EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2024
General Certificate of Education Advanced Level
Higher 1

CANDIDATE NAME							
CIVICS GROUP	2	3	-			REGISTRATION NUMBER	

PHYSICS

8867/02

Structured Questions

September 2024

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on all the work you hand in.
The use of an approved scientific calculator is expected where appropriate.

Section A
Answer **all** questions.

Section B
Answer any **one** question.

Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use paper clips, highlighters, glue or correction fluid.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
Q1	**8**
Q2	**11**
Q3	**10**
Q4	**9**
Q5	**8**
Q6	**14**
Section B	
Q7	**20**
Q8	**20**
s.f.	
P2 Total	**80**

This document consists of **24** printed pages.

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$

1 **(a)** Define *acceleration*.

……………………………………………………………………………………………………

…………………………………………………………………………………………………..[1]

(b) An object is released from rest in a viscous fluid. Fig. 1.1 shows the variation with time t of the acceleration a of the object as it falls in the fluid.

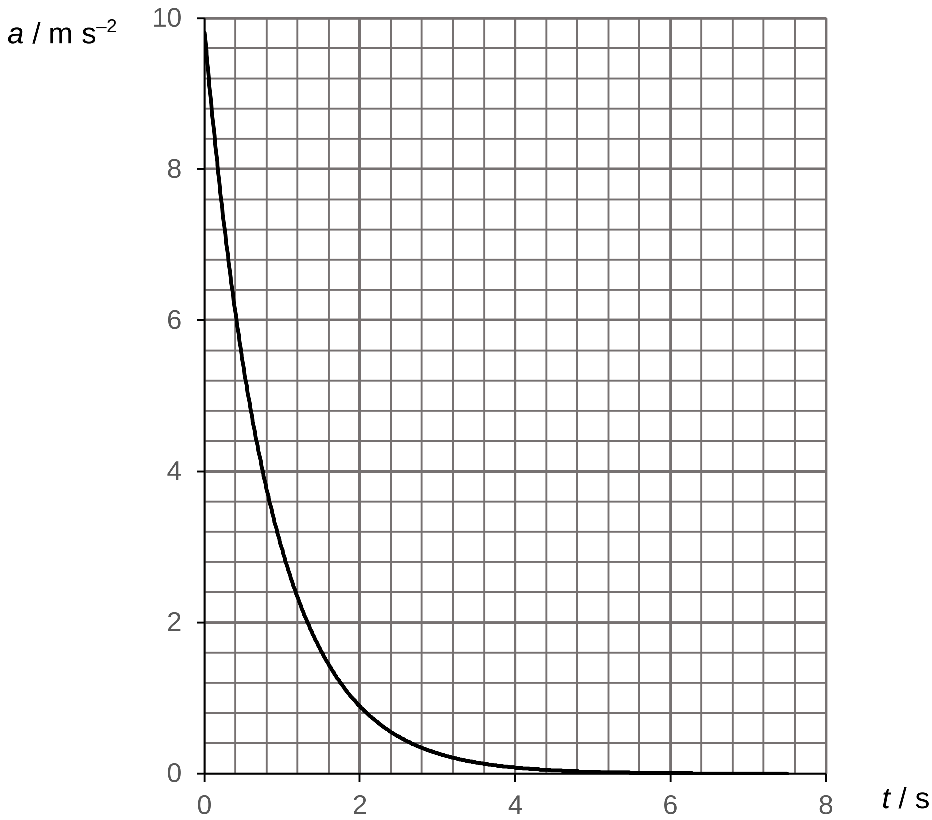


Fig. 1.1

(i) Explain why the acceleration of the object decreases with time.

……………………………………………………………………………………………

……………………………………………………………………………………………

………………………………………………………………………………………… [2]

(ii) Explain why the initial value of the acceleration is 9.8 m s^{-2}.

……………………………………………………………………………………………

………………………………………………………………………………………… [1]

(iii) Use Fig. 1.1 to estimate the speed of the object when its acceleration is zero. Explain your working clearly.

speed = ………………………. m s^{-1} [2]

(iv) In Fig. 1.2, sketch the variation of the displacement s of the object with time t, from t = 0 s to t = 8 s. There is no need to label the displacement axis.

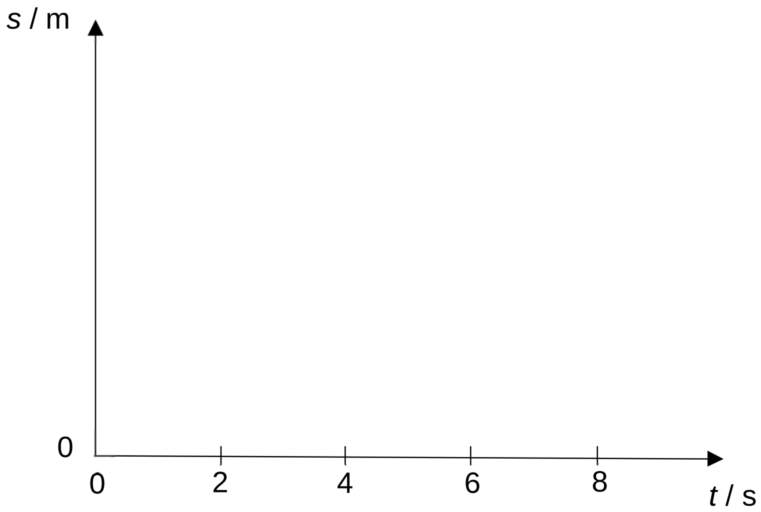


Fig. 1.2

[2]

[Total: 8]

2 **(a)** State Newton's First Law.

