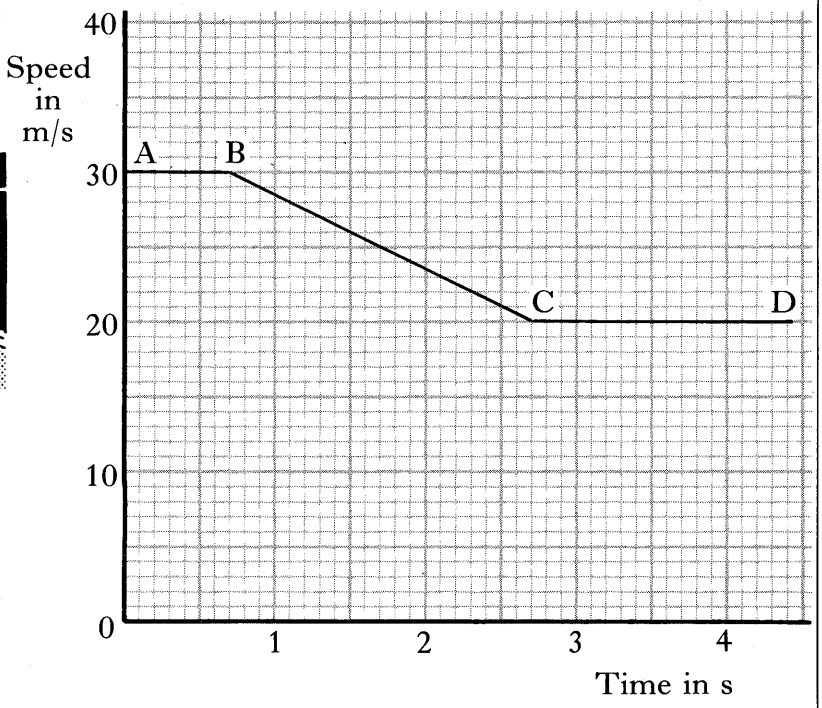
11. The driver of a car, travelling along a motorway, sees a speed limit of 20 m/s (45 mph) flashing on an overhead gantry in front of him and decides to brake. The graph shows the speed of the car from the instant the driver sees the sign.





(*a*) How long did it take the driver to react by applying the brakes of his car after seeing the sign? — **1**

(*b*) Describe the motion of the car between:

(i) B and C;

(ii) C and D. — **2**

(*c*) The driver was 100 m from the gantry when he saw the sign.
Was the car travelling at the required speed when it passed the gantry?
You **must** clearly show your working which leads you to your answer. — **3**

(*d*) Calculate the deceleration of the car. — **2**

(*e*) The total mass of the car and driver is 1000 kg.
What size of force is needed to give the deceleration in part (*d*)? — **2**

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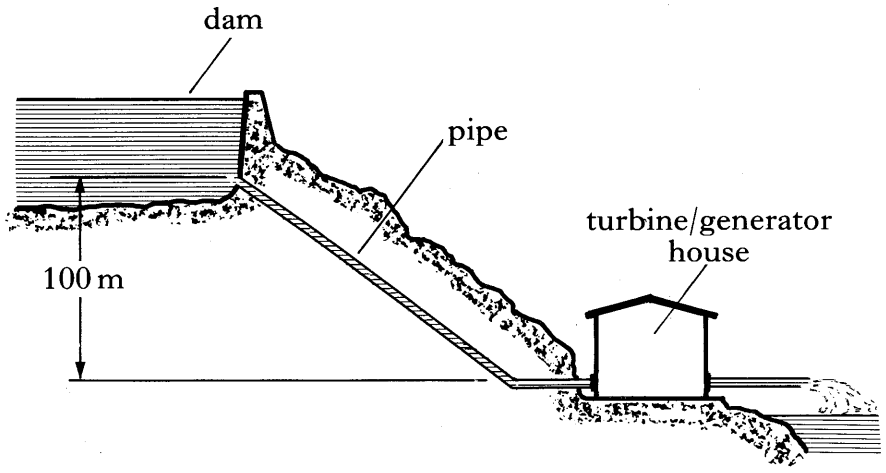
12. A remote farm has its own small hydroelectric scheme. Water flows down a pipe at a rate of 17·5 kg/s from a dam to a turbine. The top of the pipe is at a height of 100 m above the turbine as shown in the diagram below.



(*a*) Calculate the change in the potential energy of the water every second as it flows from the top of the pipe to the turbine. **2**

(*b*) The turbine drives a generator which has an output power of 7·0 kW. What is the efficiency of the system? **2**

(*c*) State **one** disadvantage of such a hydroelectric scheme. **1**

(*d*) The farm has a back-up diesel fuelled generator for use in an emergency. State **one** advantage of the hydroelectric scheme over the diesel generator. **1**

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13. (*a*) The navigation satellite shown in figure 1 moves in a circular orbit above the Earth's atmosphere.

