OCR
Oxford Cambridge and RSA

A Level Physics A

H556/02 Exploring physics

Practice paper – Set 2

Time allowed: 2 hours 15 minutes

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

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

First name										
Last name										
Centre number						Candidate number				

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **32** pages.

SECTION A

You should spend a maximum of 30 minutes on this section.

Write your answer to each question in the box provided.

Answer **all** the questions.

1 An electron, a proton, a neutron and an alpha-particle are travelling in a vacuum at the same speed.

Which of these particles has the **shortest** de Broglie wavelength?

A electron

B proton

C neutron

D alpha-particle

Your answer ☐

[1]

2 In which region of the electromagnetic spectrum is radiation of frequency 300 MHz?

A radio wave

B microwave

C visible

D X-ray

Your answer ☐

[1]

3 A small heater is connected to a power supply. The power supply is switched on for 100 s. The current in the heater is 3.0 A and it dissipates 1200 J of thermal energy.

What is the potential difference across the heater?

A 0.25 V

B 4.0 V

C 12 V

D 300 V

Your answer ☐

[1]

4 A resistance wire is connected to a cell.
The length L of the wire is changed by pulling at the ends of the wire. The volume of the wire remains the same.

What is the correct relationship between the resistance R of the wire and its length L?

A R = constant

B $R \propto L$

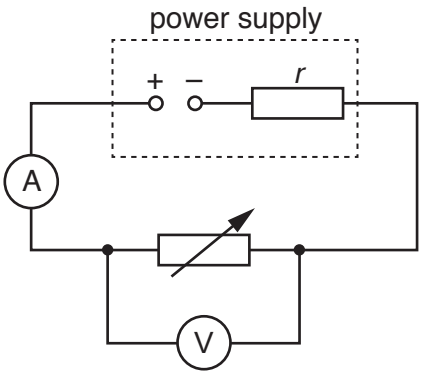
C $R \propto L^2$

D $R \propto L^{-1}$

Your answer ☐

[1]

5 A variable resistor is connected across the terminals of a power supply of constant e.m.f. and internal resistance r.



The resistance of the variable resistor is changed from zero to its maximum value.

Which of the following statements is/are correct?

1 The current in the circuit decreases.
2 The p.d. across the internal resistance decreases.
3 A graph plotted of terminal p.d. against current has a negative gradient.

A Only 1

B Only 1 and 2

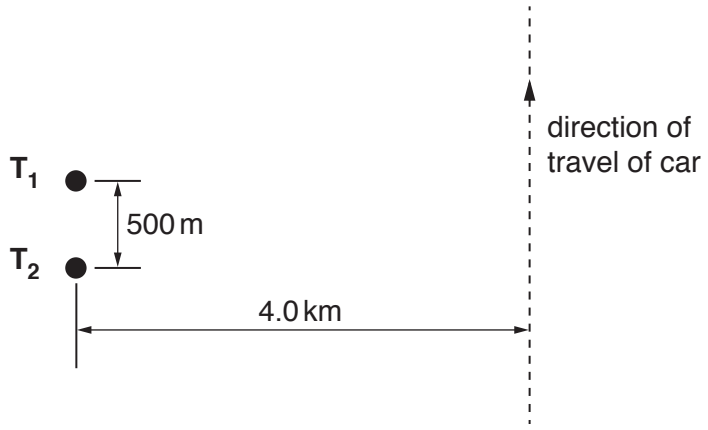
C Only 1 and 3

D 1, 2 and 3

Your answer ☐

[1]

6 Two radio wave transmitters $\mathbf{T_1}$ and $\mathbf{T_2}$ emit radio waves of wavelength 20 m. The separation between the transmitters is 500 m. The waves are in phase at the transmitters and have the same amplitude.
A car travels at a constant speed of $10\,m\,s^{-1}$ in a straight line in a direction parallel to the line joining $\mathbf{T_1}$ and $\mathbf{T_2}$. The perpendicular distance of the car from the line joining the transmitters is 4.0 km.



What is the time between two successive maximum signals detected at the car?