....

....[1]

(b) A block of mass 0.40 kg slides in a straight line with a constant speed of 0.30 m s^{-1} along a frictionless horizontal surface, as shown in Fig. 2.1.

Fig. 2.1

The block hits a spring and decelerates.

The speed of the block becomes zero when the spring is compressed by 8.0 cm.

(i) Calculate the initial kinetic energy of the block.

kinetic energy = ………………………... J [2]

(ii) The variation of the compression *x* of the spring with the force *F* applied to the spring is shown in Fig. 2.2.

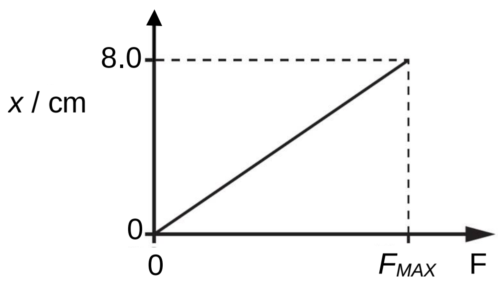


Fig. 2.2

Determine the maximum force F_{MAX} exerted on the spring by the block.

F_{MAX} = ………………………... N [3]

(iii) State and explain whether the block is in equilibrium
1. just before it hits the spring,

....

....[1]
2. at the moment its speed becomes zero.

....

....[1]

(c) Figure 2.3 shows a massive column held stationary in position by a group of people pulling at a rope.

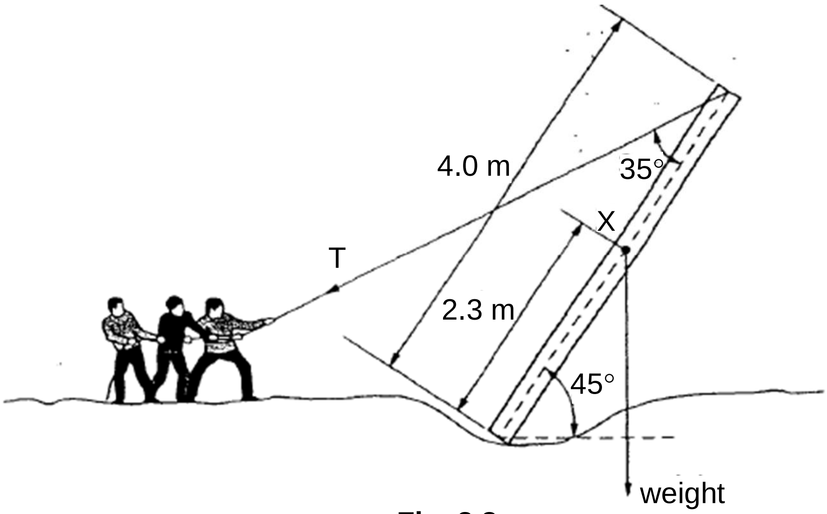


Fig. 2.3

The 4.0 m high column has a mass of 180 kg and its centre of gravity X is at a distance of 2.3 m from the base. The rope makes an angle of 35° to the column and the column itself makes an angle of 45° to the horizontal.

(i) Show that the moment exerted by the weight of the column about the base is 2.9×10^3 N m. [1]

(ii) By taking moments about the base of the column, calculate the tension *T* in the rope.

T = ……………………………… N [2]
[Total: 11]

3 **(a)** An object of mass 0.80 kg is placed at a distance r from the centre P of a flat disc rotating horizontally with an angular speed ω. It undergoes circular motion with the disc, as shown in Fig. 3.1.

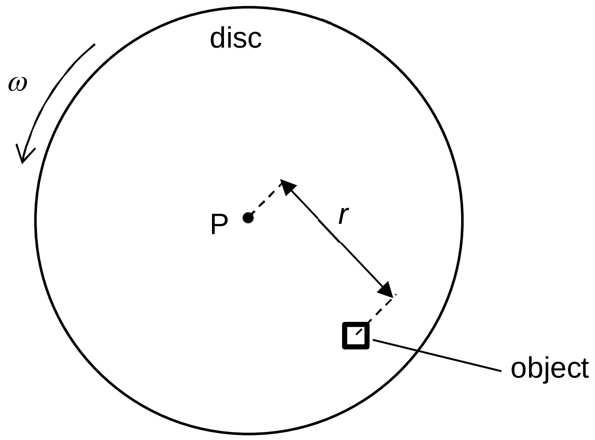


Fig. 3.1 (top view)

To determine the maximum frictional force acting on the object, the angular speed is slowly increased until the object starts to slide. For different values of r, this value of the angular speed is recorded as ω_{max}. The variation with $\frac{1}{r}$ of ω_{max}^2 is shown in Fig. 3.2.

