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National Qualifications SPECIMEN ONLY

Mark

SQ37/H/01

Physics Section 1— Answer Grid and Section 2

Date — Not applicable

Duration — 2 hours 30 minutes

* S Q 3 7 H 0 1 *

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Number of seat

Date of birth

Day Month Year

Scottish candidate number

Total marks — 130

SECTION 1 — 20 marks
Attempt ALL questions.
Instructions for the completion of Section 1 are given on *Page two*.

SECTION 2 — 110 marks
Attempt ALL questions.
Reference may be made to the Data Sheet on *Page two* of the question paper SQ37/H/02 and to the Relationship Sheet SQ37/H/11.
Write your answers clearly in the spaces provided in this booklet. Additional space for answers and rough work is provided at the end of this booklet. If you use this space you must clearly identify the question number you are attempting. Any rough work must be written in this booklet. You should score through your rough work when you have written your final copy.
Use **blue** or **black** ink.
Care should be taken to give an appropriate number of significant figures in the final answers to calculations.
Before leaving the examination room you must give this booklet to the Invigilator; if you do not, you may lose all the marks for this paper.

SQA ©

SECTION 1 — 20 marks

The questions for Section 1 are contained in the question paper SQ37/H/02.
Read these and record your answers on the answer grid on *Page three* opposite.
Do **NOT** use gel pens.

1. The answer to each question is **either** A, B, C, D or E. Decide what your answer is, then fill in the appropriate bubble (see sample question below).

2. There is **only one correct** answer to each question.

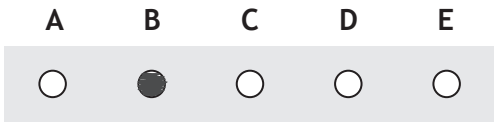
3. Any rough working should be done on the additional space for answers and rough work at the end of this booklet.

Sample Question

The energy unit measured by the electricity meter in your home is the:

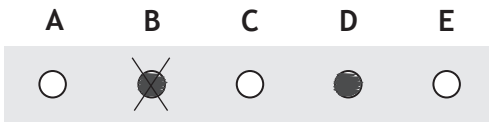
A ampere
B kilowatt-hour
C watt
D coulomb
E volt.

The correct answer is **B**—kilowatt-hour. The answer **B** bubble has been clearly filled in (see below).



Changing an answer

If you decide to change your answer, cancel your first answer by putting a cross through it (see below) and fill in the answer you want. The answer below has been changed to **D**.



If you then decide to change back to an answer you have already scored out, put a tick (✓) to the **right** of the answer you want, as shown below:

or

OBJ20AE1

You must record your answers to Section 1 questions on the answer grid on **Page 3** of your **answer booklet**

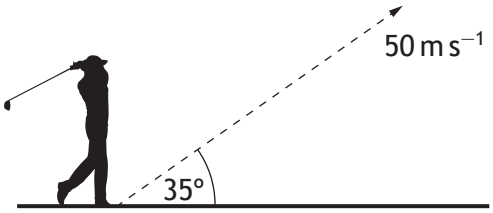
SQ37H0103

SECTION 2 — 110 marks

Attempt ALL questions

MARKS | DO NOT WRITE IN THIS MARGIN

1. A golf ball is hit with a velocity of $50{\cdot}0\,m\,s^{-1}$ at an angle of 35° to the horizontal as shown.



(a) (i) Calculate the horizontal component of the initial velocity of the ball. **1**

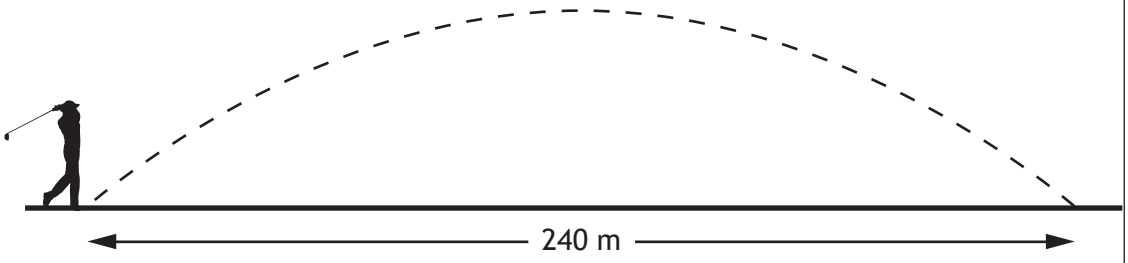
Space for working and answer

(ii) Calculate the vertical component of the initial velocity of the ball. **1**

Space for working and answer

1. (continued)

