OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

PHYSICS A 2825/02

Health Physics

Thursday **26 JANUARY 2006** Morning 1 hour 30 minutes

Candidates answer on the question paper.
Additional materials:
Electronic calculator

Candidate Name	Centre Number	Candidate Number

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces provided on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is 90.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- The first seven questions concern Health Physics. The last question concerns general physics.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	13	
2	10	
3	8	
4	18	
5	8	
6	6	
7	7	
8	20	
TOTAL	90	

This question paper consists of 19 printed pages and 1 blank page.

Registered Charity Number: 1066969
[Turn over

Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
elementary charge,	$e = 1.60 \times 10^{-19}\ \mathrm{C}$
the Planck constant,	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$
molar gas constant,	$R = 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ \mathrm{N\,m^2\,kg^{-2}}$
acceleration of free fall,	$g = 9.81\ \mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion, $s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

refractive index, $n = \frac{1}{\sin C}$

capacitors in series, $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots$

capacitors in parallel, $C = C_1 + C_2 + \ldots$

capacitor discharge, $x = x_0 e^{-t/CR}$

pressure of an ideal gas, $p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$

radioactive decay, $x = x_0 e^{-\lambda t}$

$t_{\frac{1}{2}} = \frac{0.693}{\lambda}$

critical density of matter in the Universe, $\rho_0 = \frac{3H_0^2}{8\pi G}$

relativity factor, $= \sqrt{(1 - \frac{v^2}{c^2})}$

current, $I = nAve$

nuclear radius, $r = r_0 A^{1/3}$

sound intensity level, $= 10 \lg \left(\frac{I}{I_0}\right)$

[Turn over

For Examiner's Use

Answer **all** the questions.

1 **(a)** The threshold intensity of hearing I_o has a defined value.

(i) State the value of I_o.

I_o = ... W m^{-2} [1]

(ii) Explain the meaning of the threshold intensity of hearing.

.....

..... [2]

(b) A person with normal hearing is the subject of an experiment to measure their perception of the loudness of varying sounds. Fig. 1.1 is a graph showing a curve of **equal loudness** for this person.

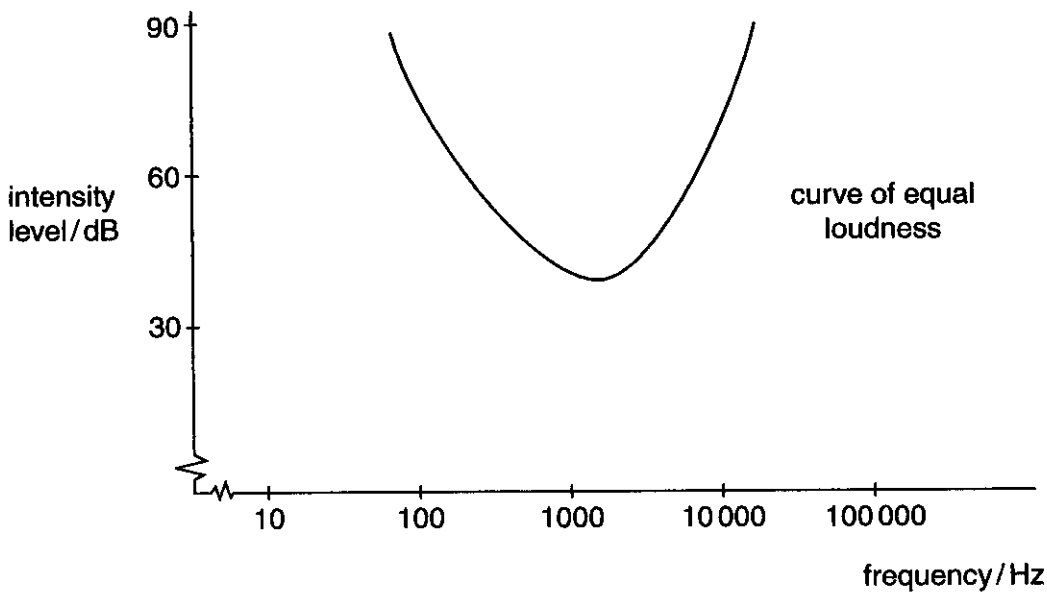

Fig. 1.1

(i) Explain the term *loudness*.