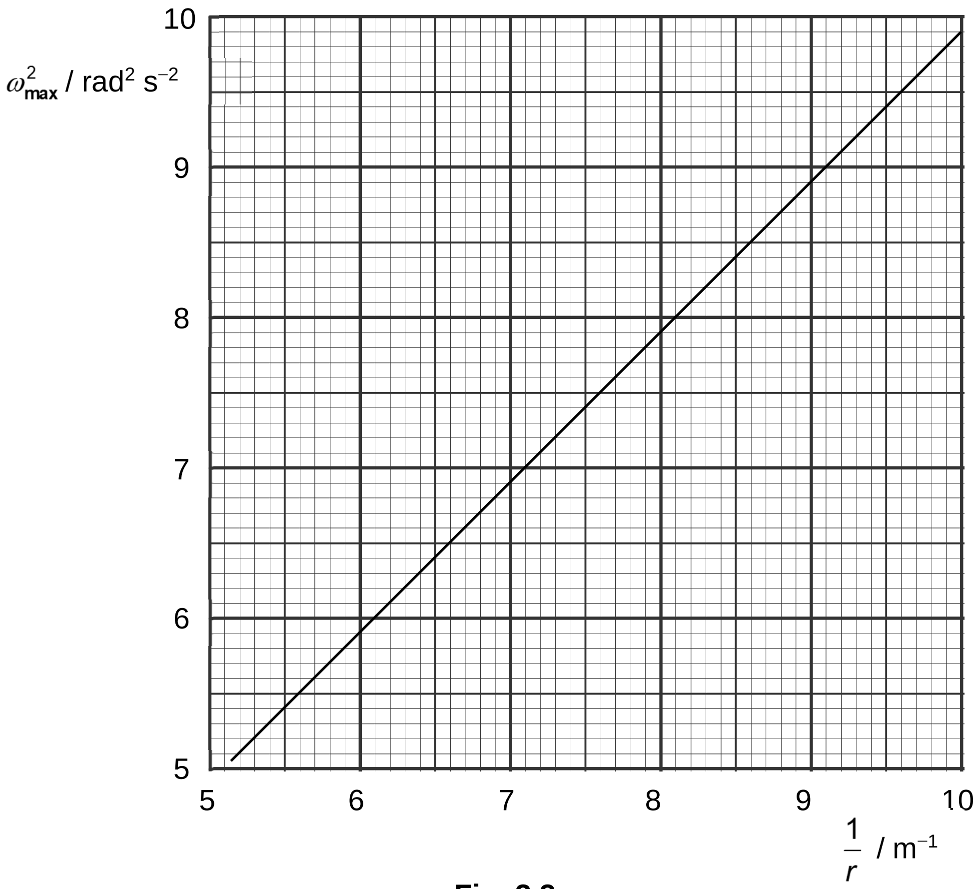


Fig. 3.2

(i) On Fig. 3.1, draw an arrow to show the direction of the frictional force acting on the object at the instant shown. Label this arrow Z. [1]

(ii) Explain the direction of the frictional force in **(a)(i)**.

……………………………………………………………………………………………….

…………………………………………………………………………………………… [1]

(b) **(i)** Determine the gradient of the line in Fig. 3.2.

gradient = ……………………………….. [2]

(ii) Suggest the physical significance of the gradient. Show any necessary working.

……………………………………………………………………………………………….

…………………………………………………………………………………………… [2]

(c) Determine the maximum frictional force acting on the object.

maximum frictional force = ………………………………..N [2]

(d) Explain why the object starts to slide as angular speed increases.

……………………………………………………………………………………………….

……………………………………………………………………………………………….

…………………………………………………………………………………………… [2]

[Total: 10]

4 **(a)** Explain what is meant by work done.

....

....[1]

(b) A leisure park ride consists of a carriage that moves along a railed track. Part of the track lies in a vertical plane and follows an arc XY of a circle of radius 13 m, as shown in Figure 4.1.

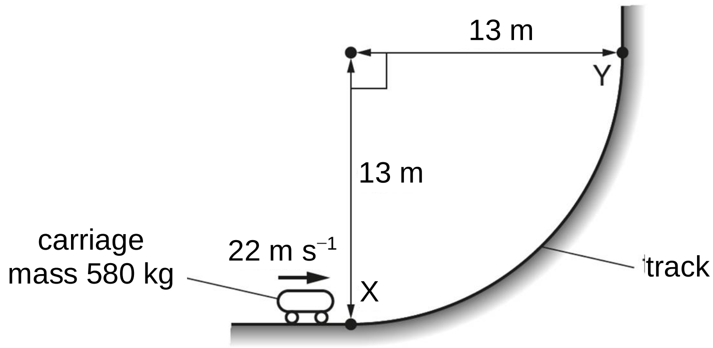


Fig. 4.1

The mass of the carriage is 580 kg. At point X, the carriage has speed 22 m s^{-1} in a horizontal direction. The speed of the carriage then decreases to 12 m s^{-1} in a vertical direction at point Y.

(i) For the carriage moving from X to Y, calculate the

1. loss in kinetic energy of the carriage,

loss in kinetic energy = ……………………….. J [2]

2. gain in gravitational potential energy of the carriage,

gain in gravitational potential energy = ……………………….. J [2]

3. length of the track travelled.

length = ……………………….... m [2]

(ii) Use your answers in **(b)(i)** to calculate the average resistive force acting on the carriage as it moves from X to Y.

resistive force = ……………………….... N [2]

[Total: 9]

5 **(a)** **(i)** State the principle of conservation of linear momentum.

