Oxford Cambridge and RSA

Friday 24 May 2024 – Morning

A Level Physics B (Advancing Physics)

H557/01 Fundamentals of Physics

Time allowed: 2 hours 15 minutes

You must have:
- the Data, Formulae and Relationships Booklet

You can use:
- a scientific or graphical calculator
- a ruler (cm/mm)

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number						Candidate number				

First name(s) ______________________________

Last name ______________________________

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **110**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **52** pages.

ADVICE
- Read each question carefully before you start your answer.

Section A

You should spend a **maximum** of **40 minutes** on this section.

Write your answer for each question in the box provided.

1 Which of these units is equivalent to the units of the spring constant, $N\,m^{-1}$?

A $kg\ m^{-2}$

B $kg\ m\,s^{-1}$

C $kg\ m\,s^{-2}$

D $kg\ s^{-2}$

Your answer ☐ **[1]**

2 Which statement about ultrasound is correct?

A Ultrasound can be diffracted and polarised.

B Ultrasound can be diffracted but cannot be polarised.

C Ultrasound cannot be diffracted but can be polarised.

D Ultrasound can neither be diffracted nor polarised.

Your answer ☐ **[1]**

The following information is used in questions **3** and **4**.

An object of height 2 cm is placed upright, 20 cm in front of a vertical convex lens.
A real image is formed 50 cm from the lens.

3 What is the power of the lens?

A 4 D

B 5 D

C 6 D

D 7 D

Your answer ☐ **[1]**

4 What is the length of the image?

A 2.5 cm

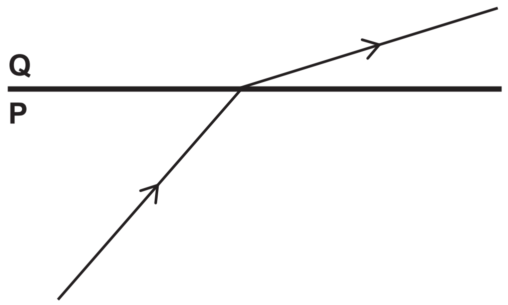
B 5.0 cm

C 7.5 cm

D 10.0 cm

Your answer ☐ **[1]**

5 The diagram shows a ray of light passing between two transparent media, **P** and **Q**.



Which row in the table describes what happens to the light as it passes from **P** to **Q**?

	Frequency	**Speed**	**Wavelength**
A	decreases	decreases	stays the same
B	increases	decreases	stays the same
C	increases	stays the same	decreases
D	stays the same	increases	increases

Your answer ☐ **[1]**

6 The area surrounding a waterfall is at a constant temperature.
The water falls 100 m to the lake below.
The specific thermal heat capacity of water is $4200\,\mathrm{J\,kg^{-1}\,K^{-1}}$.

What is the best estimate of the maximum possible temperature difference between the water at the top of the waterfall and the moment it strikes the surface of the lake?

A 0.25 K

B 0.50 K

C 0.75 K

D 1.00 K

Your answer ☐ **[1]**

7 This **incorrect** equation has been written to represent positron decay.

$$p \rightarrow n + e^{+} + \overline{v}$$

What is the reason for the equation being incorrect?

A It shows that charge is **not** conserved.

B It shows that energy is **not** conserved.

C It shows that lepton number is **not** conserved.

D It shows that mass is **not** conserved.

Your answer ☐ **[1]**

8 Which list contains only leptons?

A electron, neutrino, neutron

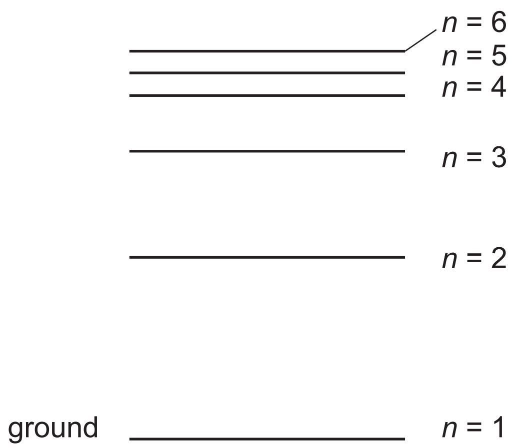
B electron, neutrino, positron

C neutrino, positron, proton

D neutrino, neutron, proton

Your answer ☐ **[1]**

9 The diagram shows the first six energy levels in a hydrogen atom.



How many wavelengths of electromagnetic radiation can the hydrogen atom emit from transitions between these energy levels?

A 9

B 12

C 15

D 18

Your answer **[1]**

10 A beam of light from a hydrogen discharge lamp is incident normally on a diffraction grating with 4.50×10^5 lines per metre.

What is the angle between the 410 nm and 656 nm lines in the first order spectrum?

A 6.5°

B 10.6°

C 17.2°

D 27.8°

Your answer **[1]**

11 A monochromatic beam of light is incident on a clean metal surface, and the frequency of the light is greater than the threshold frequency of the metal.

What happens if the original light source is replaced with one with double the frequency but the same intensity?

	Rate of emission of photoelectrons	**Maximum kinetic energy of photoelectrons**
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

Your answer ☐ **[1]**

12 The rest energy of an electron or positron is 0.511 MeV.
When an electron and positron interact, they annihilate each other.

What is the frequency of the **two** photons emitted when a positron with 0.120 MeV kinetic energy interacts with a stationary electron?

A 1.38×10^{14} Hz

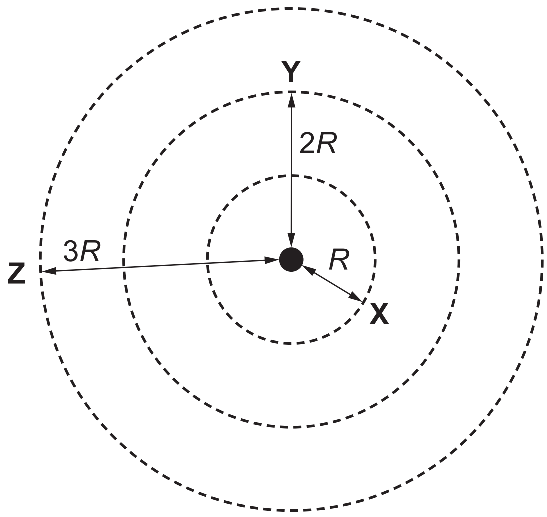
B 2.76×10^{14} Hz

C 1.38×10^{20} Hz

D 2.76×10^{20} Hz

Your answer ☐ **[1]**

13 The diagram shows three gravitational equipotentials, **X**, **Y** and **Z**, at distances *R*, 2*R* and 3*R* from an isolated point mass.



The gravitational potential of **X** is *V*.

What is the change in gravitational potential between **Y** and **Z**?

A $V/8$

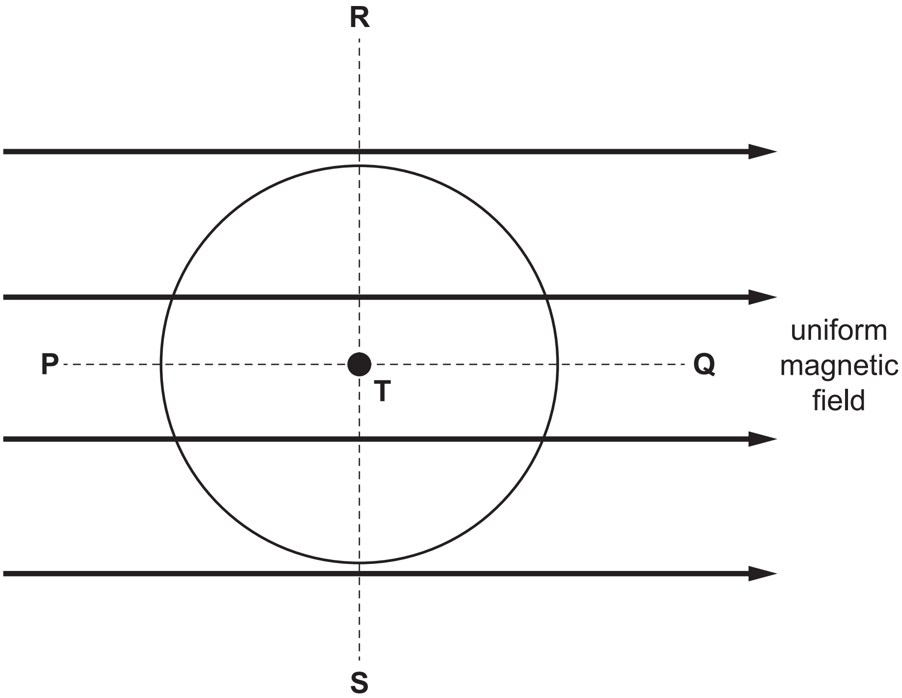
B $V/6$

C $V/4$

D $V/2$

Your answer ☐ **[1]**

14 The diagram shows a circular coil with its plane parallel to a uniform magnetic field.



The coil can move in three ways within the magnetic field:

- It can rotate about the axis **PQ**
- It can rotate about the axis **RS**
- It can rotate about the axis through **T** that is perpendicular to the magnetic field.