(b) The diagram below shows the trajectory of the ball when air resistance is negligible.



Show that the horizontal distance travelled by the ball is 240 m. **4**

Space for working and answer

2. An electric cart and driver accelerate up a slope. The slope is at an angle of 3·2° to the horizontal. The combined mass of the cart and driver is 220 kg.

(a) (i) Show that the component of the weight of the cart and driver acting down the slope is 120 N. **2**

Space for working and answer

(ii) At one point on the slope the driving force produced by the cart's motor is 230 N and at this point the total frictional force acting on the cart and driver is 48 N.

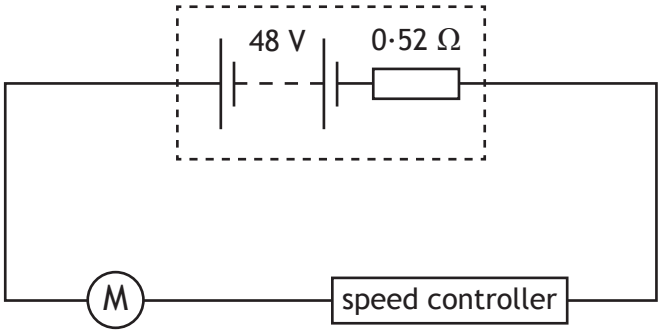
Calculate the acceleration of the cart and the driver at this point. **4**

Space for working and answer

2. (a) (continued)

(iii) Explain, in terms of the forces, why there is a maximum angle of slope that the cart can ascend. **2**

(b) The electric motor in the cart is connected to a battery of e.m.f. 48 V and internal resistance 0·52 Ω.



The current in the circuit is 22 A.

(i) Show that the lost volts in the battery is 11 V. **2**

Space for working and answer

2. (b) (continued)

(ii) Calculate the output power supplied to the circuit when the current is 22 A. **4**

Space for working and answer

(c) The driving force produced by the cart's motor is now increased.

State what happens to the potential difference across the battery.

You must justify your answer. **3**

MARKS | DO NOT WRITE IN THIS MARGIN

3. When a car brakes, kinetic energy is turned into heat and sound.

In order to make cars more efficient some manufacturers are developing kinetic energy recovery systems (KERS). These systems store some of the energy that would otherwise be lost as heat and sound.

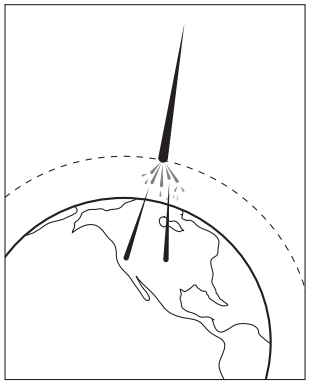
Estimate the maximum energy that could be stored in such a system when a car brakes.

Clearly show your working for the calculation and any estimates you have made. **4**

Space for working and answer

MARKS | DO NOT WRITE IN THIS MARGIN

4. Muons are sub-atomic particles produced when cosmic rays enter the atmosphere about 10 km above the surface of the Earth.



Muons have a mean lifetime of $2{\cdot}2 \times 10^{-6}$ s in their frame of reference. Muons are travelling at $0{\cdot}995c$ relative to an observer on Earth.