A 6.3×10^{-4} s

B 2.0 s

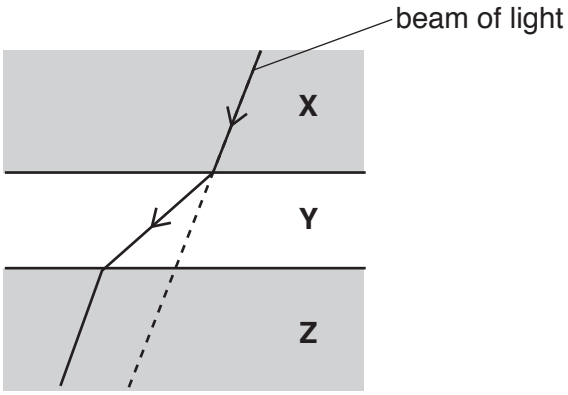
C 16 s

D 400 s

Your answer ☐

[1]

7 The diagram below shows the path of a narrow beam of light as it is refracted at the boundaries between three different transparent materials **X**, **Y** and **Z**.



The beam of light in **X** and the beam of light in **Z** are parallel.
The wavelength of the light in **X** is 640 nm.

Which statement is correct?

A The light travels faster in **X** than in **Y**.

B The wavelength of light in **Y** is shorter than 640 nm.

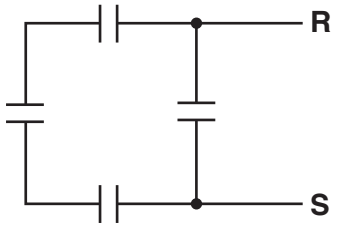
C Materials **X** and **Z** have the same value of refractive index.

D The refractive index of **Y** is greater than the refractive index of **X**.

Your answer ☐

[1]

8 The diagram below shows a circuit connected by a student.



The capacitance of each capacitor is 300 pF.
What is the total capacitance between points **R** and **S**?

A 75 pF

B 230 pF

C 400 pF

D 1200 pF

Your answer ☐

[1]

9 A current-carrying solenoid has N turns and radius r. The magnetic flux density within the core of the solenoid is B.

What is the magnetic flux linkage for this solenoid?

A NB

B $\pi r^2 B$

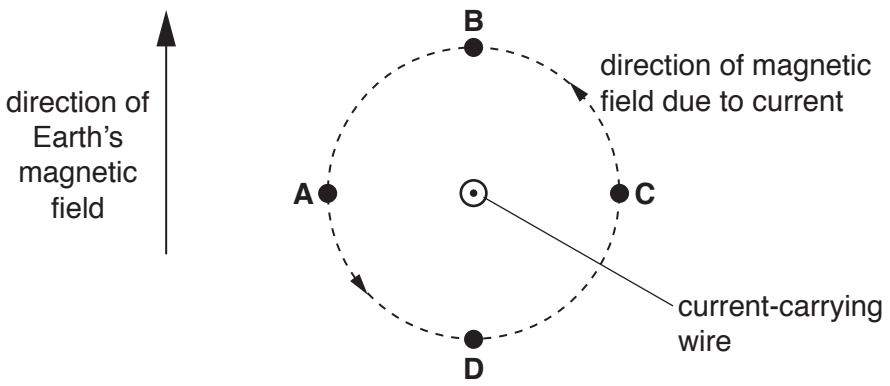
C $2\pi rBN$

D $\pi r^2 BN$

Your answer

[1]

10 The diagram below shows a current-carrying wire coming out from the plane of the paper. The current in the wire produces a magnetic field in an **anticlockwise** direction around the wire.



The direction of the Earth's magnetic field is also shown.
The Earth's magnetic field interacts with the magnetic field of the current-carrying wire.

At which point **A**, **B**, **C** or **D** is the resultant magnetic field strength a **minimum**?

Your answer

[1]

11 The table shows data on four freshly prepared radioactive samples **A**, **B**, **C** and **D**.

Sample	Number of active nuclei in the sample	Half-life of the sample
A	N	T
B	N	$3T$
C	$5N$	$0.5T$
D	$8N$	$4T$

Which sample has the **smallest** activity?

Your answer ☐

[1]

12 A positive pion (π^+) is an unstable particle produced when high-speed hadrons collide in particle accelerators. The π^+ particle has a charge of $+e$.