Which ways of moving will result in an induced e.m.f. in the coil?

A Axis **PQ** and **RS**

B Axis **PQ** only

C Axis **RS** and axis **T**

D Axis **RS** only

Your answer ☐ **[1]**

The following information is used in questions **15** and **16**.

UVA is a part of the electromagnetic spectrum with wavelengths in the range 315–400 nm.
For a typical human, human skin and the tissue immediately below it has a mass of about 4.5 kg per m^2.
On a particular day UVA is absorbed by a person's skin at a rate of 2 mW per m^2.

15 What is the best estimate of the number of UVA photons incident on 1 cm^2 of human skin each second?

A 4×10^8

B 4×10^{11}

C 4×10^{12}

D 4×10^{15}

Your answer ☐ **[1]**

16 What is the best estimate of the absorbed dose of UVA per second for a typical human?

A 0.4 mGy

B 0.9 mGy

C 4 mGy

D 9 mGy

Your answer ☐ **[1]**

17 The density of a stone is determined by measuring its mass and volume, and using the equation **density = mass ÷ volume**. The mass of the stone measures 25.6 ± 0.2 g and its volume measures 5.2 ± 0.4 cm^3.

What is the calculated value of density of the stone?

A 4.9 ± 0.4 g cm^{-3}

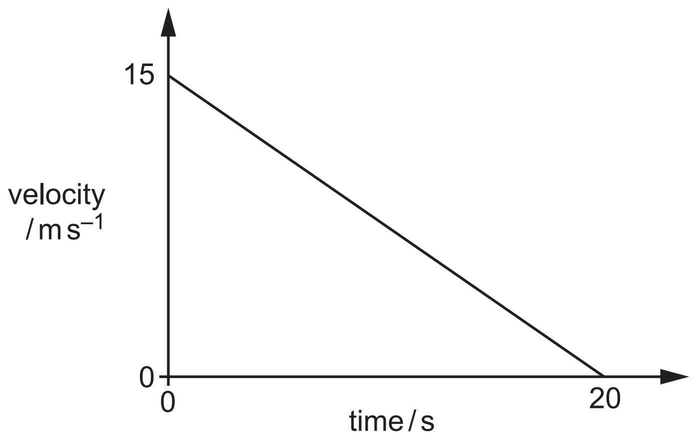
B 4.92 ± 0.34 g cm^{-3}

C 4.923 ± 0.340 g cm^{-3}

D 5 ± 0.4 g cm^{-3}

Your answer ☐ **[1]**

18 A car comes to rest after the brakes have been applied. The graph shows how the velocity of the car varies with time.



The mass of the car is 1000 kg.

What is the braking force acting on the car?

A 375 N

B 750 N

C 1330 N

D 1500 N

Your answer ☐ **[1]**

19 The isotope of polonium $^{214}_{84}Po$ decays by four transformations to a final stable isotope of lead $^{206}_{82}Pb$. The particles emitted during the transformations are, in turn α, β, β, α.
There are three unstable products formed by the transformations that occur.

How many of the **unstable** products are isotopes of polonium and how many are isotopes of lead?

	Isotopes of polonium	**Isotopes of lead**
A	0	1
B	1	1
C	1	2
D	2	0

Your answer [ ] **[1]**

20 A muon is an unstable particle. The half-life of muons measured at rest is 2.2 μs. The half-life of a muon travelling at speed *v* is measured by an observer as 8.8 μs.
c is the velocity of light.

What is the value of *v*?

A 0.90*c*

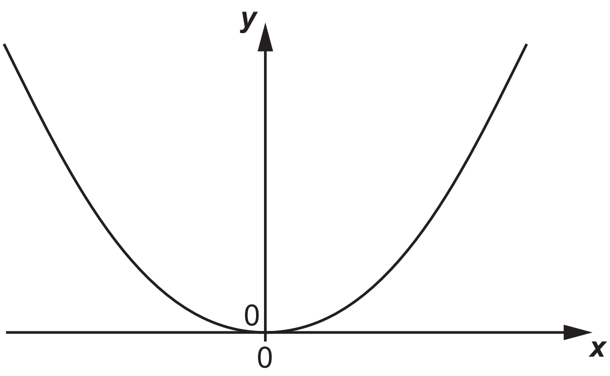
B 0.92*c*

C 0.94*c*

D 0.97*c*

Your answer [ ] **[1]**

21 The graph shows how a quantity ***y*** changes when a quantity ***x*** changes.



Which row of the table shows **two** examples of quantities ***x*** and ***y*** that have the relationship shown on the graph?

	Example 1	**Example 2**
A	***x***: displacement of an object undergoing simple harmonic motion ***y***: kinetic energy of the object	***x***: current in a fixed resistor ***y***: power dissipated in the resistor
B	***x***: displacement of an object undergoing simple harmonic motion ***y***: kinetic energy of the object	***x***: value of the resistance of a variable resistor with a fixed potential difference across it ***y***: power dissipated in the resistor
C	***x***: displacement of an object undergoing simple harmonic motion ***y***: potential energy of the object	***x***: current in a fixed resistor ***y***: power dissipated in the resistor
D	***x***: displacement of an object undergoing simple harmonic motion ***y***: potential energy of the object	***x***: value of the resistance of a variable resistor with a fixed potential difference across it ***y***: power dissipated in the resistor

Your answer ☐ **[1]**

22 A simple pendulum **P** has length *L* and mass *M*. Its period is *T*.
A simple pendulum **Q** has length 2*L* and mass *M*.

What is the period of simple pendulum **Q**?

A 0.5*T*

B 0.7*T*

C 1.4*T*

D 2.0*T*

Your answer ☐ **[1]**

23 A car of mass 1000 kg travels round a bend. The bend is a horizontal circular path of radius 50 m. The maximum speed the car can travel at without skidding is 15 m s^{-1}. On a rainy day the force of friction between the car's tyres and the road is halved.

What is the maximum speed at which the car can now travel round the same bend without skidding?

A 4.4 m s^{-1}

B 7.5 m s^{-1}

C 11 m s^{-1}

D 14 m s^{-1}

Your answer ☐ **[1]**

24 A ball of mass m falls vertically and hits the horizontal ground with speed v before bouncing vertically upwards with speed $0.8v$.

What is the change in momentum of the ball while it is in contact with the ground?

A $0.18\,mv$

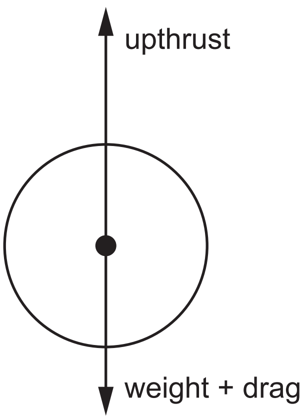
B $0.20\,mv$

C $0.37\,mv$

D $1.80\,mv$

Your answer ☐ **[1]**

25 An object is submerged in water and has three vertical forces acting on it – its weight, drag and upthrust.



weight = 490 N and upthrust = 1000 N. The object accelerates upwards at $2\,\text{m}\,\text{s}^{-2}$.

What is the value of the drag?

