Rewarding Learning

Centre Number

71	

Candidate Number

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
January 2013

Physics

Assessment Unit AS 2

assessing

Module 2: Waves, Photons and Medical Physics

[AY121]

FRIDAY 18 JANUARY, MORNING

AY121

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 75.
Quality of written communication will be assessed in question **2**.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question.
Your attention is drawn to the Data and Formulae Sheet which is inside this question paper.
You may use an electronic calculator.

For Examiner's use only	
Question Number	Marks
1	
2	
3	
4	
5	
6	
7	
8	
Total Marks	

Examiner Only	
Marks	Remark

1 **(a)** List the seven regions of the electromagnetic (e.m.) spectrum, in order of **increasing** wavelength.

____

____

____

______________________ increasing wavelength ↓

____

____

______________________ [2]

(b) **(i)** One wavelength of waves used by satellite positioning systems is 190 mm.

In which region of the e.m. spectrum does this frequency lie?

____________________ [1]

(ii) Calculate the frequency of these waves when travelling in a vacuum.

Frequency = ____________________ MHz [2]

(c) **(i)** e.m. waves are classified as transverse in type.

Name an example of another transverse wave.

Transverse ____________________ [1]

(ii) Name an example of a longitudinal wave.

Longitudinal ____________________ [1]

(iii) Both types of wave are generated by vibration. Describe the difference in the **nature** of the vibration in a medium through which each passes.

____

____ [2]

BLANK PAGE

(Questions continue overleaf)

2 (a) Describe an experiment to verify Snell's Law.

Your description should include:

1. a labelled diagram showing the arrangement of the apparatus used.
2. the procedure used to obtain the values for the angles of incidence and refraction required.
3. an explanation of how the results obtained should be used to verify Snell's Law.

1. Labelled diagram.

[2]

2. Procedure.

____

____

____

____

____

____

____

____ [3]

3. Explanation.

____

____

____ [2]

Quality of written communication [2]

Examiner Only	
Marks	Remark

(b) A ray of light travels from air into a liquid of refractive index 1.41.

The angle of incidence is 58°. Calculate the angle of deviation, *x*°, of the light ray in the liquid as shown in **Fig. 2.1**.

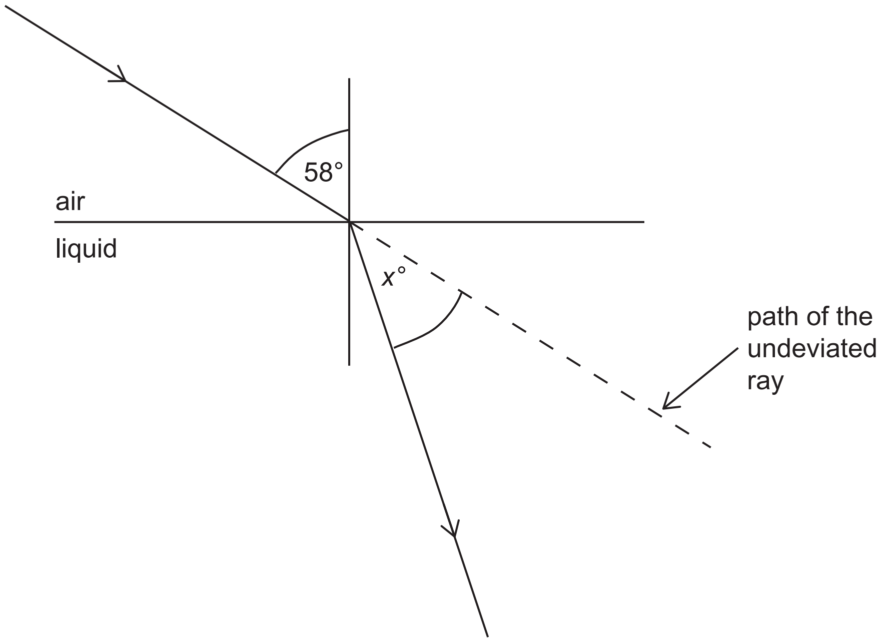

Fig. 2.1

Angle of deviation = __________ °   [2]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

3 (a) **Fig. 3.1** shows an object OA placed on the principal axis of a lens. An **upright**, **diminished**, **virtual image** of this object is produced by the lens.

On **Fig. 3.1** draw and label a suitable lens to produce this image.