What is the quark combination of the π^+ particle?

A $u\,\bar{u}$

B $u\,\bar{d}$

C $d\,\bar{u}$

D $d\,\bar{d}$

Your answer ☐

[1]

13 The nuclei of uranium-235 ($^{235}_{92}U$) and carbon-12 ($^{12}_{6}C$) have different radii.

What is the ratio $\dfrac{\text{radius of the uranium nucleus}}{\text{radius of the carbon nucleus}}$?

A 2.5

B 2.7

C 15

D 20

Your answer ☐

[1]

14 Ultrasound is reflected at a boundary between two materials.

Which property of the materials governs the intensity of the ultrasound reflected at the boundary?

A density

B decay constant

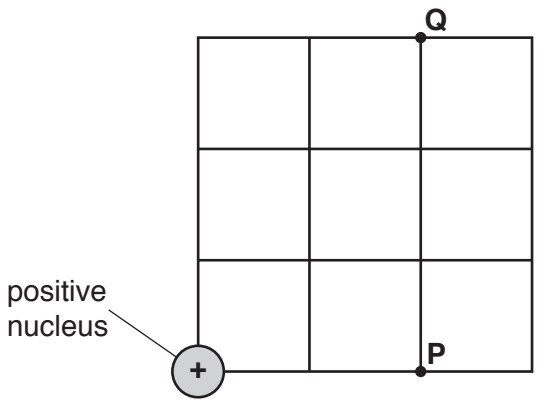
C acoustic impedance

D attenuation coefficient

Your answer ☐

[1]

15 An electron at point **P** experiences an electric force of magnitude 1.8 μN due to the positive nucleus.



What is the magnitude of the force experienced by the same electron when it is at point **Q**?

A 0.28 μN

B 0.55 μN

C 1.0 μN

D 1.8 μN

Your answer ☐

[1]

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Question 16 begins on page 10

SECTION B

Answer **all** the questions.

16 (a) Two resistors of resistances R_1 and R_2 are connected in **parallel**.
Show that the total resistance R of this combination is given by the equation

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} .$$

[3]

(b) A filament lamp **X** is part of an electrical circuit. The circuit has a battery of electromotive force (e.m.f.) 6.0 V and negligible internal resistance. The potential difference across the lamp can be increased **continuously** from 0 to 6.0 V. This potential difference is measured using a voltmeter.
The lamp glows brightly at 6.0 V.

(i) Draw a circuit diagram for this electrical arrangement.

[2]

(ii) Describe and explain the variation of the resistance of this lamp as the potential difference across it is changed from 0 to 6.0 V.

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..... **[4]**

(iii) The filament lamp **X** is now connected in a different circuit as shown in Fig. 16.

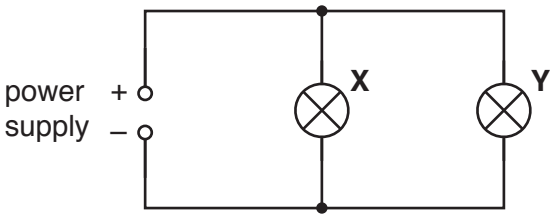

Fig. 16

The power dissipated in **X** is three times more than the power dissipated in the filament lamp **Y**. The filament wire of lamp **X** has a diameter half that of lamp **Y**.
The filament wires of **X** and **Y** are made of the same material and are at the same temperature.

Calculate the ratio

$$\frac{\text{mean drift velocity of charge carriers in lamp } \mathbf{X}}{\text{mean drift velocity of charge carriers in lamp } \mathbf{Y}}.$$

ratio = ... **[3]**

17 Fig. 17 shows a potential divider circuit consisting of a fixed resistor of resistance R and a negative temperature coefficient (NTC) thermistor.