A 410 N

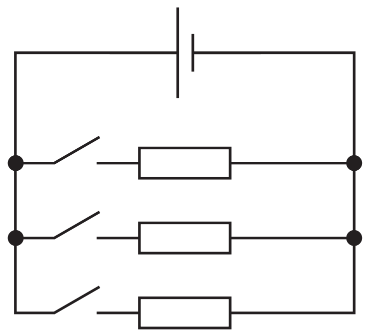
B 590 N

C 1390 N

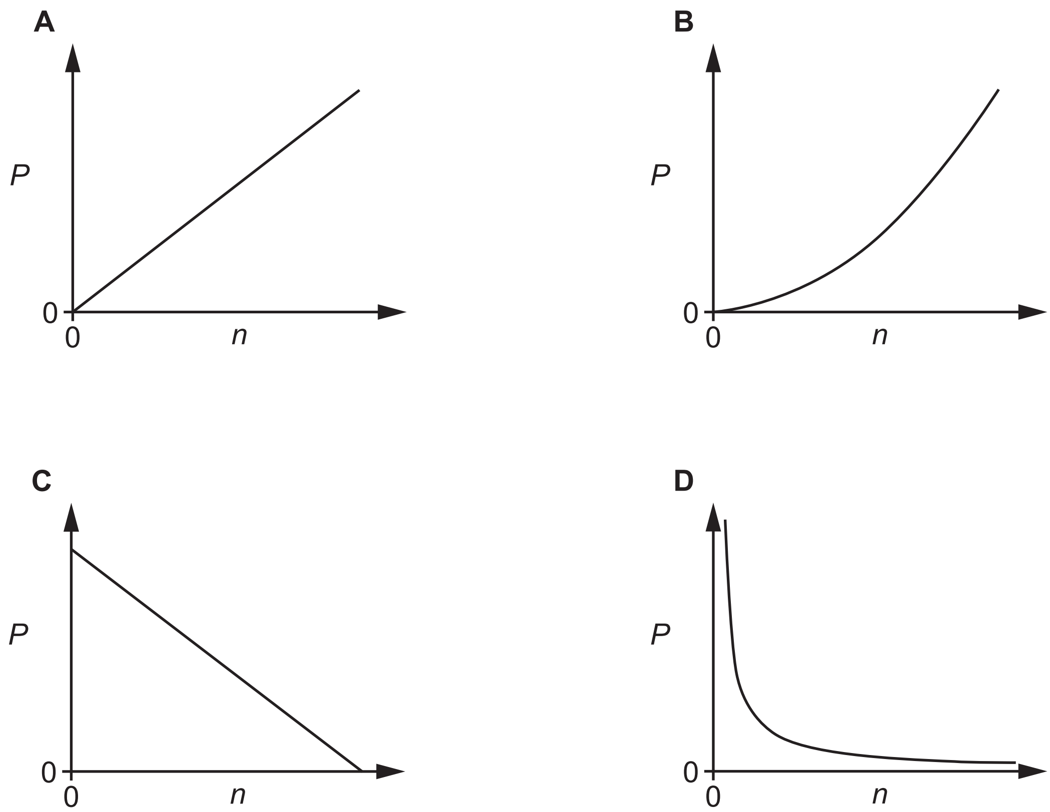
D 1590 N

Your answer ☐ **[1]**

26 The diagram shows identical resistors connected in parallel to a cell with negligible internal resistance.

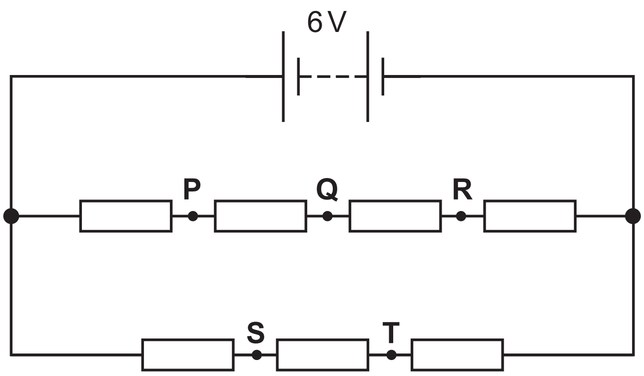


Which graph shows how the power *P*, dissipated in the circuit, varies with the number of resistors *n*, in the circuit?



Your answer [ ] **[1]**

27 The diagram shows seven identical resistors connected in a circuit with a 6 V battery.



Which pair of points has a potential difference of 0.5 V between them?

A **P** and **S**

B **P** and **T**

C **Q** and **S**

D **R** and **S**

Your answer ☐ **[1]**

28 Wires **X**, **Y** and **Z** are made from different metals. They have the same length and the same stretching force is applied to them.

The table gives information about the wires.

Wire	**Cross-sectional area**	**Extension caused by stretching force**
X	A	$2e$
Y	$\frac{1}{2}A$	$\frac{1}{2}e$
Z	$2A$	$\frac{1}{2}e$

Which list gives the metals in order of their Young modulus values, from smallest to largest?

A **X**, **Y**, **Z**

B **X**, **Z**, **Y**

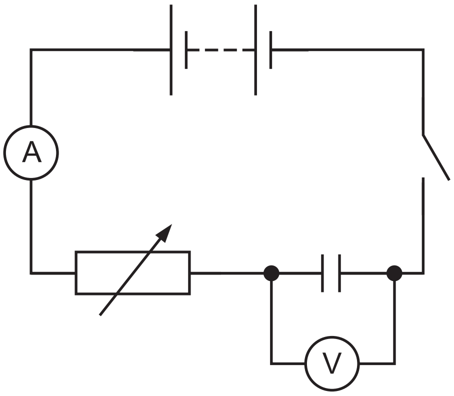
C **Y**, **X**, **Z**

D **Y**, **Z**, **X**

Your answer ☐ **[1]**

29 The diagram shows a circuit used to find the capacitance of a capacitor.

The capacitor is initially uncharged.



The switch is closed and the variable resistor is continuously adjusted to keep the current at 2.5 mA. At the same time, the reading on the voltmeter is observed and noted at regular intervals. 10 seconds after the switch is closed the voltmeter reading is 3.2 V.

What is the capacitance of the capacitor?

A 780 μF

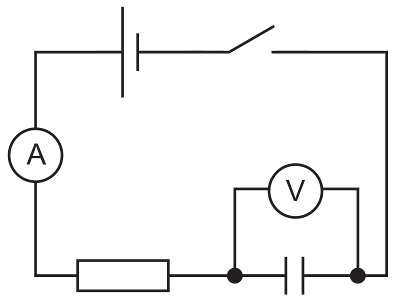
B 7.8 mF

C 8.0 mF

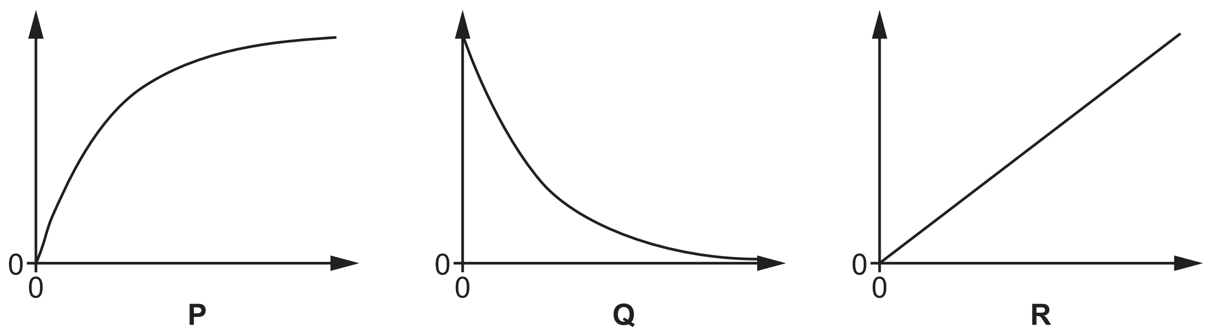
D 80 mF

Your answer ☐ **[1]**

30 The capacitor in this circuit is initially uncharged.



The graphs all show the variation of different quantities associated with the circuit after the switch is closed.



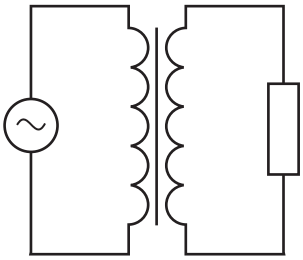
Which row in the table describes the three graphs?

	Graph P	**Graph Q**	**Graph R**
A	charge on capacitor against potential difference across it	current through resistor against time	potential difference across capacitor against time
B	current through resistor against time	potential difference across capacitor against time	charge on capacitor against potential difference across it
C	potential difference across capacitor against time	current through resistor against time	charge on capacitor against potential difference across it
D	potential difference across capacitor against time	charge on capacitor against potential difference across it	current through resistor against time

Your answer ☐ **[1]**

Section B

31 The diagram shows the circuit for a 100% efficient transformer. It has an alternating potential difference connected across the primary coil and a resistor connected across the secondary coil.



(a) Explain how an alternating current in the primary coil causes an alternating current in the secondary coil.

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.... **[3]**

(b) The table shows the values of the resistor and of the potential differences in the coils.