………………………………………………………………………………………………

……………………………………………………………………………………………….[1]

(ii) State the relation between force and momentum.

………………………………………………………………………………………………

……………………………………………………………………………………………….[1]

(b) A fast-moving neutron of mass *m* collides head-on with a stationary nitrogen atom of mass 14*m* as illustrated in Fig. 5.1.

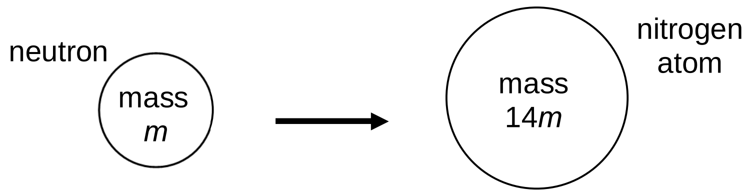


Fig. 5.1

The neutron is captured by the atom to form a heavy isotope of nitrogen of 15*m.*

(i) Explain the subsequent motion of the isotope given that the collision is head-on.

……………………………………………………………………………………………….

………………………………………………………………………………………………. [1]

(ii) Calculate the ratio of kinetic energy of the heavy isotope of nitrogen to the initial kinetic energy of the neutron.

ratio of kinetic energy = ………………………………. [3]

(iii) Hence or otherwise, explain whether the collision process whereby the neutron is captured is elastic or inelastic.

……………………………………………………………………………………………..……..

……………………………………………………………………………………………..… [2]

[Total: 8]

6 **(a)** A battery B, a variable resistor R and a uniform resistance wire PQ are connected in series, as shown in Fig. 6.1.

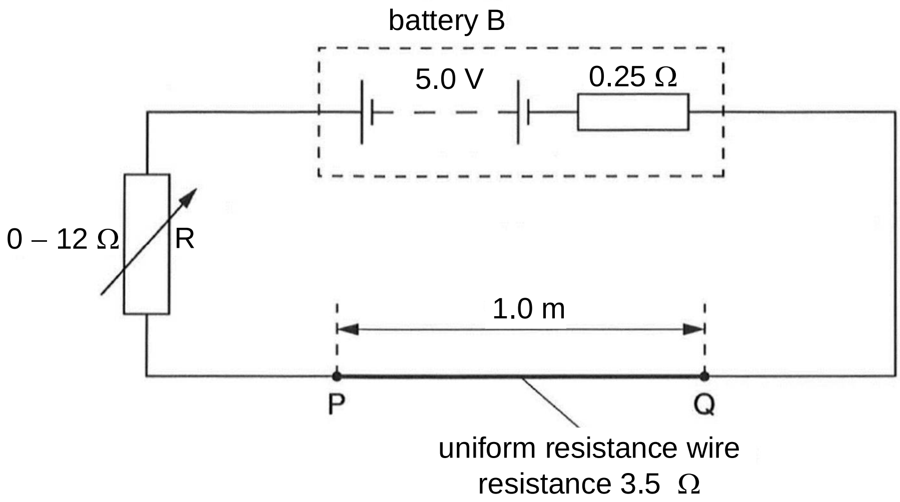


Fig. 6.1

Battery B has electromotive force (e.m.f.) 5.0 V and internal resistance 0.25 Ω.

Wire PQ has length 1.0 m and resistance 3.5 Ω.

(i) The resistance of R is slowly increased from 0 to 12 Ω.

Describe and explain the variation in the terminal potential difference (p.d.) across B. Numerical values are not required.

....

....

....

....[3]

The resistance of R is set to 4.0 Ω.

Calculate

(ii) the terminal p.d. across B,

p.d. = ………………………… V [3]

(iii) the efficiency of power transfer of B.

efficiency = ……………………….. % [2]

(c) A battery of electromotive force (e.m.f.) 4.5 V and negligible internal resistance is connected to two filament lamps X and Y and a resistor R', as shown in Fig. 6.2.

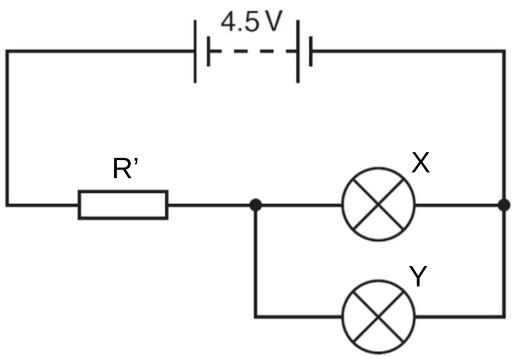


Fig. 6.2

The current in lamp X is 0.15 A. The I-V characteristics of the filament lamps are shown in Fig. 6.3.