(a) Show that the mean distance travelled by the muons in their frame of reference is 660 m. **2**

Space for working and answer

(b) Calculate the mean lifetime of the muons as measured by the observer on Earth. **3**

Space for working and answer

4. (continued)

(c) Explain why a greater number of muons are detected on the surface of the Earth than would be expected if relativistic effects were not taken into account. **1**

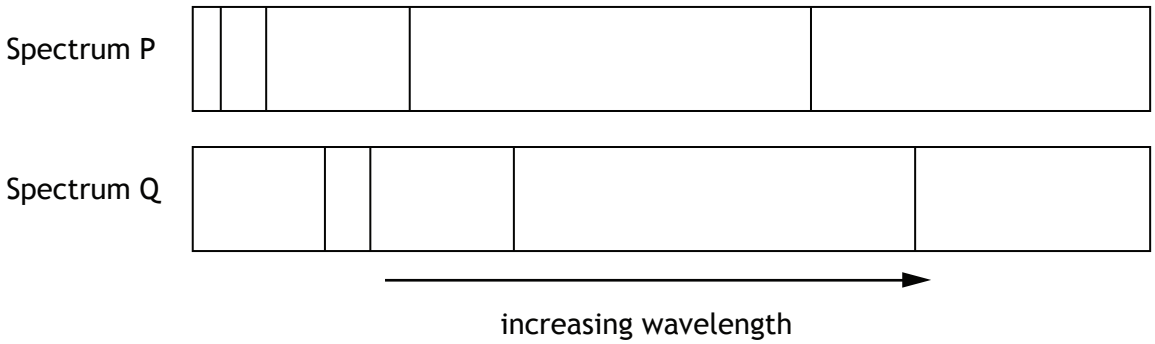
MARKS | DO NOT WRITE IN THIS MARGIN

5. A picture of a helmet designed to be worn when riding a bicycle is shown.

The bicycle helmet has a hard outer shell and a soft expanded polystyrene foam liner.

Using your knowledge of physics, comment on the suitability of this design for a bicycle helmet. **3**

6. (a) The diagram below represents part of the emission spectra for the element hydrogen.



Spectrum P is from a laboratory source.

Spectrum Q shows the equivalent lines from a distant star as observed on the Earth.

(i) Explain why spectrum Q is redshifted. **2**

(ii) One of the lines in spectrum P has a wavelength of 656 nm. The equivalent line in spectrum Q is measured to have a wavelength of 676 nm.

Calculate the recessional velocity of the star. **5**

Space for working and answer

6. (continued)

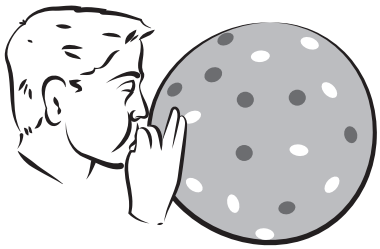
(b) The recessional velocity of a distant galaxy is $1{\cdot}2 \times 10^7\,m\,s^{-1}$.

Show that the approximate distance to this galaxy is $5{\cdot}2 \times 10^{24}\,m$. **2**

Space for working and answer

(c) A student explains the expansion of the Universe using an "expanding balloon model".

The student draws "galaxies" on a balloon and then inflates it.



Using your knowledge of physics, comment on the suitability of this model. **3**

MARKS DO NOT WRITE IN THIS MARGIN

7. Protons and neutrons are composed of combinations of up and down quarks. Up quarks have a charge of $+\frac{2}{3}e$ while down quarks have a charge of $-\frac{1}{3}e$.

(a) (i) Determine the combination of up and down quarks that makes up:

(A) a proton; **1**

(B) a neutron. **1**

(ii) Name the boson that is the mediating particle for the strong force. **1**

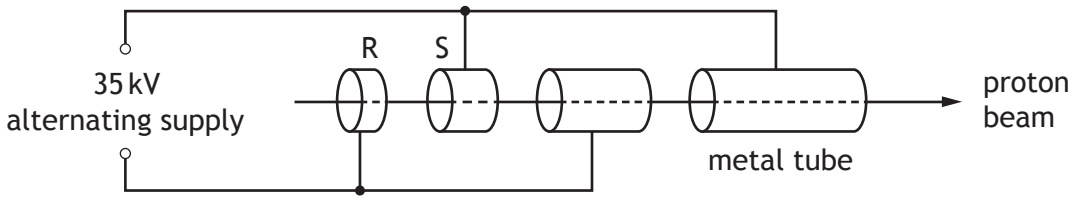
(b) A neutron decays into a proton, an electron and an antineutrino.