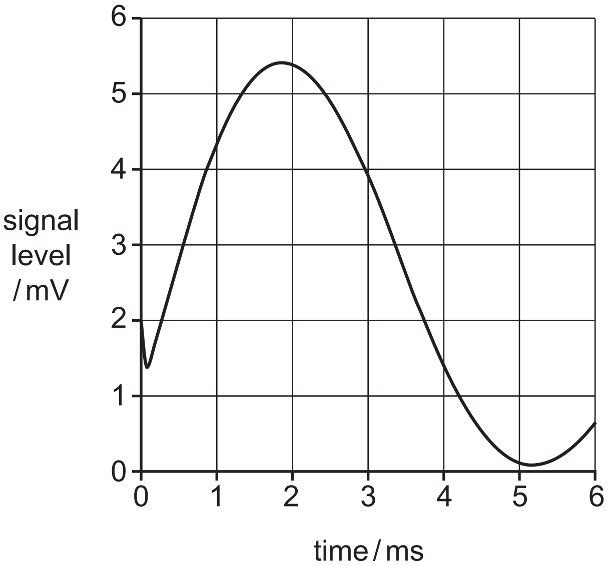
Primary potential difference /V	**Primary current /A**	**Secondary potential difference /V**	**Secondary current /A**	**Resistance /Ω**
20		50		800

Complete the table to show the currents in the coils. **[2]**

32 This question is about an exercise carried out by some students to show the digitisation and reconstruction of an analogue signal.

(a) **Fig. 32.1** shows the signal given to the students.

Fig. 32.1



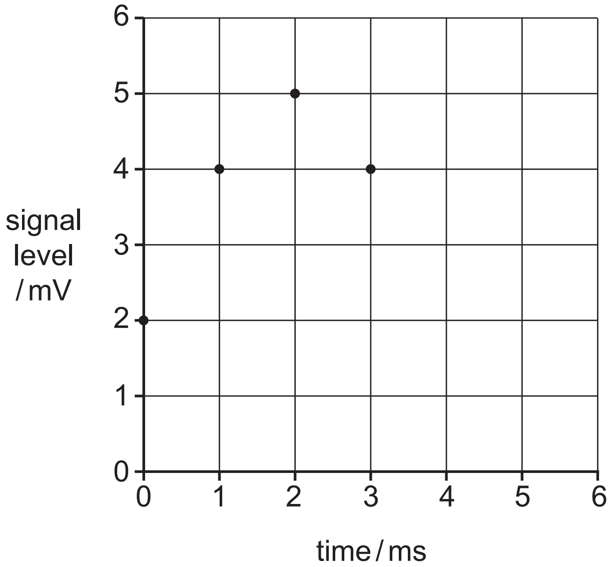
The students:

- sample the signal every millisecond
- round the value to the nearest millivolt
- and then convert the value to a binary number.

The students start to use the table to record their results and the graph in **Fig. 32.2** to show the reconstructed signal.

time / ms	**signal level / mV**	**digitised signal level**
0	2	010
1	4	100
2	5	101
3	4	100
4		
5		
6		

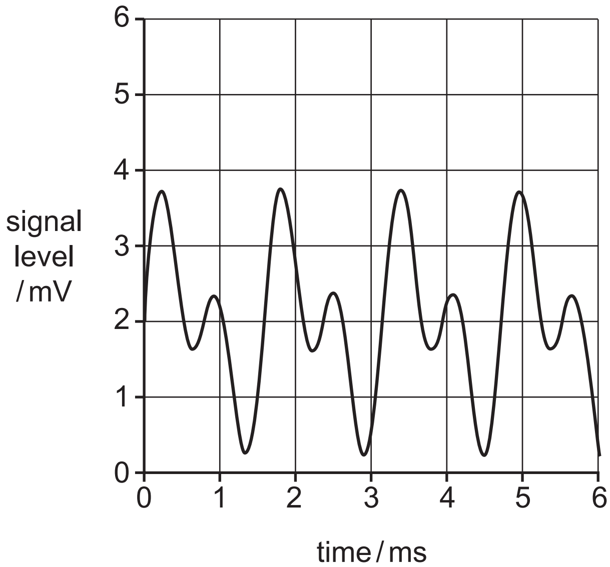
Fig. 32.2



Use information from **Fig. 32.1** to complete the table and the reconstructed signal in **Fig. 32.2**. **[2]**

(b) **Fig. 32.3** shows another signal given to the student.

Fig. 32.3



Explain why, when this signal is digitised with the same sampling rate and number of levels, it cannot be accurately reconstructed. You do not need to plot the reconstructed signal.

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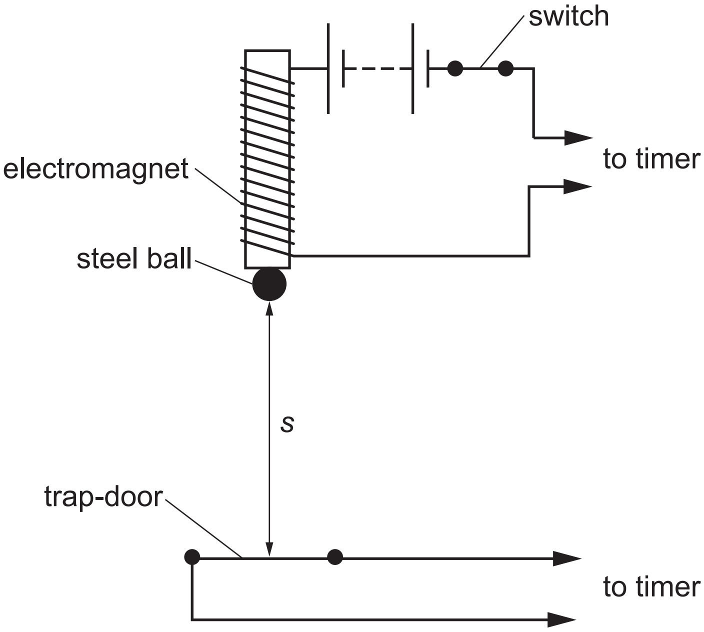
.... **[2]**

33 **Fig. 33.1** shows an experiment that can be carried out to measure the time taken for a steel ball to fall through a known distance *s*.

Fig. 33.1



When the switch is opened the steel ball is released. At the same time an electronic timer is started. When the steel ball hits the trap-door it opens and the timer is stopped.

(a) In one experiment the ball falls through a height of 0.75 m in 0.41 s.

Calculate the acceleration due to gravity based on this result.

acceleration = ... m s^{-2} **[1]**

(b) In another experiment the time t taken for the steel ball to fall from the electromagnet to the trap-door is measured for several values of s. A graph of t^2 against s is drawn.

Explain how the graph can be used to determine the acceleration due to gravity.

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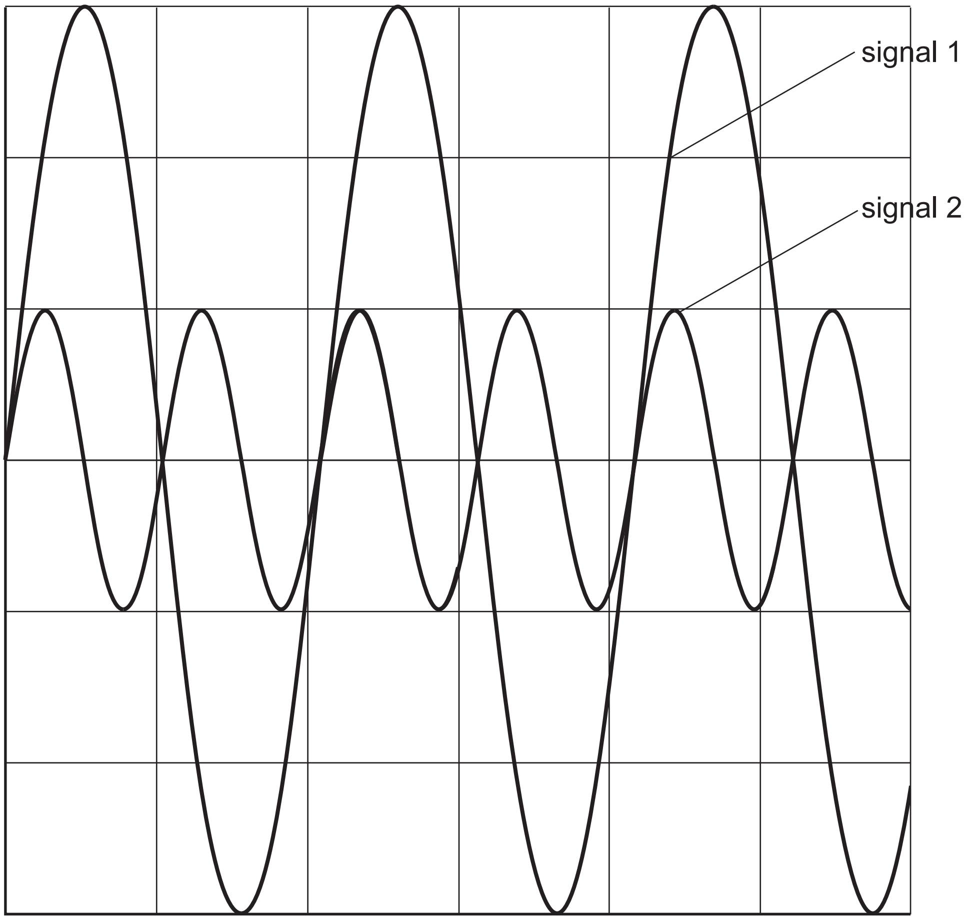
.... **[2]**

34

(a) **Fig. 34.1** shows a dual-trace oscilloscope being used to display two electrical signals.
The horizontal time-base of the oscilloscope is set at 50 ms per division and the vertical gain is set at 0.2 V per division.