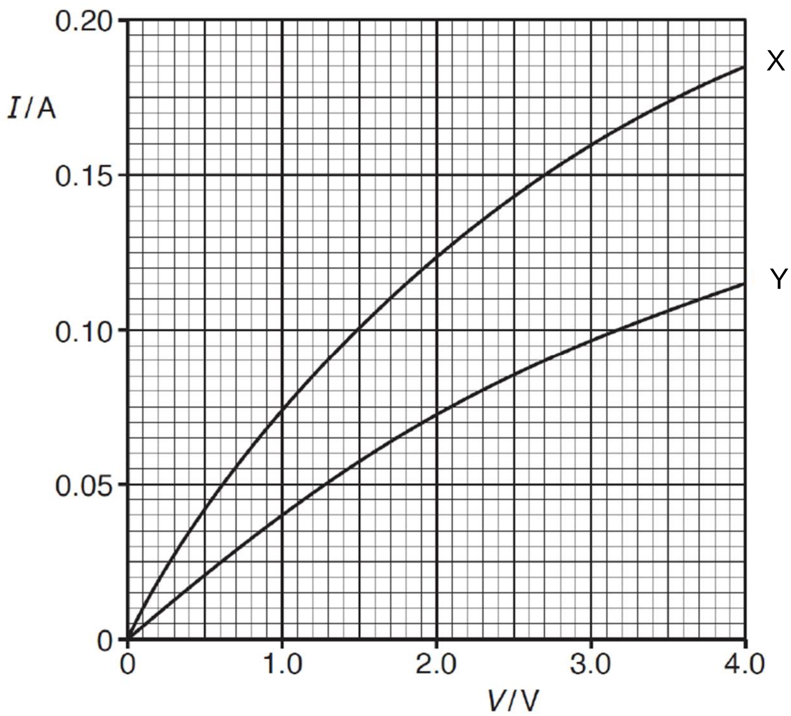


Fig. 6.3

(i) Use Fig. 6.3 to determine the current in the battery. Explain your working.

current = ……………………………….A [2]

(ii) Calculate the resistance of resistor R'.

resistance = ………………………..Ω [2]

(iii) The filament wires of the two lamps are made from material with the same resistivity at their operating temperature in the circuit. The diameter of the wire of lamp X is twice the diameter of the wire of lamp Y.

Determine the ratio $\dfrac{\text{length of filament wire of lamp X}}{\text{length of filament wire of lamp Y}}$.

ratio = ………………………………….. [2]

[Total: 14]

Section B

Answer **one** question from this section.

7 (a) A student measures the count rate C_1 of a freshly prepared sample of radioactive material at room temperature. The variation of C_1 with time t is shown in Fig. 7.1.

An identical second sample of the radioactive material is then prepared. The student repeats the experiment when the initial count rate of the second sample is the same as the first sample, but this time with the second sample at a higher temperature. The variation with time t of the count rate C_2 for the second sample is shown in Fig. 7.2.

The trend lines for both graphs are also shown in Fig. 7.1 and Fig. 7.2.