$$^{1}_{0}\text{n} \rightarrow {}^{1}_{1}\text{p} + {}^{0}_{-1}e + \overline{\nu}$$

Name of this type of decay. **1**

8. A linear accelerator is used to accelerate protons.

The accelerator consists of hollow metal tubes placed in a vacuum.



The diagram shows the path of protons through the accelerator.

Protons are accelerated across the gaps between the tubes by a potential difference of 35 kV.

(a) The protons are travelling at $1{\cdot}2 \times 10^{6}\ m\,s^{-1}$ at point **R**.

(i) Show that the work done on a proton as it accelerates from **R** to **S** is $5{\cdot}6 \times 10^{-15}$ J. **2**

Space for working and answer

(ii) Calculate the speed of the proton as it reaches **S**. **5**

Space for working and answer

(b) Suggest one reason why the lengths of the tubes increase along the accelerator. **1**

MARKS | DO NOT WRITE IN THIS MARGIN

9. (a) The following statement represents a fusion reaction.

$$4\,{}^{1}_{1}H \rightarrow {}^{4}_{2}He + 2\,{}^{0}_{1}e^{+}$$

The masses of the particles involved in the reaction are shown in the table.

Particle	*Mass* (kg)
${}^{1}_{1}H$	$1{\cdot}673 \times 10^{-27}$
${}^{4}_{2}He$	$6{\cdot}646 \times 10^{-27}$
${}^{0}_{1}e$	negligible

(i) Calculate the energy released in this reaction. **4**

Space for working and answer

(ii) Calculate the energy released when 0·20 kg of hydrogen is converted to helium by this reaction. **3**

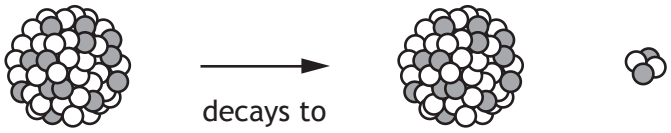
Space for working and answer

9. (a) (continued)

(iii) Fusion reactors are being developed that use this type of reaction as an energy source.

Explain why this type of fusion reaction is hard to sustain in these reactors. **1**

(b) A nucleus of radium-224 decays to radon by emitting an alpha particle.



The masses of the particles involved in the decay are shown in the table.

Particle	*Mass* (kg)
radium-224	$3{\cdot}720 \times 10^{-25}$
radon-220	$3{\cdot}653 \times 10^{-25}$
alpha	$6{\cdot}645 \times 10^{-27}$

Before the decay the radium-224 nucleus is at rest.

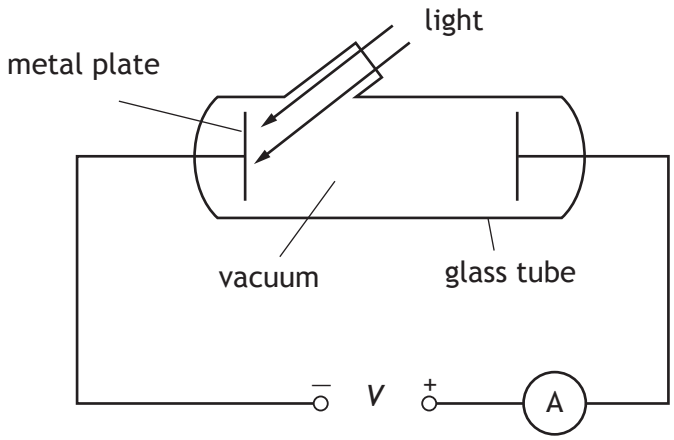
After the decay the alpha particle moves off with a velocity of $1{\cdot}460 \times 10^{7}\,\text{m}\,\text{s}^{-1}$.