Fig. 34.1



Compare the frequencies and amplitudes of signal 1 and signal 2.

Frequencies ....

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Amplitudes ....

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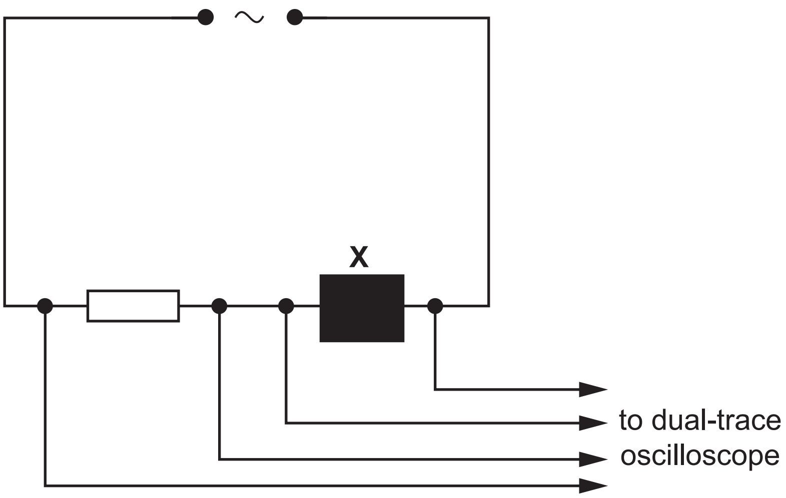
....

[2]

(b) **Fig. 34.2** shows a circuit containing a source of alternating emf, a resistor and a component, **X**. A dual-trace oscilloscope is used to observe the potential differences across the resistor and the component **X**.

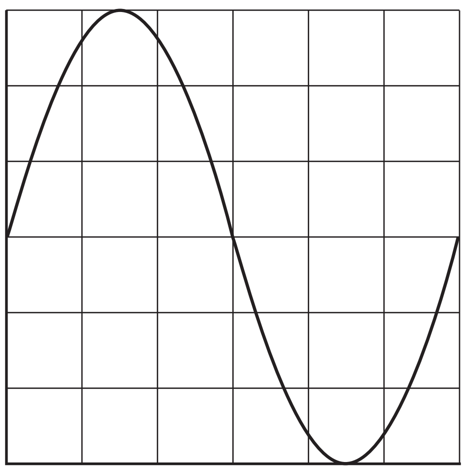
Fig. 34.2



The peak value of the potential difference across the resistor is 6 V.
The peak value of the potential difference across the component **X** is 4 V and the potential difference across the component **X** has the same frequency, and a phase difference of $\pi/2$ with the potential difference across the resistor.

Fig. 34.3 shows the trace of the potential difference across the resistor.

Fig. 34.3



Draw the trace for the potential difference across the component **X** on **Fig. 34.3**.

[2]

35 When hydrogen reacts chemically, the hydrogen molecules must have enough energy to break the H-H bonds between the atoms.
The Boltzmann factor for the H-H bonds in hydrogen at a temperature of 1000 K is 1.64×10^{-23}.

(a) Calculate the energy required to break all the H-H bonds in one mole of hydrogen.

energy = ... J **[3]**

(b) The average energy of hydrogen molecules at 300 K is below the energy needed to break the H-H bonds.

Explain why hydrogen still reacts at a reasonable rate at 300 K.

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.... **[2]**

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Section C continues on page 30

Section C

36 **Fig. 36.1** shows how the extension of a metal alloy wire varies with increasing load.
Fig. 36.2 shows the same information for a rubber strip.
The metal alloy wire fractures when its extension exceeds 16×10^{-4} m.

Fig. 36.1

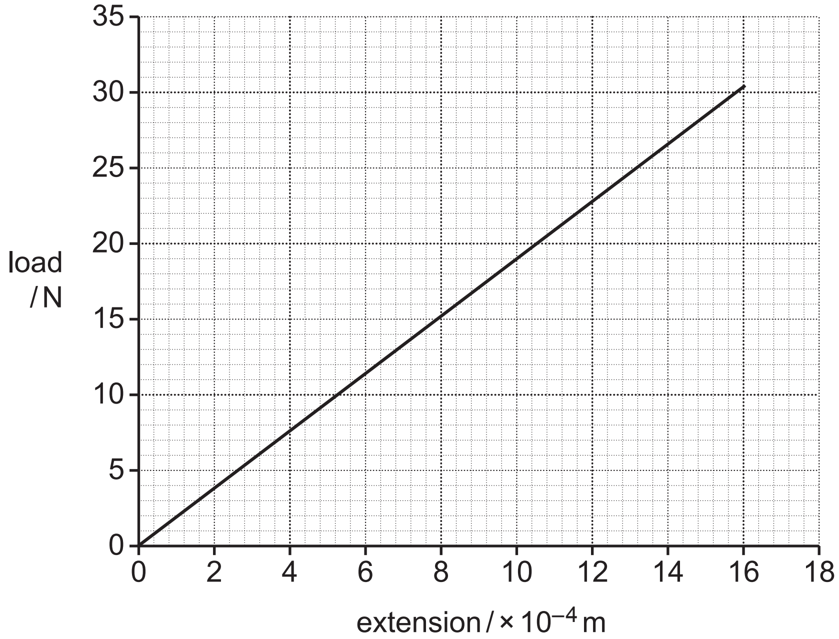
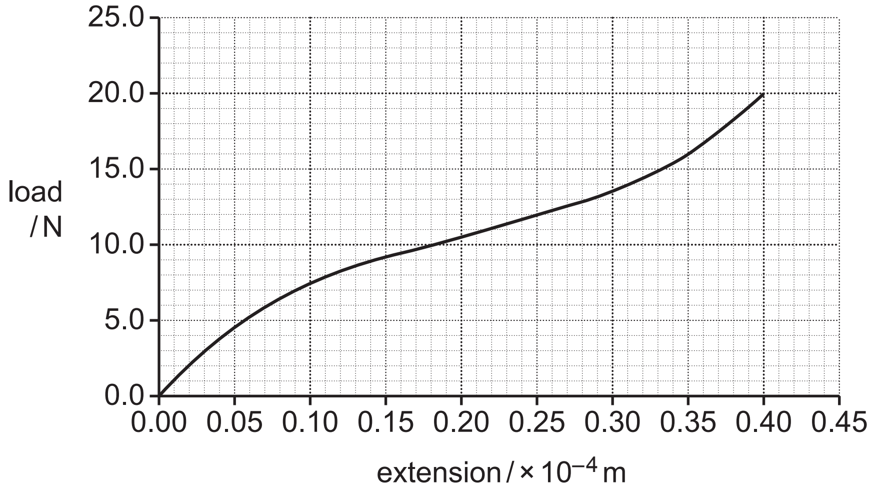


Fig. 36.2



(a) When the wire and the rubber strip are first loaded with 10 N the loads oscillates vertically with microscopic amplitudes for a short time.

(i) Use information from **Fig. 36.1** to calculate the stiffness **k** of the wire.

stiffness = ... $N\,m^{-1}$ **[2]**

(ii) The mass suspended from the wire oscillates vertically with simple harmonic motion.

Calculate the period of oscillation for the wire when it carries a 10 N load.

period = ... s **[2]**

(iii) Explain why the oscillations of the wire are simple harmonic but those of the rubber strip are not.

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.... **[2]**

(b)* Use ideas about the microscopic structures of metal alloys and polymers, such as rubber, to explain the different shapes of the graphs in **Fig. 36.1** and **Fig. 36.2**.