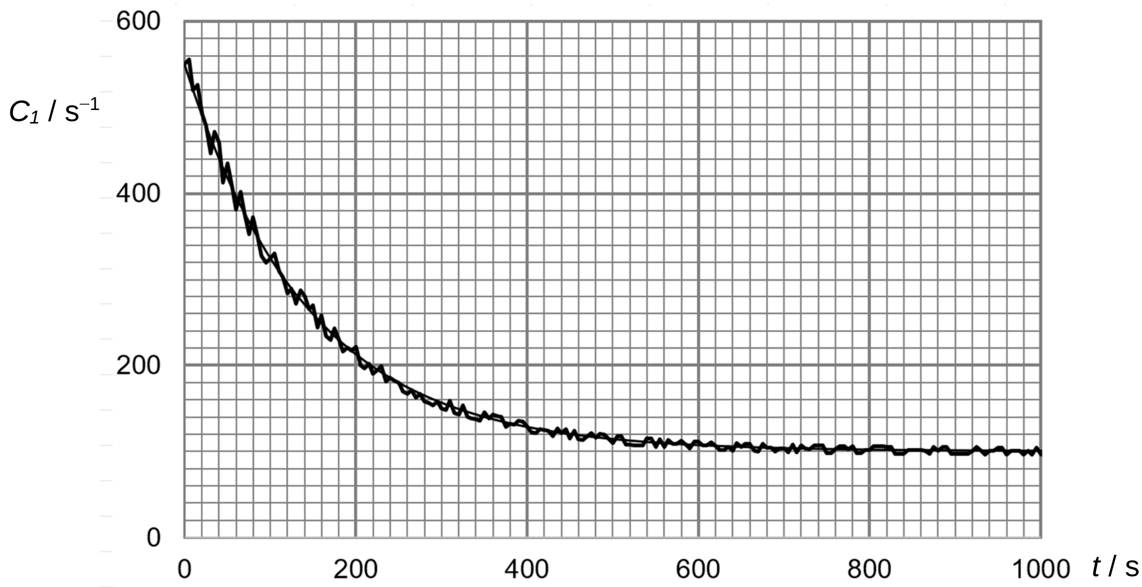


Fig. 7.1

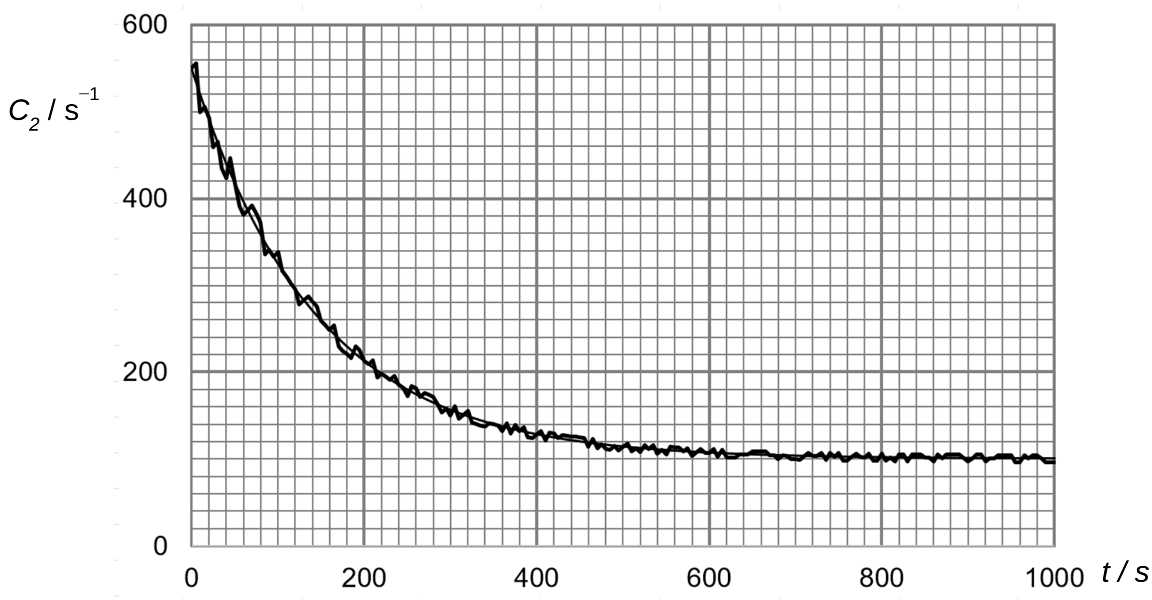


Fig. 7.2

Use Fig. 7.1 and Fig. 7.2 to answer the following questions.

(i) Compare the short-term and long-term variations in the count rates measured by the student. Hence, state and explain the evidence that is provided by these two experiments for

1. the *random* nature of radioactive decay,

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………[2]

2. the *spontaneous* nature of radioactive decay.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………[2]

(ii) Estimate a value for the background count rate.

background count rate = …………………….. s^{-1} [1]

(iii) Define *half-life* in radioactive decay.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………[1]

(iv) Determine the half-life of the radioactive material.

half-life = ………………………………….. [3]

(b) Fig. 7.3 shows the variation with nucleon number A of the binding energy (B.E.) per nucleon of nuclei.

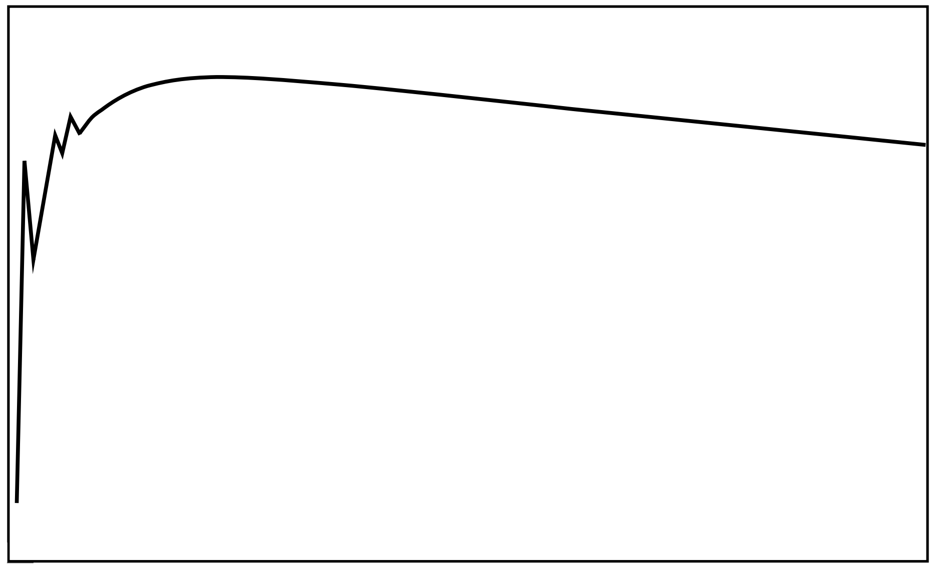


Fig. 7.3

(i) When uranium-235 absorbs a neutron, it can undergo fission to produce barium-141 and krypton-92. Complete the following nuclear equation that describe this process:

$${}^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{141}_{56}\text{Ba} + {}^{92}_{36}\text{Kr} + \ldots\ldots\ldots\ldots + \text{ energy released}$$

[1]

(ii) Explain what is meant by *nuclear fission*.

…………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

(iii) On Fig. 7.3, indicate the approximate positions of:

$^{235}_{92}U$ (marked with a cross × and labelled with the symbol U),
$^{141}_{56}Ba$ (marked with a cross × and labelled with the symbol Ba) and
$^{92}_{36}Kr$ (marked with a cross × and labelled with the symbol Kr). [1]

(iv) The neutron that is absorbed by the stationary uranium nucleus has negligible kinetic energy. Use your answer to **(b)(iii)** to explain why energy is released in the fission process.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………[2]

(v) Table 7.1 gives the values of the mass and binding energy (B.E.) per nucleon of some nuclei and particles.