Mark clearly the focal points of the lens and draw two rays from the point A of the object to locate the image. Label the image IB. Indicate the position of the eye to view the image.

Fig. 3.1

[5]

(b) (i) Complete **Fig. 3.2** to illustrate how rays from the normal least distance of distinct vision (25 cm) would be refracted by the eye if the person is long sighted.

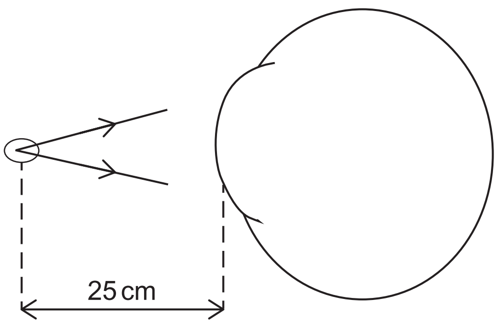

Fig. 3.2

[1]

(ii) Complete **Fig. 3.3** below by adding a suitable lens and completing the paths of the rays to illustrate how this defect may be corrected.

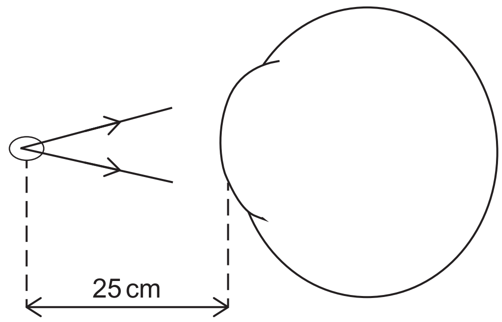

Fig. 3.3

[2]

(iii) A person suffering from long sight can only see objects clearly over a range of distances from 40.0 cm to infinity from his eyes.

Calculate the focal length of the lens needed to correct the least distance of distinct vision to 25.0 cm.

Focal length = ____________________ cm [2]

(iv) Calculate the power of this correcting lens.

Power = ____________________ D [1]

Examiner Only	
Marks	Remark

4 **(a)** **(i)** Explain what is meant by a standing wave in terms of energy.

____

____ [1]

(ii) What conditions are needed to produce a standing wave?

____

____ [2]

(iii) Name the physical principle applied to explain the formation of a stationary wave.

______________________________ [1]

(b) **(i)** A loudspeaker, connected to a signal generator, is placed close to the open end of a resonance tube closed at the opposite end. The frequency of the signal generator is adjusted so that the first two positions of resonance are obtained. On **Fig. 4.1** and **Fig. 4.2** draw representations of the modes of vibration at these positions of resonance, and label all nodes (N) and antinodes (A).

Fig. 4.1 (first mode of vibration)

[1]

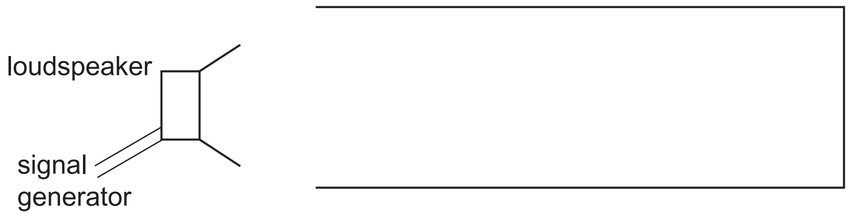

Fig. 4.2 (second mode of vibration)

[2]

(ii) If the tube is 0.30 m long, calculate the frequencies of the notes needed to produce these first two positions of resonance. Assume the velocity of sound is 340 $m s^{-1}$.

Examiner Only	
Marks	Remark

Frequency of first mode = ____________________ Hz [1]

Frequency of second mode = ____________________ Hz [1]

5 (a) The intensity of the sound from a car alarm is measured at a certain distance from the car and found to be $2.5 \times 10^{-3}\ \mathrm{W\,m^{-2}}$.

Examiner Only	
Marks	Remark

(i) Calculate the sound intensity level at this distance from the car. ($I_0 = 1.0 \times 10^{-12}\ \mathrm{W\,m^{-2}}$)

Sound intensity level = ____________________ dB [3]

(ii) To comply with the local sound pollution regulations at this distance the sound output from the alarm needs to be reduced by 4 dB. Calculate the new intensity of the sound from the car alarm measured at the same distance, that complies with the regulations.