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.... **[6]**

37 **Fig. 37.1** shows a violin. When a note is played, a stationary wave is formed on a string between the bridge and the fingerboard with a frequency determined by the position of the finger on the fingerboard.

Fig. 37.1

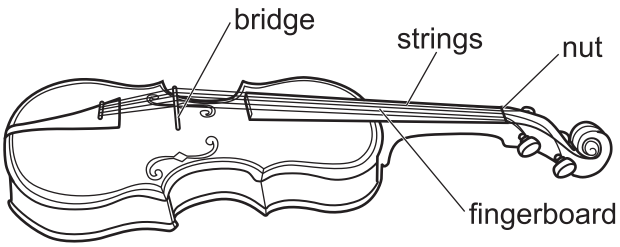
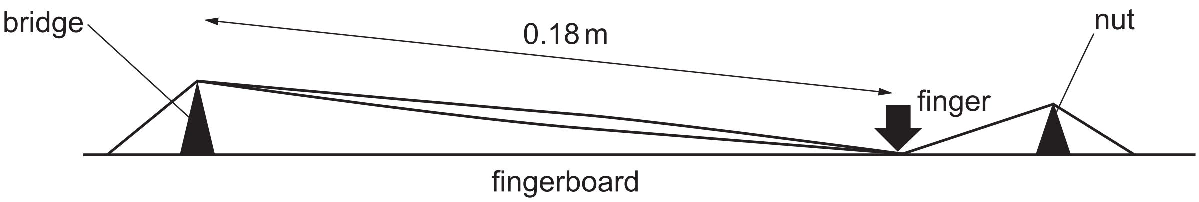


Fig. 37.2 shows a standing wave formed on a violin string when it is freely oscillating at a natural frequency of 370 Hz.

The length of the vibrating section of the string is 0.18 m.

Fig. 37.2



The speed v of a transverse wave on a stretched string is given by the equation

$$v = \sqrt{(T/\mu)}$$

where T is the tension of the string and μ is the mass per unit length of the string.

All the strings on the violin have the same tension and are made from the same material. One of the strings has a diameter 1.4 times greater than the string shown in **Fig. 37.2**.

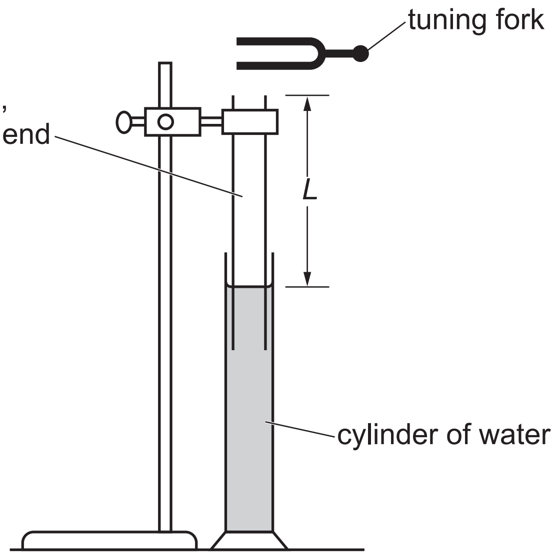
(a) Calculate the length of this string when it oscillates with a natural frequency of 370 Hz.

length = ... m **[3]**

(b)

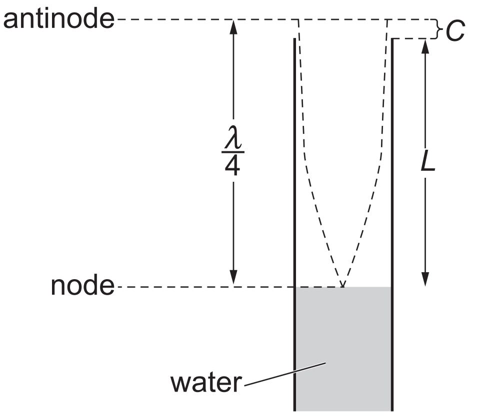
(i) **Fig. 37.3** shows apparatus used to determine the speed of sound in air.
The wavelength of the sound = λ.

Fig. 37.3



The tuning fork is struck and vibrates at a note of frequency 440 Hz. The clamped tube is raised so the length L increases from a very small value. The amplitude of the note reaches a maximum value when length L is 17.0 cm. At this length the air in the tube resonates with a node at the water surface and an antinode at a short distance C above the end of the tube as shown in **Fig. 37.4**.

Fig. 37.4



Show that the **minimum** value of the speed of sound in air is about 300 m s^{-1} and state any assumptions made. Include a calculation in your answer.

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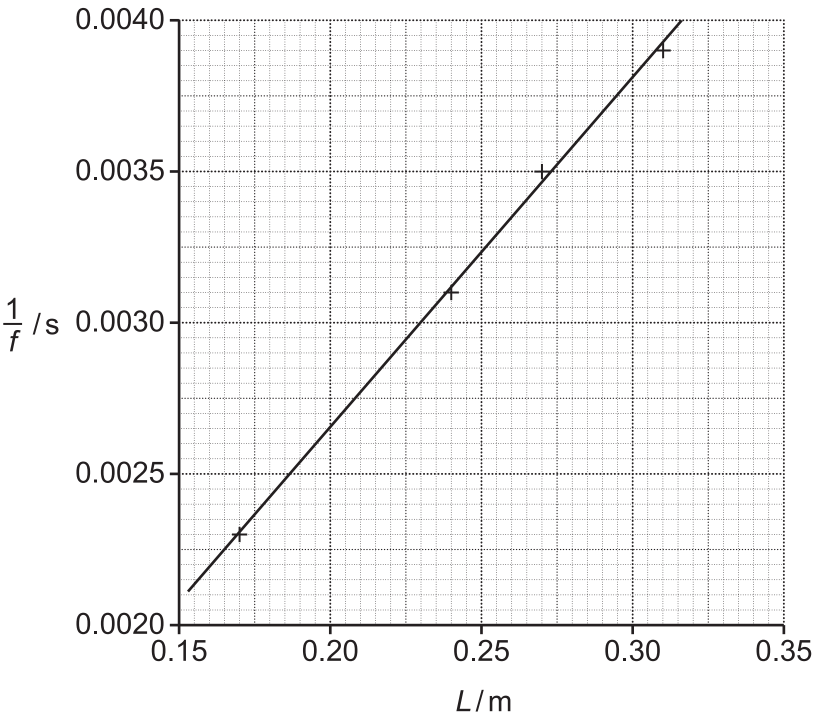
.... **[3]**

The measurement is repeated with a number of tuning forks of different frequencies f. A graph of $1/f$ against length of air column L is plotted as shown in **Fig. 37.5**.

Fig. 37.5



(ii) The gradient of the line = $\frac{4}{v}$ where v is the speed of sound in air. Use the graph to determine the speed of sound in air.

v = ... $m\,s^{-1}$ **[2]**

(iii) Explain why the gradient of the line = $\frac{4}{v}$.

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.... **[3]**

(iv) Discuss the suggestion that using a loudspeaker above the tube connected to a signal generator will give a more reliable determination of the speed of sound than using tuning forks.

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.... **[2]**

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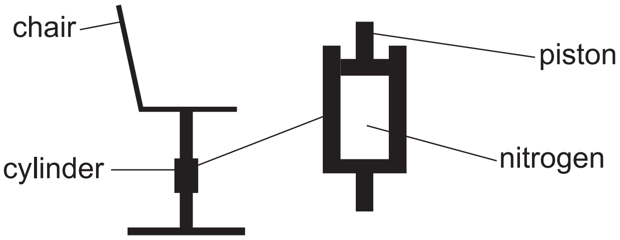
38

(a) **Fig. 38.1** shows an office chair fitted with a gas strut.
The gas strut consists of a cylinder containing nitrogen and a lubricated gas-tight piston. This cushions the downward movement of the seat when someone sits on it.

Fig. 38.1



The gas strut on the chair has a piston with a cross-sectional area of 15.0 cm^2.
When the chair is empty the length l of the cylinder is 10.0 cm and the pressure inside it is 170 kPa.

A person sits on the chair when the room temperature is 18 °C, and the length of the cylinder decreases to 3.0 cm.

(i) Show that the mass of the person is about 61 kg.