.....

..... [2]

(ii) Suggest what information may be deduced from the graph between frequencies of 100 and 10000 Hz.

.....

..... [2]

For Examiner's Use

(c) Fig. 1.2 shows data for the loudness L, perceived by a person and the corresponding intensity level for sounds of different intensities.

intensity, I / W m^{-2}	perceived loudness, L	intensity level / dB
2.0×10^{-12}	L	3.0
4.0×10^{-12}	$2L$	6.0
1.6×10^{-11}	$4L$	12
2.6×10^{-10}	$8L$	24
	$16L$	

Fig. 1.2

(i) Show that the intensity level at the ear of a sound of intensity 4.0×10^{-12} W m^{-2} is 6.0 dB.

[1]

(ii) State a value for the intensity level that corresponds to a sound of perceived loudness 16 L.

intensity level = ... dB [1]

(iii) Calculate the intensity associated with the intensity level stated in **(ii)**.

intensity = ... W m^{-2} [2]

(iv) Explain with reference to the data in Fig. 1.2, why the intensity level scale is useful *when describing sounds audible to the human ear.*

.....

.....

..... [2]

[Total: 13]

[Turn over

2 Two students are discussing typical values for forces exerted by muscles in the arm. One student suggests that in order to lift a 24 N load, a force of about 1000 N needs to be applied by the biceps muscle.

The other student comments that the design of the human body would be better if the lever systems in the body had mechanical advantages greater than 1. She argues that less effort would be needed by the muscles in such lever systems to do the same work as muscles in lever systems with a mechanical advantage less than 1.

Fig. 2.1 represents a forearm of weight 50 N, supporting a 24 N load. It also shows the distances of the lines of action of the forces from the pivot.

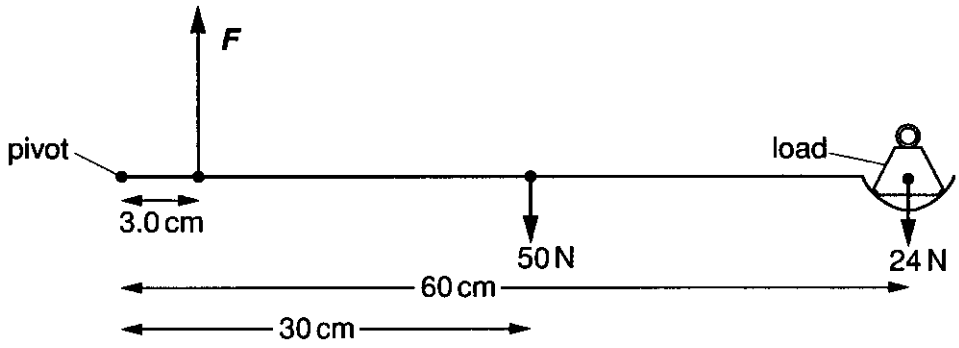

Fig. 2.1

(a) Use the data in Fig. 2.1 to show that the force ***F***, exerted by the biceps muscle in order to maintain the arm in equilibrium is about 1000 N.

[3]

For Examiner's Use

(b) Calculate the mechanical advantage of the forearm as shown in Fig. 2.1. Ignore the weight of the forearm.

mechanical advantage = ... [2]

(c) Explain, with reference to the work done by muscles in lever systems, why it would be disadvantageous for muscle and bone systems to have a mechanical advantage greater than 1.

.....

.....

.....

.....

.....

.....

.....

..... [5]

[Total: 10]

For Examiner's Use

3 Describe the use of a contrast medium, such as barium, in the imaging of internal body structures. Your answer should include

- how an image of an internal body structure is produced from an X-ray beam
- an explanation of the use of a contrast medium
- examples of the types of structure that can be imaged by this process.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [8]

[Total: 8]

4 **(a)** Fig. 4.1 shows objects at different distances from an eye. The eye is viewing object **O** but can simultaneously see objects **A** and **B** clearly.