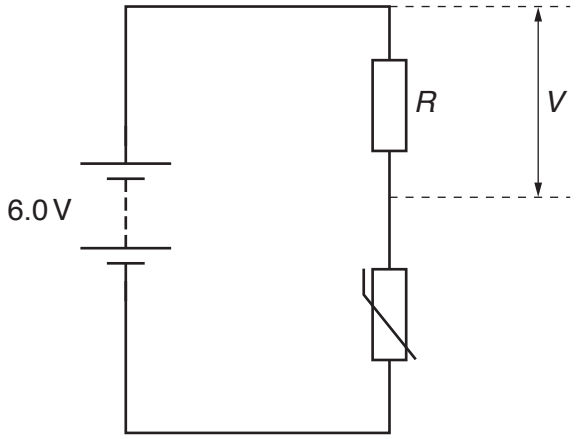

Fig. 17

The battery has electromotive force (e.m.f.) of 6.0 V and negligible internal resistance.
The thermistor is at room temperature. The resistance of the thermistor is 0.25 R.

(a) Calculate the potential difference V across the resistor.

V = ... V **[2]**

(b) A voltmeter whose resistance is 5 R is connected across the fixed resistor.
The voltmeter reading is **less** than your answer in **(a)**.
Explain why the voltmeter reading is less and suggest an alternative measuring device.

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..... **[2]**

(c) The circuit shown in Fig. 17 is now placed in a cold fridge. The temperature of the thermistor slowly decreases to a constant value.
Describe and explain, in terms of current in the circuit, the variation of the potential difference *V* across the fixed resistor with time.

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..... **[4]**

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18 (a) In Fig. 18.1 the solid line represents the displacement s against distance x graph for a **progressive** transverse wave on a stretched string at time $t = 0$. The dotted line shows the graph for the same wave at a later time $t = 2.5$ ms.

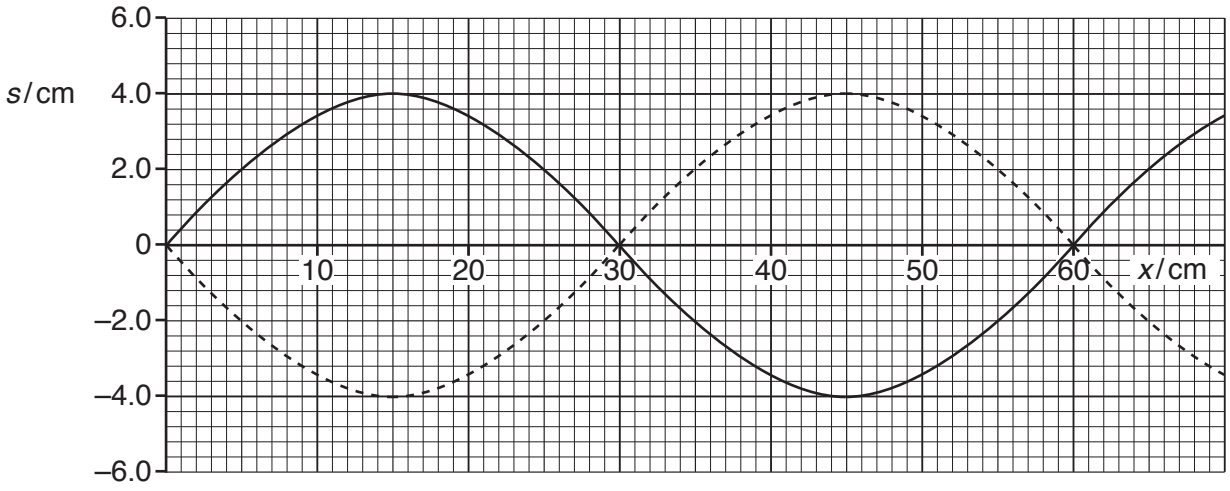

Fig. 18.1

Determine the frequency f of this wave.