Calculate the velocity of the radon-220 nucleus after the decay. **3**

Space for working and answer

MARKS | DO NOT WRITE IN THIS MARGIN

10. The diagram shows equipment used to investigate the photoelectric effect.



(a) When blue light is shone on the metal plate there is a current in the circuit. When blue light is replaced by red light there is no current.

Explain why this happens. **2**

(b) The blue light has a frequency of $7{\cdot}0 \times 10^{14}$ Hz.

The work function for the metal plate is $2{\cdot}0 \times 10^{-19}$ J.

Calculate the maximum kinetic energy of the electrons emitted from the plate by this light. **3**

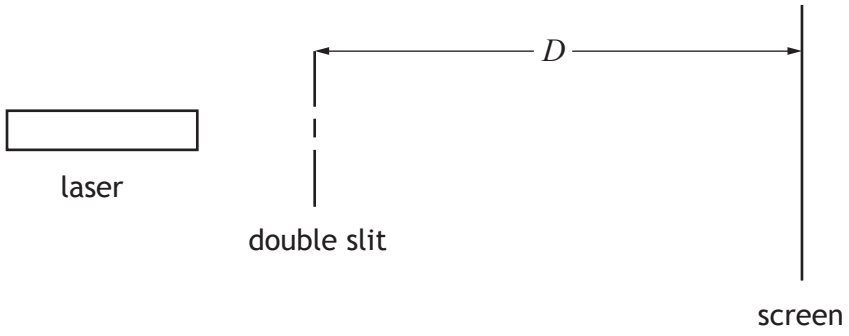
Space for working and answer

MARKS | DO NOT WRITE IN THIS MARGIN

11. A helium-neon laser produces a beam of coherent red light.

(a) State what is meant by *coherent light*. **1**

(b) A student directs this laser beam onto a double slit arrangement as shown in the diagram.



A pattern of bright red fringes is observed on the screen.

(i) Explain, in terms of waves, why bright red fringes are produced. **1**

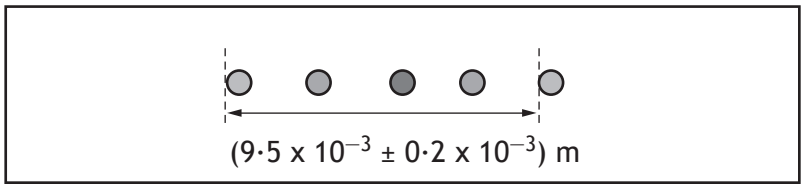
11. (b) (continued)

(ii) The average separation, Δx, between adjacent fringes is given by the relationship

$$\Delta x = \frac{\lambda D}{d}$$

where: λ is the wavelength of the light
D is the distance between the double slit and the screen
d is the distance between the two slits

The diagram shows the value measured by the student of the distance between a series of fringes and the uncertainty in this measurement.



The student measures the distance, *D*, between the double slit and the screen as (0·750 ± 0·001) m.

Calculate the best estimate of the distance between the two slits.

An uncertainty in the calculated value is not required. **4**

Space for working and answer

11. (b) (continued)

(iii) The student wishes to determine more precisely the value of the distance between the two slits *d*.

Show, by calculation, which of the student's measurements should be taken more precisely in order to achieve this.

You must indicate clearly which measurement you have identified. **3**

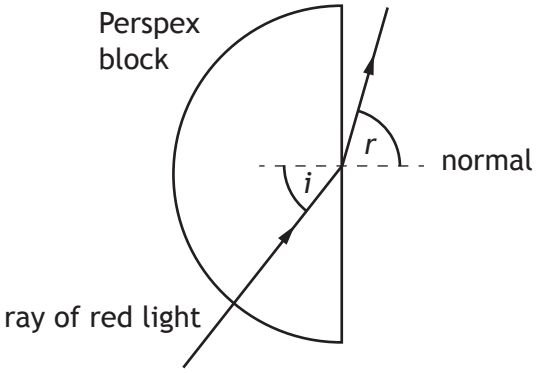
Space for working and answer

(iv) The helium-neon laser is replaced by a laser emitting green light. No other changes are made to the experimental set-up.