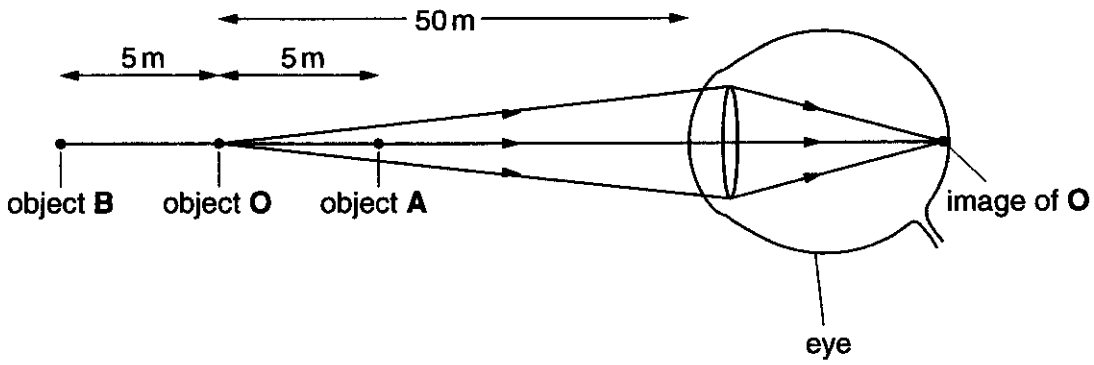

Fig. 4.1

(i) State the term used to describe the maximum separation of two objects that may both be viewed clearly and simultaneously.

..... [1]

(ii) For the optical system in Fig. 4.1, which is focused on object **O**, suggest where the image of object **B** might be found in focus.

..... [1]

(iii) Explain, with reference to the image of object **B**, why accommodation is unnecessary in order to view both object **A** and **B** clearly and simultaneously.

.....

..... [1]

(b) Outline the function of the ciliary muscles during accommodation and describe the resulting effect this has on the optical system of the eye.

.....

.....

.....

..... [2]

[Turn over

For Examiner's Use

(c) In order to determine the power of her spectacle lens, a student uses it to form a real image of a light bulb on a piece of paper placed on the ground.

Using this information, state

(i) one fact about the lens

..... [1]

(ii) the eye defect from which the student suffers.

..... [1]

The measurements made by the student are as follows.
distance between light bulb and lens = 200 cm
distance between image and lens = 100 cm

(iii) Calculate the focal length of the lens.

focal length = ... cm [3]

(iv) Calculate the power of the lens.

power = ... D [2]

For Examiner's Use

(d) The unaided eye of this student has a power of 59.0 D when viewing an object at infinity. When using her spectacle lens, the near point is 25 cm from her eye.

Calculate the distance of the near point for her unaided eye.

distance = ... cm [6]

[Total: 18]

[Turn over

5 Fig. 5.1 shows data for the intensity of a parallel beam of X-rays after penetration through varying thicknesses of a material.

intensity / MW m^{-2}	thickness / mm
0.91	0.40
0.69	0.80
0.52	1.20
0.40	1.60
0.30	2.00
0.23	2.40
0.17	2.80

Fig. 5.1

(a) On Fig. 5.2 plot a graph of transmitted X-ray intensity against thickness of absorber. [3]