f = ... Hz **[3]**

***(b)** Fig. 18.2 shows an arrangement used to investigate **stationary** sound waves in a tube closed at one end.

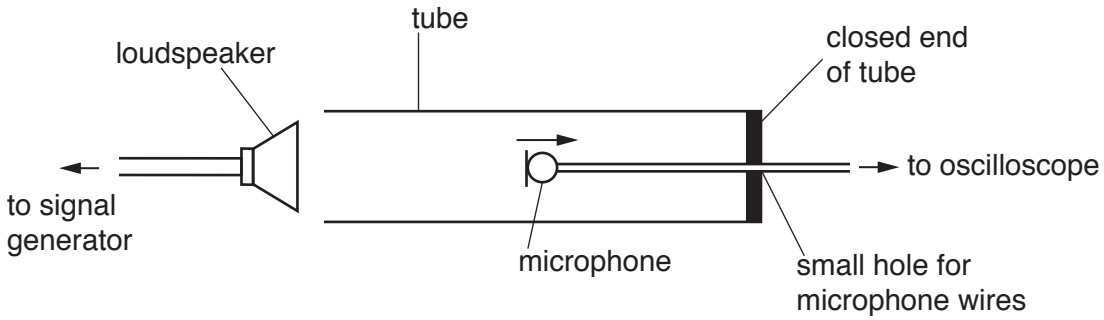

Fig. 18.2

A loudspeaker is placed at the open end of the tube. The loudspeaker emits sound of constant frequency.
A small microphone is placed inside the tube. The microphone is connected to an oscilloscope. The microphone is slowly moved from the open end of the tube towards its closed end. The signal detected by the microphone shows regions of maximum and minimum intensity of sound. The distance between adjacent positions of maximum signal is 0.26 m.

Fig. 18.3 shows the signal displayed on the oscilloscope when the output signal from the microphone is maximum. The time-base on the oscilloscope is set at 0.50 ms div^{-1}.

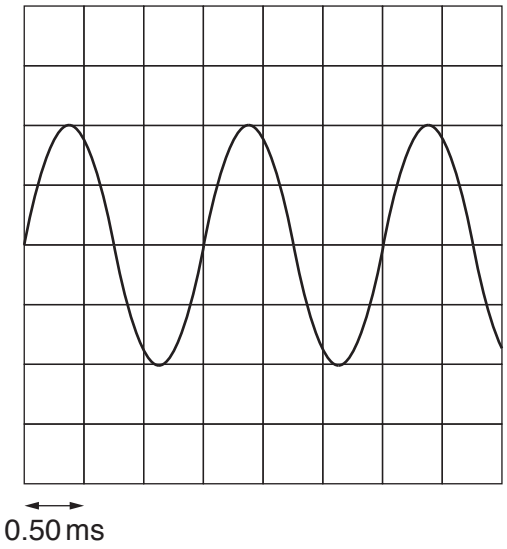

Fig. 18.3

Explain the presence of the regions of maximum and minimum intensities of sound within the tube and determine the speed of sound.

.... [6]

19 (a) Electromagnetic radiation of wavelength 300 nm is incident on the surface of two metals **X** and **Y**. Metal **X** has work function 2.0 eV and metal **Y** has work function 5.0 eV.

With the help of calculations, explain any difference between the emission of photoelectrons from the surfaces of the metals **X** and **Y**.

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..... **[4]**

***(b)** Two groups of researchers, **A** and **B**, conduct photoelectric effect experiments on a new material. The maximum kinetic energy KE_{max} of the photoelectrons emitted from the material is determined for different frequencies f of the electromagnetic radiation incident on the material.

Fig. 19 shows incomplete graphs of KE_{max} against f from the groups **A** and **B**.