Explain the effect this change has on the separation of the fringes observed on the screen. **2**

12. A student is investigating the refractive index of a Perspex block for red light.

The student directs a ray of red light towards a semicircular Perspex block as shown.



The angle of incidence i is then varied and the angle of refraction r is measured using a protractor.

The following results are obtained.

i (°)	r (°)	$\sin i$	$\sin r$
10	16	0·17	0·28
15	25	0·26	0·42
20	32	0·34	0·53
25	37	0·42	0·60
30	53	0·50	0·80

(a) (i) Using square ruled paper, draw a graph to show how sin r varies with sin i. **3**

(ii) Use the graph to determine the refractive index of the Perspex for this light. **2**

Space for working and answer

12. (a) (continued)

(iii) Suggest **two** ways in which the experimental procedure could be improved to obtain a more accurate value for the refractive index. **2**

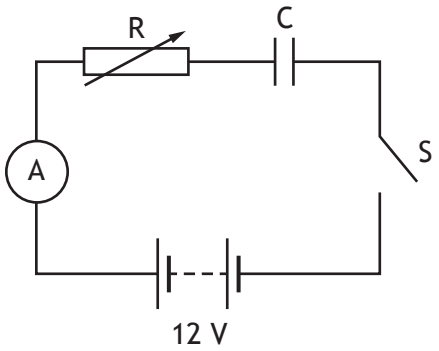
(b) The Perspex block is replaced by an identical glass block with a refractive index of 1·54 and the experiment is repeated.

Determine the maximum angle of incidence that would produce a refracted ray. **3**

Space for working and answer

13. A 200 μF capacitor is charged using the circuit shown.

The 12 V battery has negligible internal resistance.



The capacitor is initially uncharged.

The switch S is closed. The charging current is kept constant at 30 μA by adjusting the resistance of the variable resistor, R.

(a) Calculate the resistance of the variable resistor R just after the switch is closed. **3**

Space for working and answer

(b) (i) Calculate the charge on the capacitor 30 s after the switch S is closed. **3**

Space for working and answer

13. (b) (continued)

(ii) Calculate the potential difference across R at this time. **4**

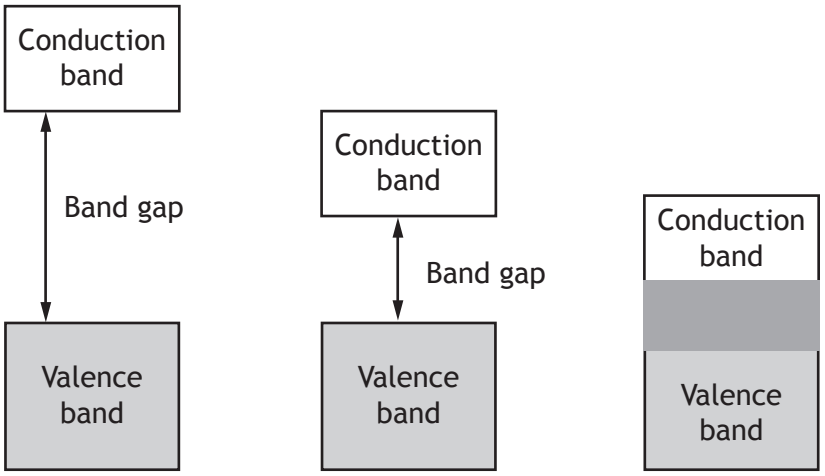
Space for working and answer

14. The electrical conductivity of solids can be explained by band theory.

The diagrams below show the distributions of the valence and conduction bands of materials classified as *conductors*, *insulators* and *semiconductors*.

Shaded areas represent bands occupied by electrons.