Nucleus/ particle	mass / u	B.E. per nucleon / MeV
$^{235}_{92}U$	235.123	7.18
$^{141}_{56}Ba$	140.912	8.24
$^{92}_{36}Kr$	91.913	8.56
$^{1}_{1}p$	1.007	0
$^{1}_{0}n$	1.009	0

Table 7.1

Show that the binding energy per nucleon for $^{235}_{92}U$ is 7.18 MeV in Table 7.1.

[2]

(vi) The uranium nucleus is at rest before the fission process in **(b)(i)** occurs.

Using the data provided in Table 7.1, calculate the total energy released in this reaction.

energy released = ……………………………… J [2]

(vii) Suggest in what form(s) the energy released could appear as immediately after the fission reaction.

……………………………………………………………………………………………

……………………………………………………………………………………………[1]

(c) Prolonged exposure to ionising radiation can be dangerous. In addition to limiting the time of exposure and avoiding direct contact, suggest one other general principle that is followed when handling radioactive materials.

……………………………………………………………………………………………

……………………………………………………………………………………………[1]

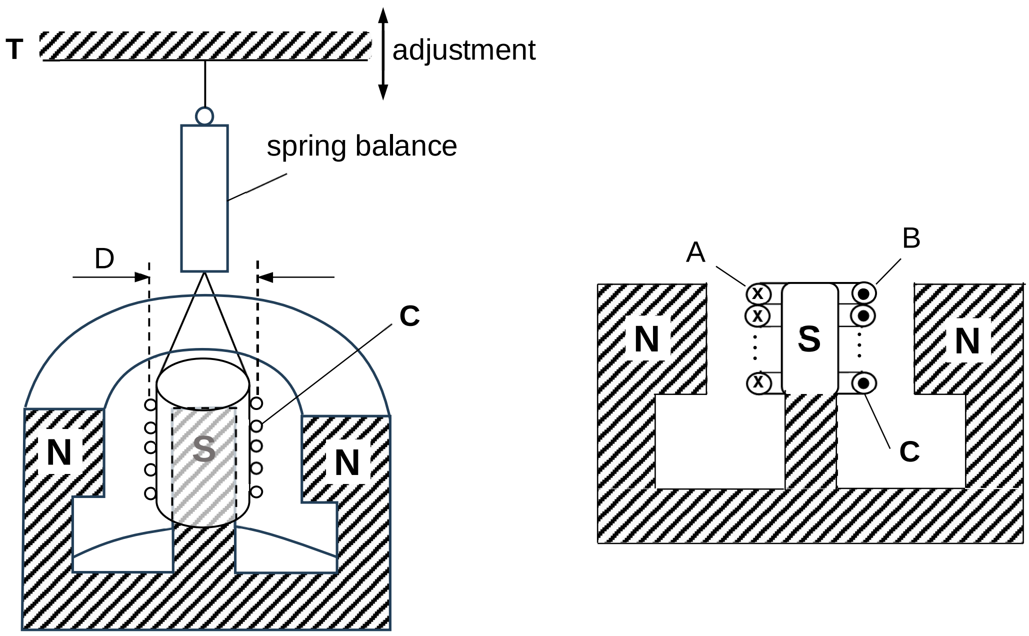
[Total:20]

8 **(a)** Define magnetic flux density.

....

....[1]

(b) Fig. 8.1 shows a loudspeaker magnet consisting of a circular north pole **N** and a cylindrical south pole **S**. Part **C** is a moving coil that coils around **S**, and it is attached to a spring balance, which is attached to an adjustable support **T**.



(a) section view

(b) side view

Fig. 8.1

Current was passed through the coil **C**, and the adjustable support **T** was then adjusted so that the coil **C** was restored to its original position. The readings *F* on the balance for various currents *I* are recorded below.

I / A	0.20	0.41	0.60	0.81
F / N	1.50	2.02	2.48	3.05

Table 8.1

(i) The direction of current flowing in the coil is indicated in Fig. 8.1(b). Draw two arrows, one each at positions A and B, to indicate the direction of the magnetic force acting on the coil. Explain your answer.

....

....

....

.... [3]

(ii) In Fig. 8.2, draw a graph using values from Table 8.1 to determine the force per unit current required to restore coil **C** to its original position**,** and find the zero error of the balance.