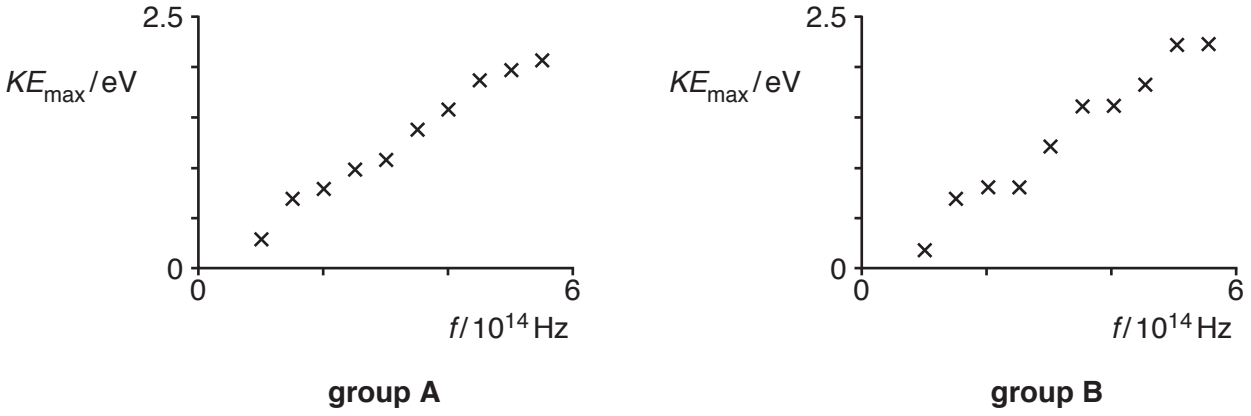

Fig. 19

The value of the Planck constant h is determined from the completed KE_{max} against f graphs. The result from each group is shown below.

group A: $h = (6.3 \pm 0.3) \times 10^{-34}$ J s
group B: $h = (6.6 \pm 0.6) \times 10^{-34}$ J s

Explain how a graph of KE_{max} against *f* can be used to determine *h*. Discuss the accuracy and precision of the results from each group.

.... **[6]**

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20 **(a)** Fig. 20.1 shows a capacitor connected to a power supply.

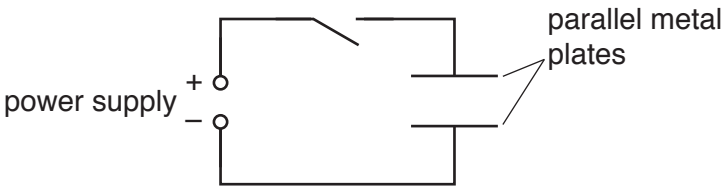

Fig. 20.1

The capacitor consists of two parallel metal plates separated by air.
The switch is closed to charge the capacitor.
The switch is then opened and the separation between the charged plates is **doubled**.
State and explain what happens to the energy stored by the capacitor.

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..... **[3]**

(b) A student is carrying out an experiment in the laboratory to determine the capacitance *C* of a capacitor. Fig. 20.2 shows the circuit used by the student.

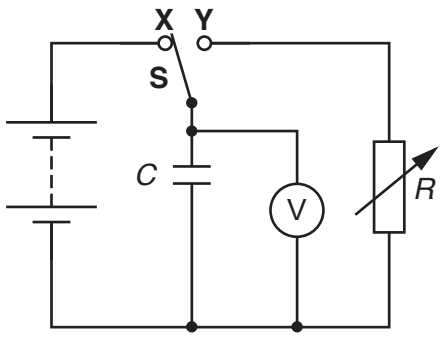

Fig. 20.2

The switch **S** is first connected to **X** to charge the capacitor. The switch is then moved to **Y** at time $t = 0$. The time T taken for the potential difference V across the capacitor to halve is determined for different values of resistance R.

(i) Fig. 20.3 shows the graph of T against R as plotted by the student.