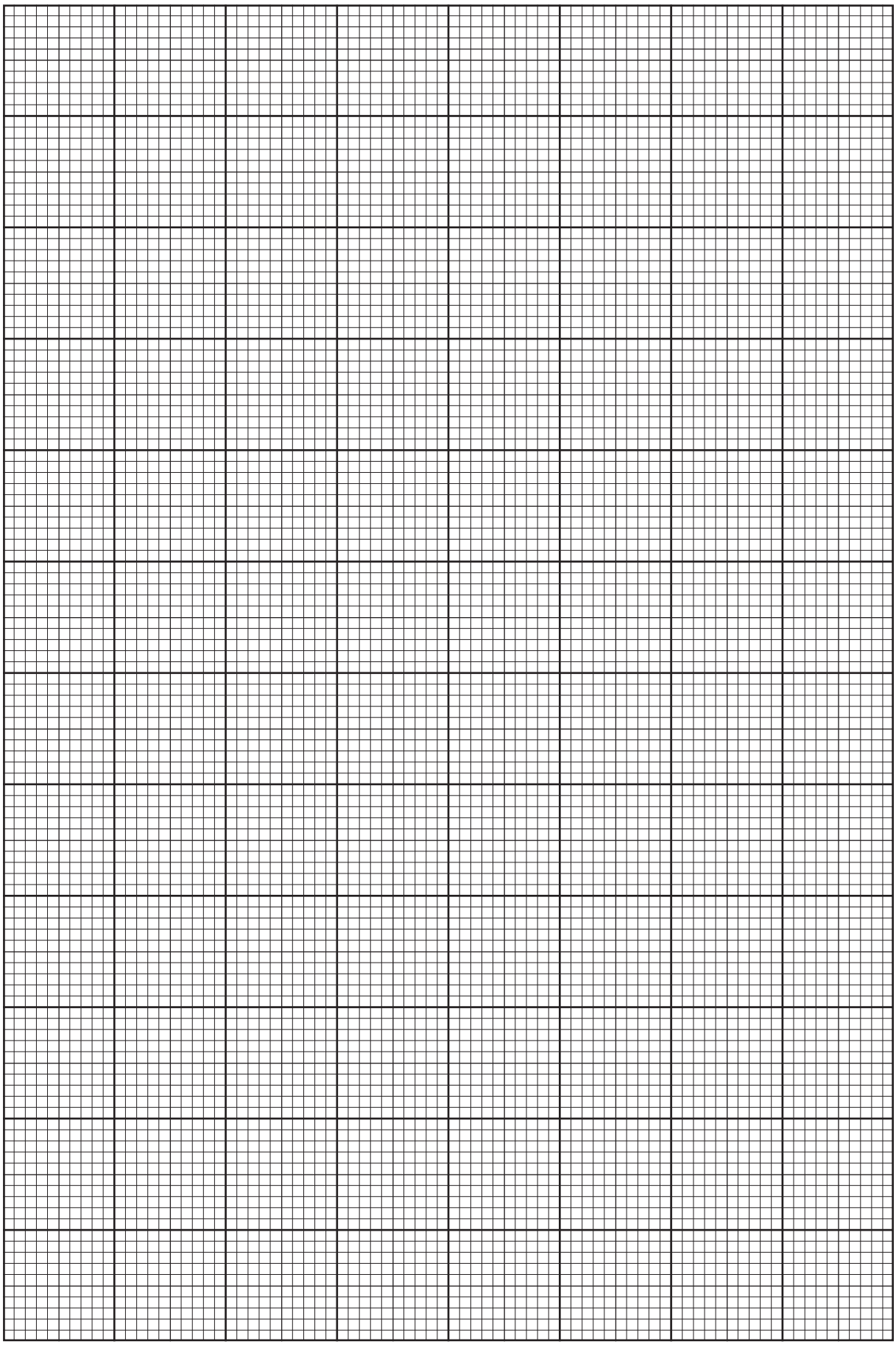
The band gap is also indicated.