[2]

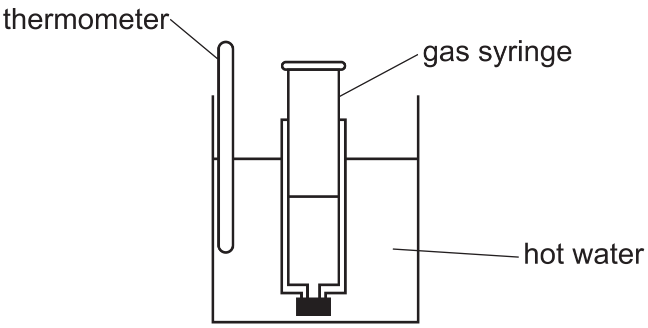
(ii) At the end of the day the temperature is 30 °C and the same person sits on the chair.

Calculate the length l of the cylinder at the end of the day, when a person of mass 61 kg sits on the chair.

length of cylinder = ... m **[2]**

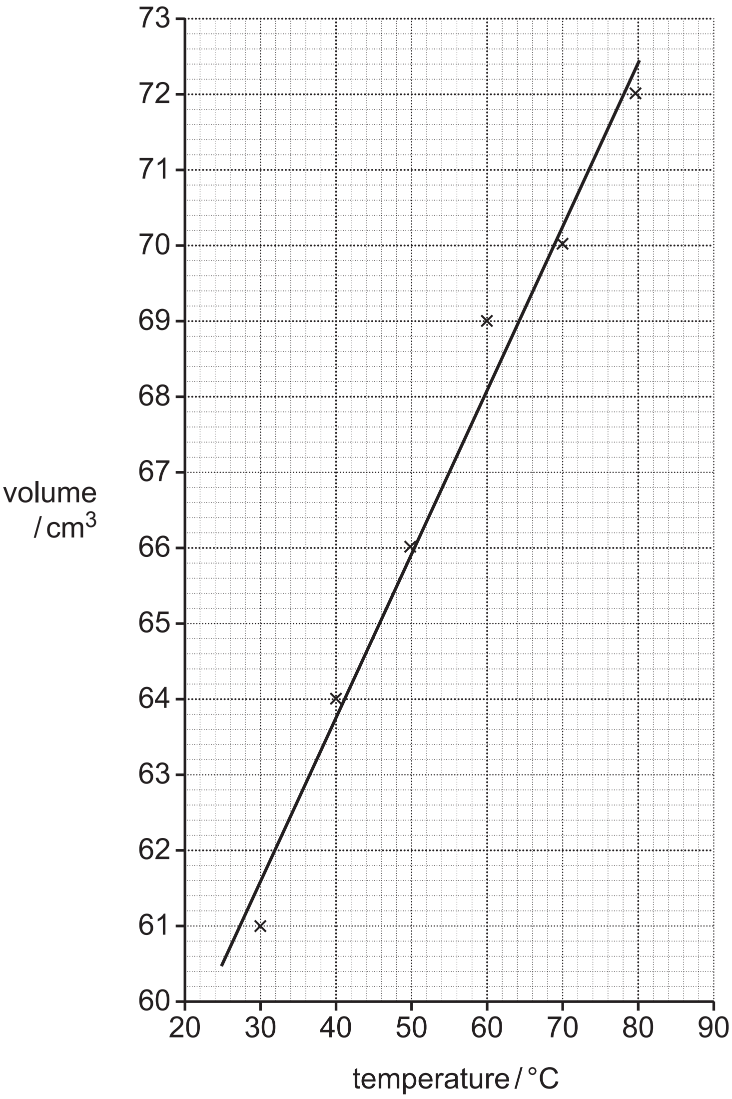
(b) **Fig. 38.2** shows the equipment used in an experiment to investigate the relationship between the volume of a fixed mass of air and its temperature, at constant pressure.

Fig. 38.2



The end of the gas syringe is sealed. It has an initial volume of air trapped inside it. The syringe is put into a beaker of hot water with a thermometer.
The volume of air in the syringe is measured at different water temperatures as the water cools from 80 °C to 30 °C.

The graph shows the results of the experiment.



(i) The gas syringe used in this experiment measures volume to the nearest 1 cm^3 and the thermometer measures temperature to the nearest 1 °C.

Use this information to calculate the percentage uncertainties in the measured volume and temperature at 30 °C.

% uncertainty in volume = ...

% uncertainty in temperature = ...
[2]

(ii) Use the graph to calculate a value of absolute zero of temperature.

absolute zero of temperature = ... °C **[3]**

39

(a) Radioactive decay happens when an unstable nucleus emits a particle or electromagnetic radiation to become more stable. This is a random process.

Explain the meanings of the terms '**unstable nucleus**' and '**random process**' in relation to radioactive decay.

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.... **[2]**

(b) Thorium-232 is a radioactive metal that can be added to welding rods to improve their performance. These welding rods are said to be thoriated.

Thorium-232 decays through the emission of alpha particles and it has a half-life of 1.4×10^{10} years.

Through a series of decays, thorium-232 produces radon-220, which is a radioactive gas.

Radon-220 decays through the emission of alpha particles, and it has a half-life of 55 seconds.

Compare the risks of harm to someone handling a thoriated welding rod from the thorium itself with the risk of harm from the radon gas it produces.

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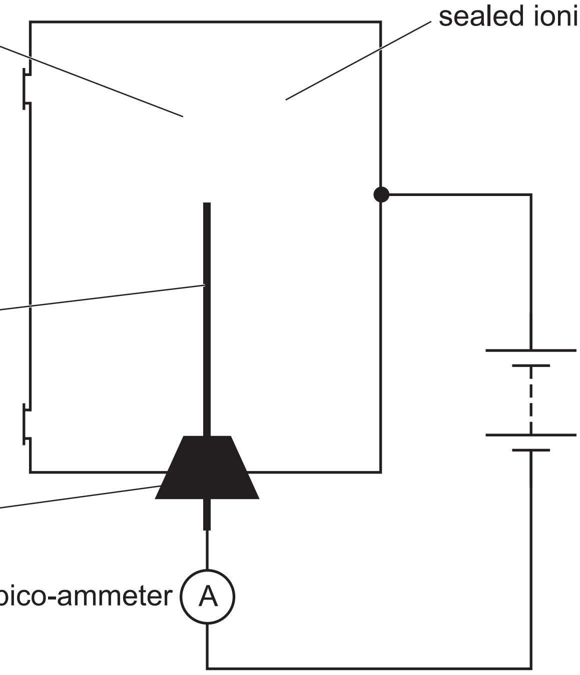
.... **[4]**

(c) In an experiment, radon-220 gas is used to determine its half-life. The diagram shows the equipment used.



A battery and a pico-ammeter are connected between the metal case of the ionisation chamber and the central wire.
Radon-220 in the ionisation chamber emits alpha particles, which cause ionisation of the air in the chamber and a small ionisation current flows in the circuit. This ionisation current is proportional to the rate of emission of alpha particles from the radon-220.

(i) Explain why the ionisation current is proportional to the number of radon-220 atoms remaining in the chamber.

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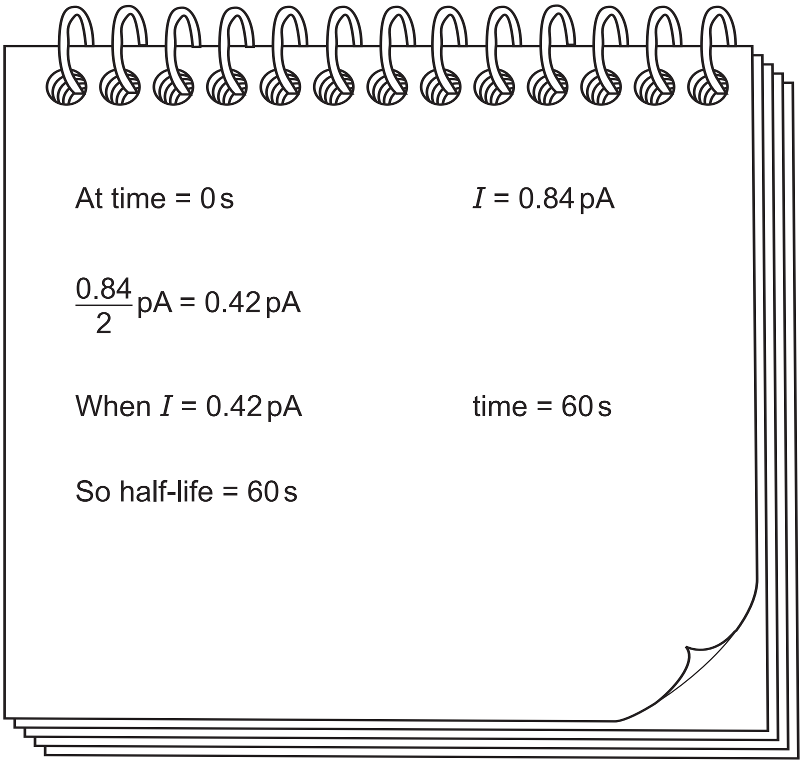
.... **[1]**

The reading on the pico-ammeter is noted every 20 seconds.