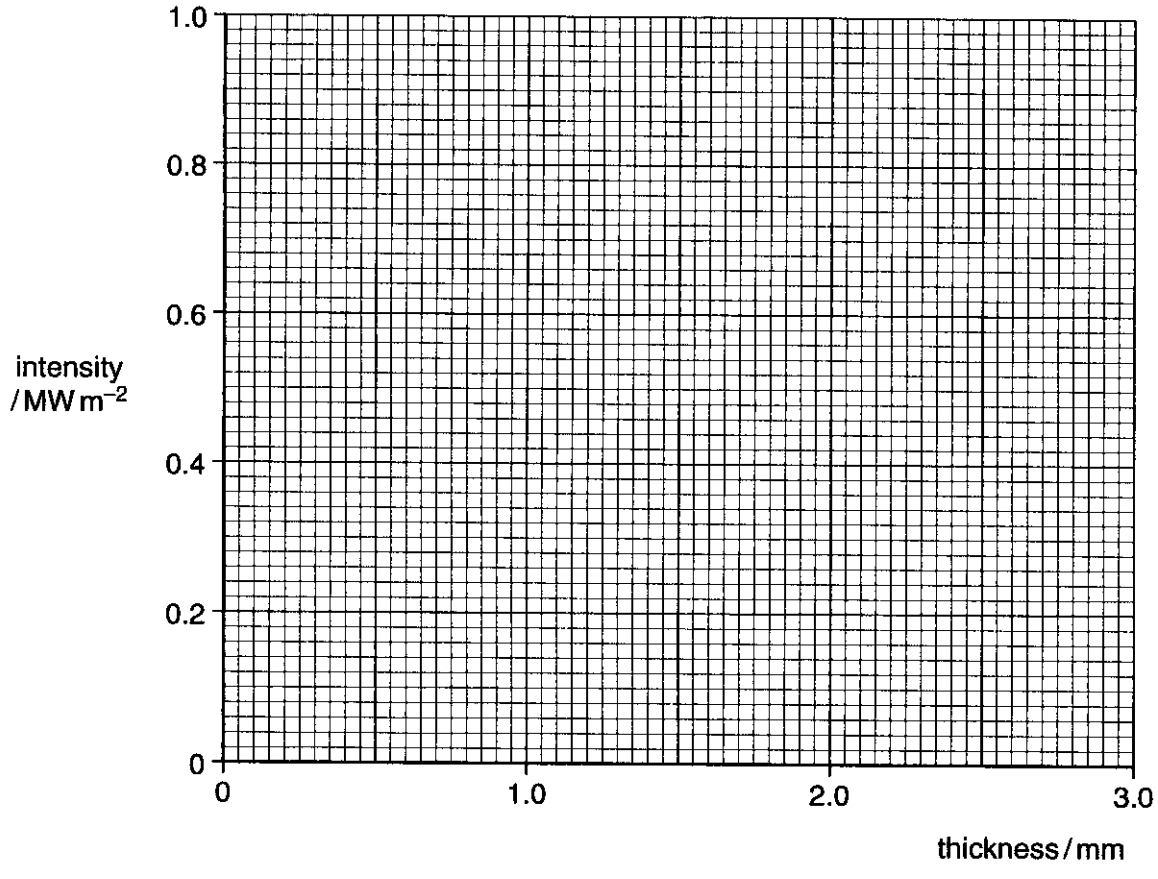

Fig. 5.2

(b) **(i)** Find the thickness that reduces the intensity of the incident beam by one half.

thickness = ... mm [1]

(ii) Use your answer to **(b)(i)** to calculate the linear attenuation coefficient μ. Give the unit for your answer.

μ = ... unit ..... [4]

[Total: 8]

6 Ionising radiation causes damage to biological tissue. Damage is not only dependent on the energy deposited per kg of tissue (the absorbed dose) but also on the distribution within the volume of tissue. The quantity *dose equivalent* takes both the absorbed dose and energy distribution into account.

(a) State how dose equivalent is related to absorbed dose. Define any symbols used.

.....

.....[1]

(b) With reference to the ionising properties of α–particles and β–particles, suggest why the same quantity of energy deposited per kg of tissue by α-particles causes more damage than if deposited by β–particles.

.....

.....

.....

.....[3]

[Turn over

For Examiner's Use

(c) In the UK, the annual dose equivalent of background radiation is about 6 mSv. The maximum permitted dose level (MPL) for a radiation worker is 20 mSv per year for the whole body.

A radiographer takes 20 X-rays of patients each day for 250 days of the year. The dose equivalent received by the radiographer for each X-ray is 1.0 μSv.