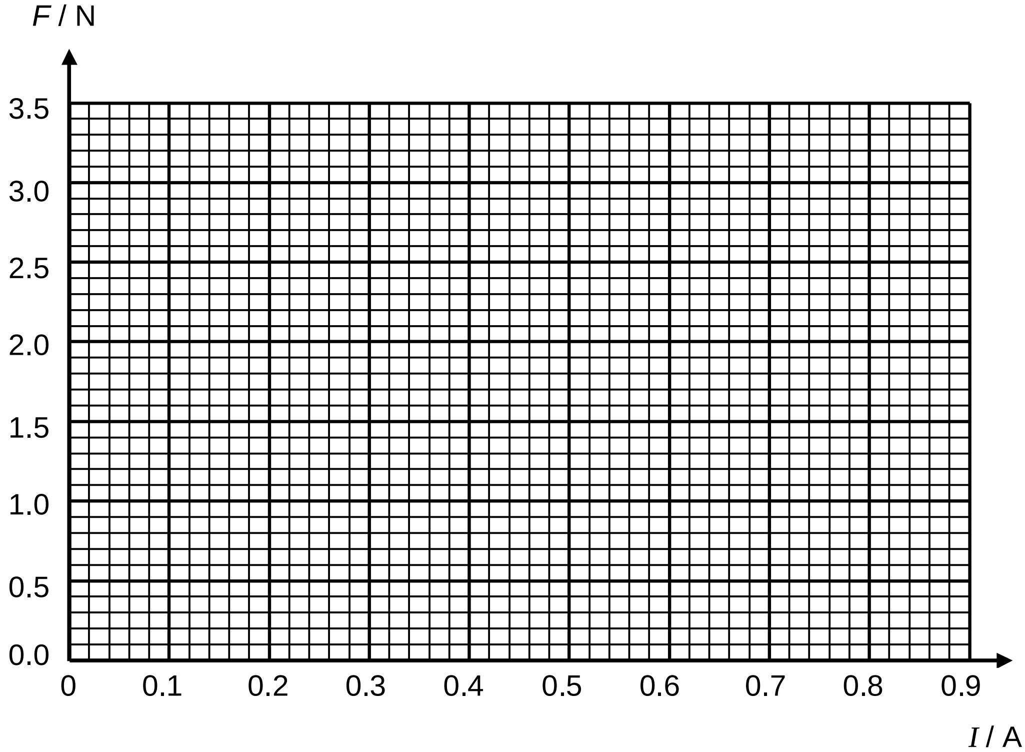


Fig. 8.2

force per unit current = ………………………….N A^{-1}

zero error of the balance = ……………………. N [4]

(iii) If the mean diameter, *D*, of the coil is 0.025 m and the number of turns is 50, calculate the flux density at the coil, assuming that the field is radial.

magnetic flux density= ……………………T [2]

(c) Fig. 8.3 shows the path of a beam of electrons before it passes through a magnetic field.

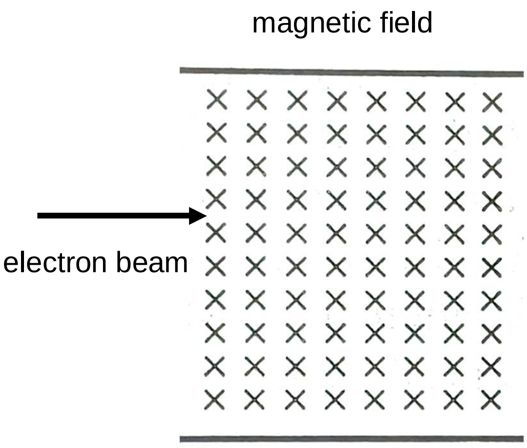


Fig. 8.3

The magnetic flux density in the uniform magnetic field is 0.0050 T. Each electron enters the magnetic field with a speed of $v = 5.0 \times 10^{6}$ m s^{-1}.

(i) The magnetic force causes the electrons to accelerate in the magnetic field. Explain whether the force does work on the electron.

………………………………………………………………………………………………

……………………………………………………………………………………………… [1]

(ii) Determine the magnetic force acting on the electron.

magnetic force = ……………………….N [2]

(iii) Show that the radius of the electrons' path is 5.7 mm.

[2]

(iv) If a proton beam is used instead and the protons travel at the same speed as the electrons, explain qualitatively why this setup may not be practical in a typical school laboratory.

……………………………..……………………………………………………………

…..……………………………………………………………………………………. [2]

(d) Another beam of electrons enters a uniform electric field between two parallel plates at right angles to the field as shown in Fig. 8.4. The region between the plates is a vacuum.

Each electron has mass *m*, charge *e* and speed *v*.

The length of the plates is *x*, the separation of the plates is *d* and the potential difference across the plates is *V*.

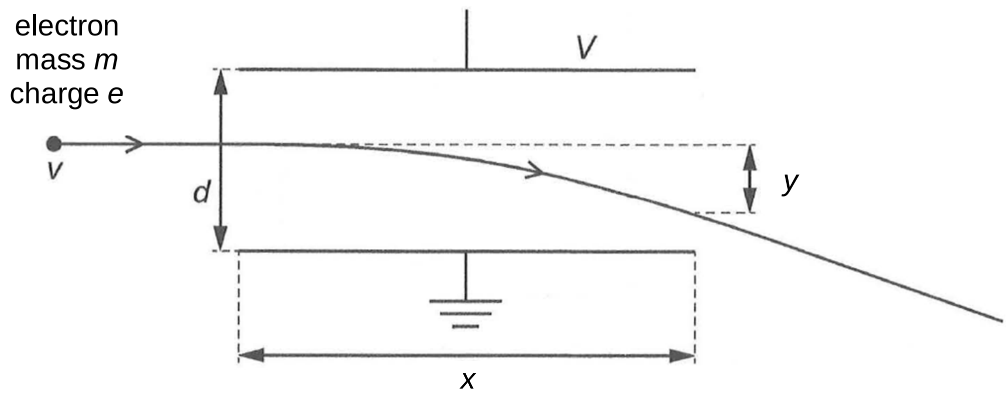


Fig 8.4

The vertical deflection of the electron is *y* at the point where it leaves the region between the plates.

Write down an equation for *y* in terms of *d*, *e*, *m*, *v*, *V,* and *x*. Show your working.

y =……………………………. [3]

[Total:20]