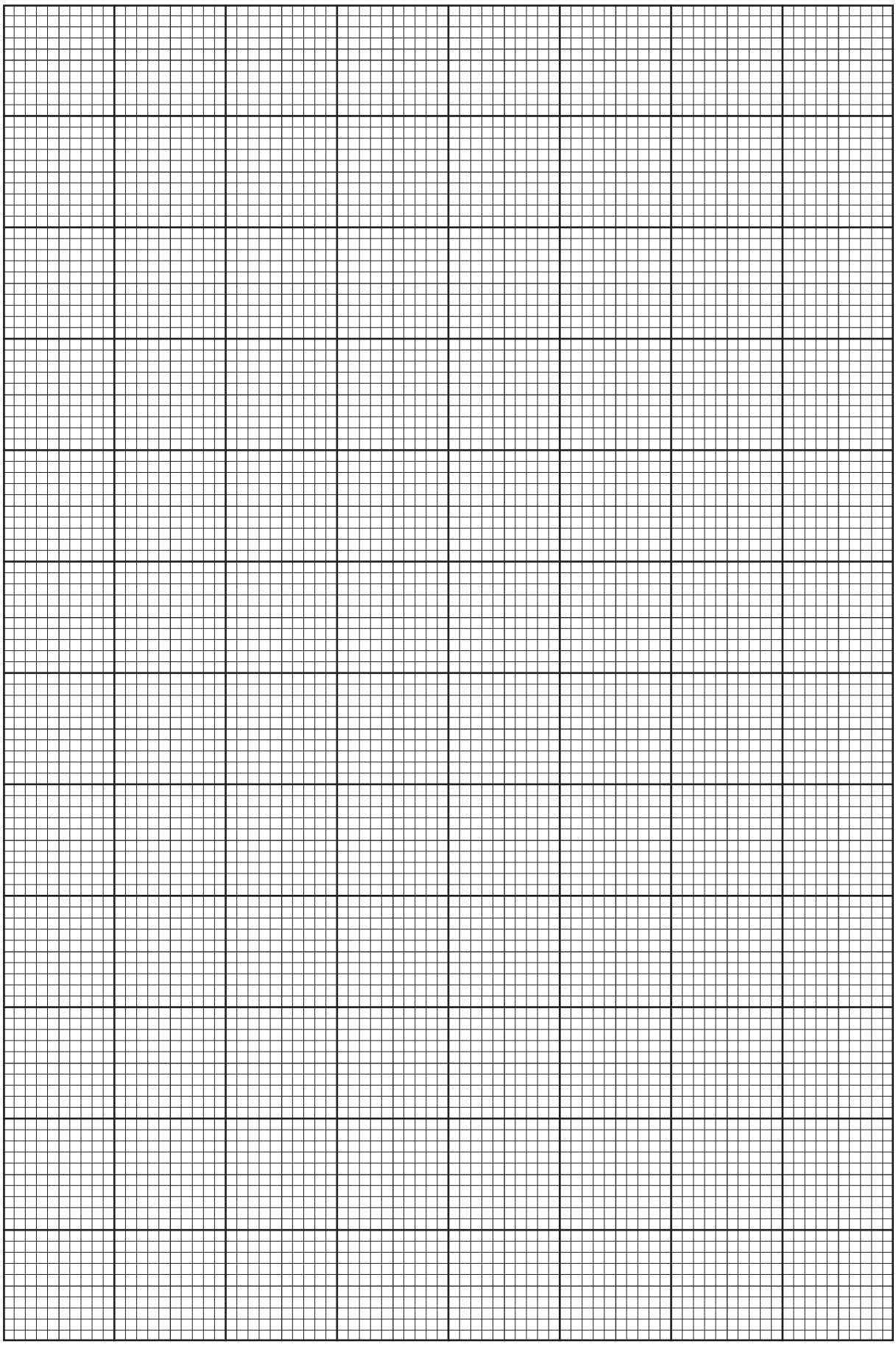


(a) State which material is a semiconductor. **1**

(b) A sample of pure semiconductor is heated. Use band theory to explain what happens to the resistance of the sample as it is heated. **2**

[END OF SPECIMEN QUESTION PAPER]





MARKS | DO NOT WRITE IN THIS MARGIN

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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