(i) Calculate the annual dose equivalent for the radiographer.

dose equivalent = ... Sv [1]

(ii) Comment on whether the dose received is within the MPL for a radiation worker.

.....

..... [1]

[Total: 6]

For Examiner's Use

7 Explain the use of optic fibres in endoscopes. Your answer should include

- the medical uses for which an endoscope is employed
- how light rays pass through optic fibres
- an explanation of the use of coherent and non-coherent bundles of optic fibres.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [7]

[Total: 7]

[Turn over

For Examiner's Use

8 This question is about the design and use of Christmas tree lights.

Design of bulbs

An engineer intends to design light bulbs for use in a set of Christmas tree lights to be powered by a 240V mains supply.

Each bulb, when operating normally, will use 0.50W and will have a filament 6.0mm long, made of tungsten.

resistivity of tungsten at normal working temperature = $1.1 \times 10^{-6}\,\Omega\,m$

(a) State **one** advantage of connecting these bulbs in parallel, rather than in series.

.....

.....

..... [1]

(b) Suppose the bulbs are connected in **parallel**. Calculate

(i) the current through each bulb

current = ... A [2]

(ii) the resistance of each bulb filament

resistance = ... Ω [2]

(iii) the radius of each bulb filament.

radius = ... m [3]

(iv) Hence suggest why these bulbs are impractical.

.....

.....

..... [1]

For Examiner's Use

Use of bulbs

A householder has two sets of Christmas tree lights.

Set A consists of 24 bulbs, each of resistance 200 Ω, connected in series.

Set B consists of 48 bulbs, each of resistance 50 Ω, connected in series.

All bulbs fail when their power dissipation reaches 0.75 W.

(c) **Set A** is connected to a 240 V mains supply. Fig. 8.1 shows the wiring of four of these bulbs.

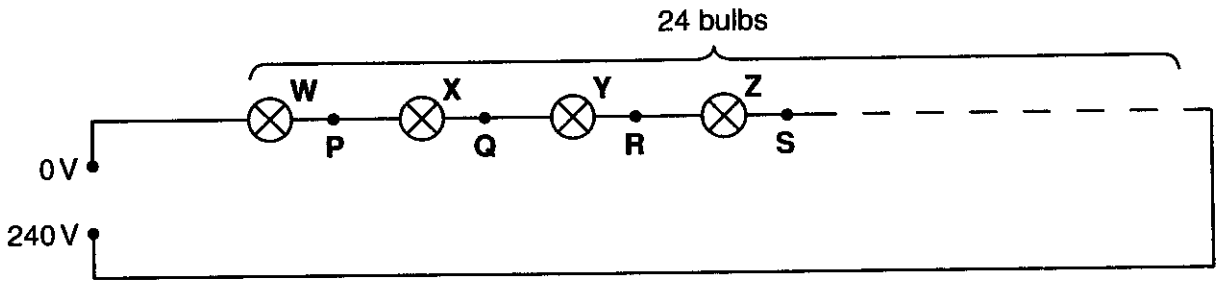

Fig. 8.1

During use, the filament of bulb **Y** fails and its resistance becomes infinite. In order to find which bulb has failed, the householder connects one terminal of a voltmeter to the 0 V terminal of the mains and notes the voltmeter reading when its other terminal is connected successively to points **P**, **Q**, **R** and **S**.
Enter in the table the voltmeter reading for each connection.
Explain your answer.

connection	reading / V
P	
Q	
R	
S	

.....

.....

.....

.....

.....

..... [4]

[Turn over

For Examiner's Use

(d) (i) The householder has no correct replacement bulbs for **Set A**. Each time a **Set A** bulb fails, it is replaced by a **Set B** bulb.
Explain why this is unsatisfactory and what will happen as more bulbs are replaced in this way.

.....

.....

.....

.....

.....

..... [3]

(ii) Calculate how many bulbs from **Set A** can be replaced by **Set B** bulbs before the system fails altogether.
Assume that the resistance of each bulb is independent of the current.

number = ... [4]

[Total: 20]

END OF QUESTION PAPER

BLANK PAGE