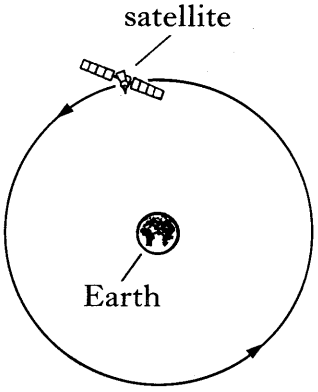

figure 1

Explain why:

(i) the satellite does not move in a straight line into space;

(ii) the satellite does not fall straight down to Earth. **2**

(*b*) Many satellites do not have circular orbits but travel as shown in figure 2.

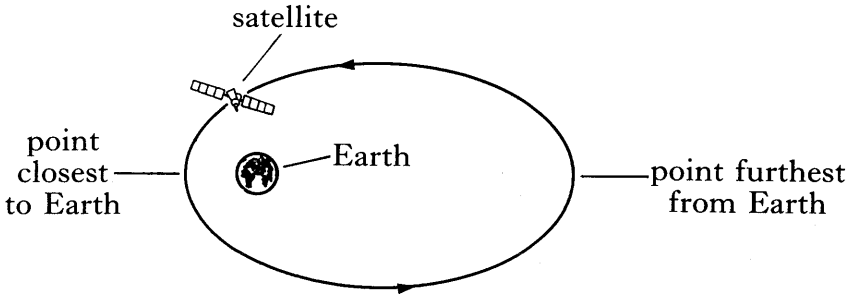

figure 2

The Earth's atmosphere gradually becomes thinner until at a height of 1000 km above the surface there is almost no air.

Study the information given in the table below.

Satellite	*Minimum height above Earth (km)*	*Maximum height above Earth (km)*	*Life-time in orbit*
"Spy"	120	450	2 weeks
Sputnik I	225	945	3 months
Explorer I	360	2550	12 years
Navigation	1110	1110	1000 years

Explain why the "spy" satellite has such a short life-time in orbit while the navigation satellite is expected to remain in orbit much longer. **3**

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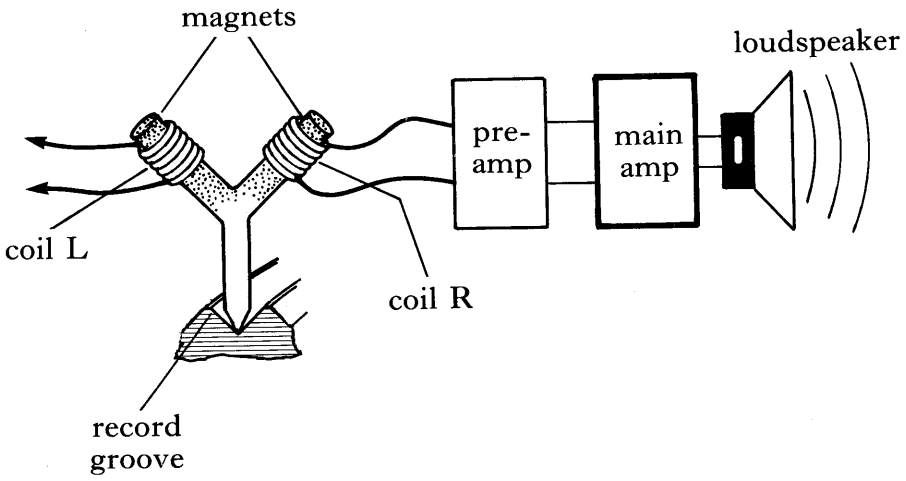
13. (continued)		
(*c*) A satellite of mass 80 kg orbits the Earth at a speed of 4000 m/s. The satellite is constructed mainly from a metal alloy of specific heat capacity 320 J/kg °C.		
(i) Calculate the kinetic energy of the satellite when in orbit.	2	
(ii) Calculate the change in the temperature of the satellite which might be expected if all its kinetic energy is rapidly converted to heat energy as the satellite comes back to Earth.	2	
(iii) Suggest why in practice the change in temperature you have calculated in part (ii) will not be obtained.		1
14. A stereo LP disc produces signals using a stylus as shown below.		



(*a*) Explain why electrical signals are produced in coil L and coil R.		3
(*b*) How will the frequency of the sound from the loudspeaker be affected if the LP disc is played at a greater speed?		1
(*c*) The voltage of the signal from the coil R is 0·20 mV. This is applied to a pre-amplifier and produces an output voltage of 12 V. Calculate the voltage gain of the pre-amplifier.		2
(*d*) The voltage from the pre-amplifier is applied to a main amplifier with a power gain of 400. An output of 100 W is produced.		
(i) Calculate the input power to the main amplifier.	2	
(ii) Find the input resistance of the main amplifier.		2

[END OF QUESTION PAPER]