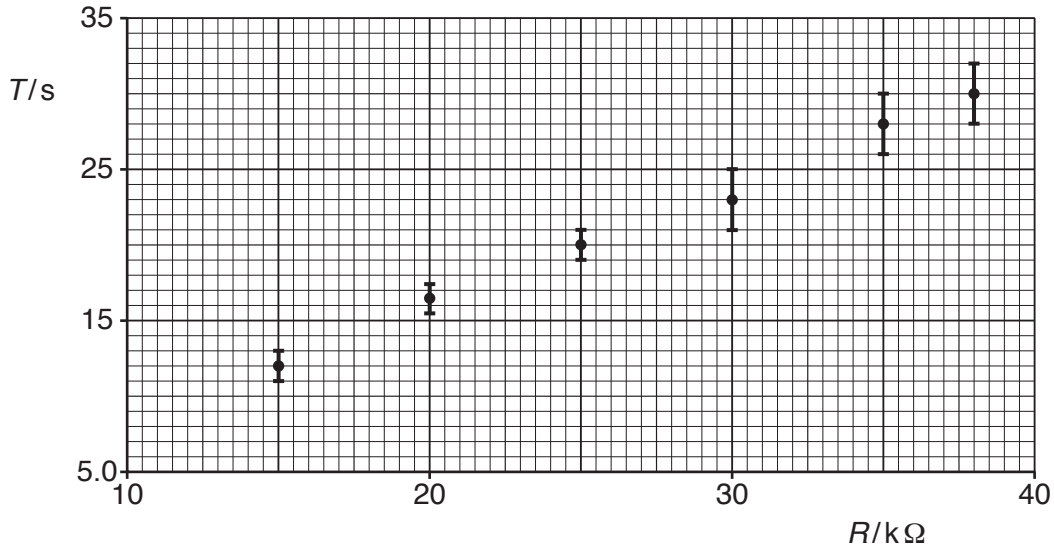

Fig. 20.3

1 Draw a straight line of best fit. **[1]**

2 Use $V = V_0 e^{-t/CR}$ to show that $T = -\ln(0.5)CR$.

[2]

3 Determine a value for the capacitance C.

C = ... F **[3]**

(ii) Describe, without doing any calculations, how you can use Fig. 20.3 to determine the percentage uncertainty in *C*.

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..... **[2]**

Question 21 begins on page 24

21 **(a)** Fig. 21.1 shows two oppositely charged ions to the left of a point **X**.

Fig. 21.1

The separation between the centres of the ions is 3.0×10^{-10} m. Each ion has charge of magnitude 1.6×10^{-19} C.

(i) Explain why the direction of the **resultant** electric field strength at point **X** is to the left.

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..... **[2]**

(ii) Calculate the minimum energy in eV required to completely separate the ions.

energy = ... eV **[3]**

(b) A **proton** travels from point **P** to point **Q** in a uniform electric field as shown in Fig. 21.2.

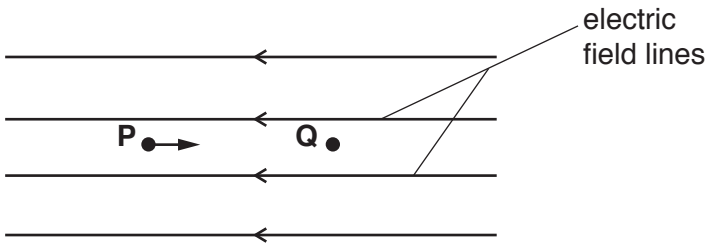

Fig. 21.2

The velocity of the proton at **P** is $7.2 \times 10^6\,m\,s^{-1}$ and the velocity at **Q** is $2.4 \times 10^6\,m\,s^{-1}$. The distance between **P** and **Q** is 1.2 cm.

Calculate

(i) the magnitude of the deceleration of the proton

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

(ii) the electric field strength *E*.

E = ... $N\,C^{-1}$ **[2]**

22 A nucleus of hydrogen-3 ($^{3}_{1}H$) is unstable and it emits a beta-minus particle (electron).

(a) The emitted beta-minus particle enters a region of uniform magnetic field.
Fig. 22.1 shows the path of the particle **before** it enters the magnetic field.

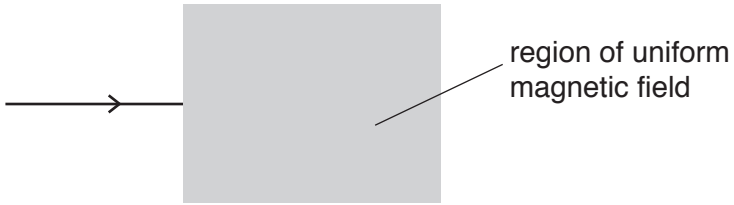

Fig. 22.1

The direction of the magnetic field is into the plane of the paper.

Describe and explain the path of the particle in the magnetic field.

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..... **[2]**

(b) The nucleons inside the $^{3}_{1}H$ nucleus experience gravitational force and one other type of force.
Name this other type of force and describe its nature.

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..... **[3]**

(c) Write a decay equation for beta-minus in terms of a quark model.

[2]

(d) The fusion of two $^{3}_{1}H$ nuclei produces a stable nucleus of $^{4}_{2}He$ and some fast-moving neutrons.