The table shows a typical set of results for this experiment.

Time / s	**Ionisation current I / pA**	**ln (I / A)**
0	0.84	–27.81
20	0.64	–28.08
40	0.50	–28.32
60	0.42	–28.50
80	0.28	–28.90
100	0.23	–29.10
120	0.18	–29.35
140	0.13	
160	0.10	

A student calculates the half-life using values from the table:



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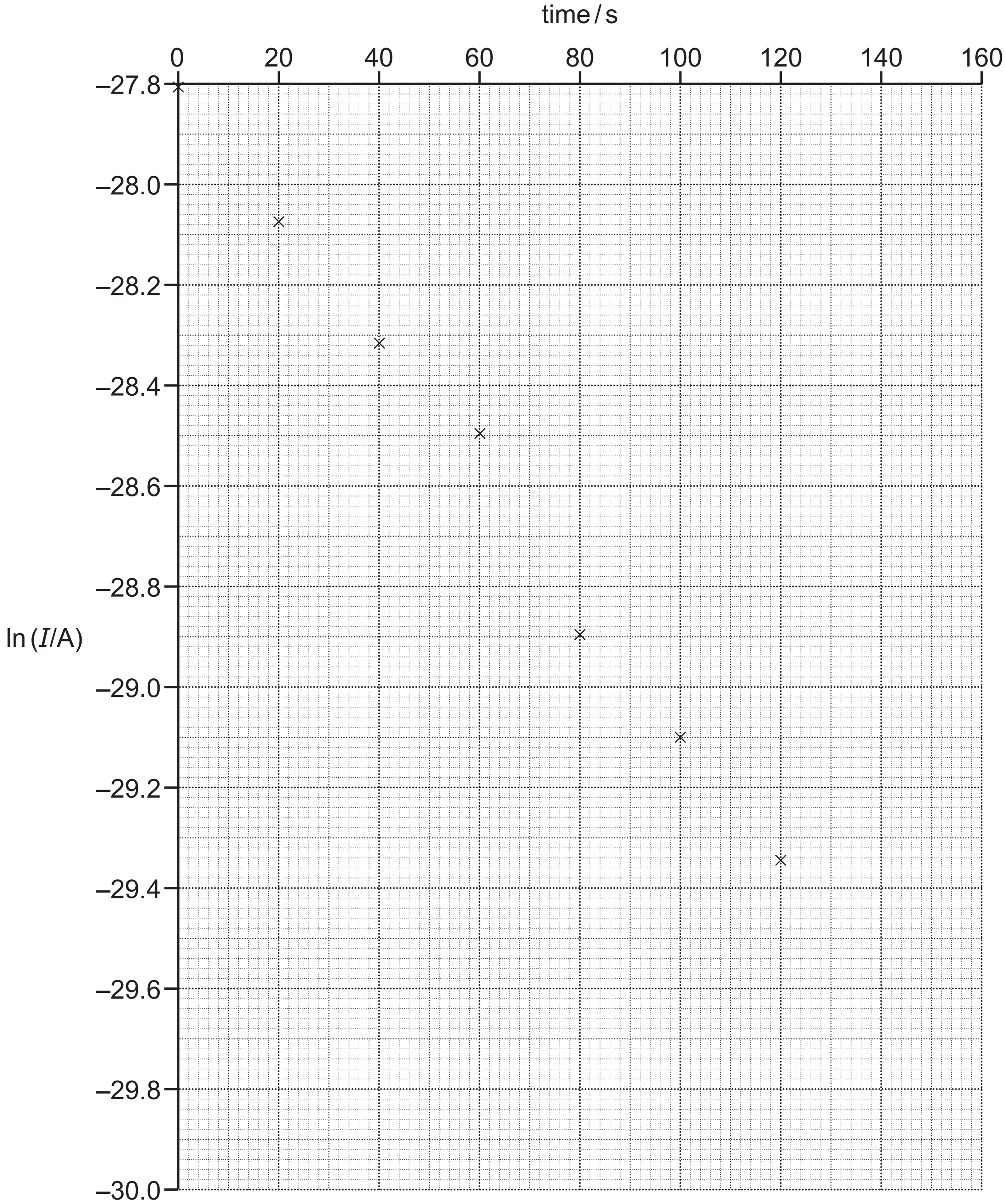
Question 39 continues on page 46

(ii)* Another student starts to plot a graph of ln (I) against time.



Use the table to complete the graph and use it to determine a value for the half-life of the radon-220.

Explain why the graph gives a half-life closer to the accepted value.

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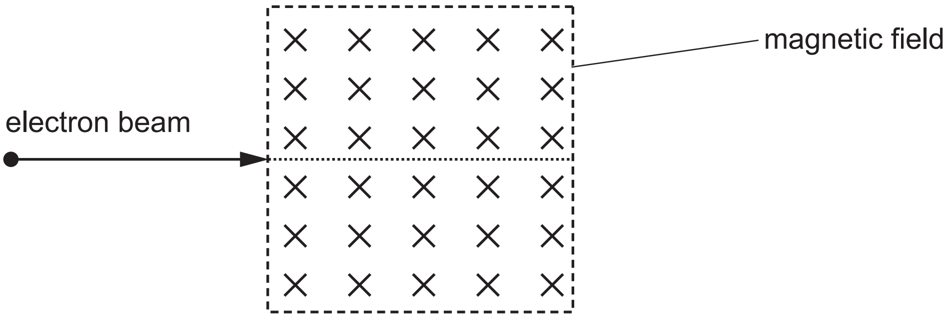
.... **[6]**

40 Electrons are accelerated horizontally from rest through a potential difference of 1.0 kV. They form an electron beam that enters a region in which a magnetic field of 20 mT acts vertically downwards. The whole experiment is enclosed in a vacuum.

Fig. 40.1 shows the experiment from above. The magnetic field is downwards into the page.

Fig. 40.1



(a)
(i) Show that the speed of the electrons when they enter the magnetic field is about $1.9 \times 10^7\,m\,s^{-1}$.

Ignore relativistic effects.

[2]

(ii) Describe the path followed by the electron beam when it is passing through the region of magnetic field. You may add to **Fig. 40.1** in your description.

Include calculations in your answer.

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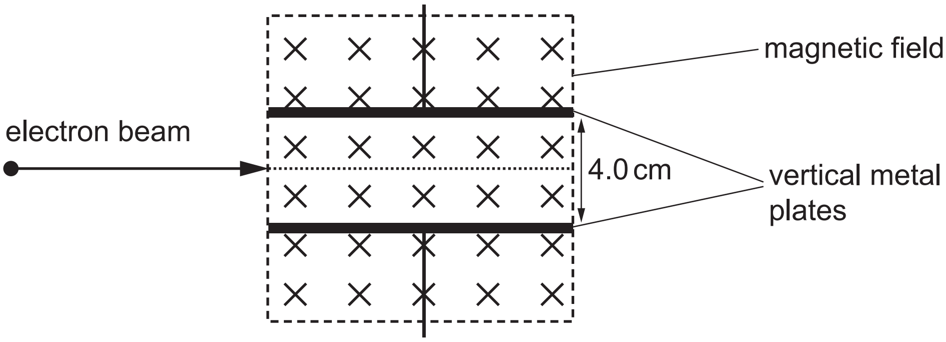
.... **[4]**

(b) **Fig. 40.2** shows the same experiment when two vertical metal plates are positioned parallel to the initial velocity of the electron. A potential difference is applied across these plates to provide an electric field.
The two metal plates are 4.0 cm apart.

Fig. 40.2



A student adjusts the magnitude of the potential difference applied between the plates, so that the deflection of the electron beam is as small as possible and the beam continues in a straight line in the original direction.

Calculate the magnitude of the potential difference that must be applied.

Potential difference = ... V **[2]**

(c) The same equipment is used to accelerate negative ions through a potential difference of 1.0 kV. With the same magnetic field, a potential difference of 120 V is needed between the metal plates to make the ion beam pass through the region in a straight line.

Calculate the ratio of the charge of the ion *q* to its mass *m*.

Charge mass ratio $\frac{q}{m}$ = ... $\mathrm{C\,kg^{-1}}$ **[4]**

END OF QUESTION PAPER

EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.