(i) Explain why the fusion of the $^{3}_{1}H$ nuclei must produce two neutrons.

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..... **[2]**

(ii) The total energy released in this fusion reaction is 11 MeV. The binding energy per nucleon of the $^{4}_{2}He$ nucleus is 7.1 MeV.
Calculate in J the binding energy per nucleon of the $^{3}_{1}H$ nucleus.

binding energy per nucleon = ... J **[3]**

23 **(a)** The medical tracer technetium-99m is used in gamma scans. Technetium-99m has a half-life of 6.0 hours and it emits gamma rays.
A fresh sample of a radiopharmaceutical containing technetium-99m is prepared in the radiography department of a hospital. The initial activity of the radiopharmaceutical is 820 MBq. The radiopharmaceutical is injected into the patient some time later when its activity has dropped to 630 MBq.

Calculate the time in hours between the radiopharmaceutical being produced and it being injected into the patient.

time = ... h **[3]**

(b) A gamma camera is connected to a computer and a display. Sophisticated software is used to produce a quality scan (image) of the patient.

(i) Briefly describe the function of the collimator, scintillator and photomultiplier tubes in a gamma camera.

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..... **[3]**

(ii) Fig. 23 shows two types of lead collimator tubes **T** and **S** available for a gamma camera.

Fig. 23

Tube **T** is thin and long. Tube **S** is broad and short.

Discuss which type of tube would be more suitable in a gamma camera.

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..... **[2]**

24 A patient with a blood clot in his muscle is having an ultrasound A-scan.
Fig. 24.1 shows an ultrasound transducer placed on the patient's skin.

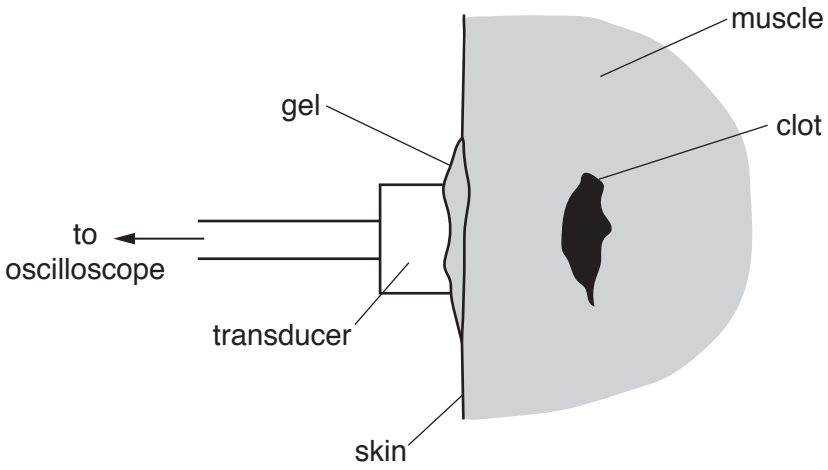

Fig. 24.1 (not to scale)

The ultrasound transducer produces pulses of ultrasound. An oscilloscope is connected to the transducer. Fig. 24.2 shows part of the oscilloscope display.

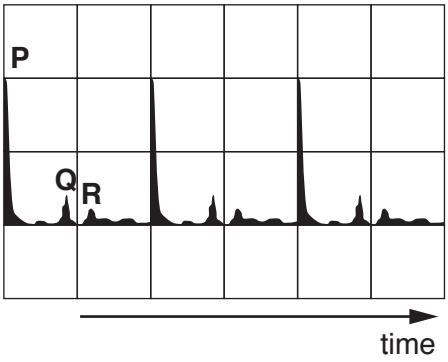

Fig. 24.2

(a) In Fig. 24.2, **P** is one of the signal pulses produced by the transducer.
Explain the origin of the pulses **Q** and **R**.

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..... **[2]**

(b) The **front** of the blood clot is 1.5 cm from the skin.
The density of the patient's muscle is 1070 kg m^{-3}.
The time difference between pulses **P** and **Q** in Fig. 24.2 is 19 μs.
Determine the acoustic impedance *Z* of patient's muscle. State an appropriate unit for your answer.

Z = ... unit: ..... **[4]**

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).