Sound intensity = ____________________ $\mathrm{W\,m^{-2}}$ [2]

Examiner Only	
Marks	Remark

(b) **Fig. 5.1** shows the frequency response of the human ear.

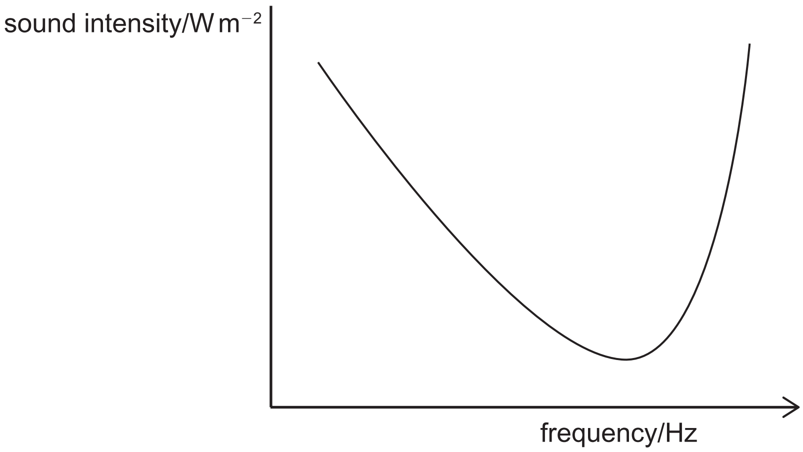

Fig. 5.1

(i) On **Fig. 5.1** mark clearly with an X the position on the curve of the threshold of hearing with a sound intensity of 1.0×10^{-12} W m^{-2}. [1]

(ii) State the approximate frequency of sound at this threshold of hearing.

Frequency = ____________________ Hz [1]

(iii) The ability to distinguish between frequencies varies and is best between 60 Hz and 1 kHz. What frequency difference can be distinguished in this range?

____________________ Hz [1]

(iv) State the frequency range detectable by an average human ear.

From __________________ Hz to __________________ Hz. [1]

Examiner Only	
Marks	Remark

6 **(a)** A medical flexible endoscope contains two bundles of optical fibres and several other channels.

(i) State the function of the two optical fibre bundles

Bundle 1: ______________________________

Bundle 2: ______________________________ [1]

Explain clearly how the arrangement of fibres in the two bundles differs.

____

____

______________________________ [2]

(ii) State a possible function of one of the other channels.

______________________________ [1]

(iii) A thin optical fibre used in an endoscope is 1.45 m long. If the refractive index of the fibre is 1.53 calculate the minimum time taken for a pulse of monochromatic light to pass from one end of the fibre to the other end.

The refractive index is the ratio of the speed of light in one medium to another medium. In this case light travels 1.53 times faster in air compared to its speed in the optical fibre.

Time taken ____________ s [2]

(b) (i) One of the main components of an MRI scanner is the scanner magnet. How is the magnetic field of the scanner created?

____

____ [1]

(ii) Which recent technological advance has vastly reduced the cost of producing this magnetic field?

____

____ [1]

(iii) Outline **one** advantage of MRI compared to CT scanning.

____

____ [1]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

7 (a) The energy of a photon depends on its frequency and wavelength.

Sketch a graph in **Fig 7.1** to show how the energy of a photon is related to its wavelength.

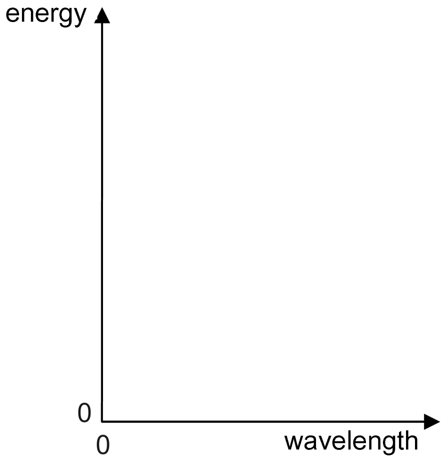

Fig 7.1

[1]

(b) (i) What is meant by the **work function** of a metal?

____

____

____ [1]

(ii) The work function of a certain metal is 2.40 eV. What is the maximum wavelength of light which will cause the emission of photoelectrons from this metal?

Give the answer in nanometres.

Wavelength = ____________________ nm [4]

(c) **Fig. 7.2** is a simplified energy level diagram for the hydrogen atom.

Examiner Only	
Marks	Remark

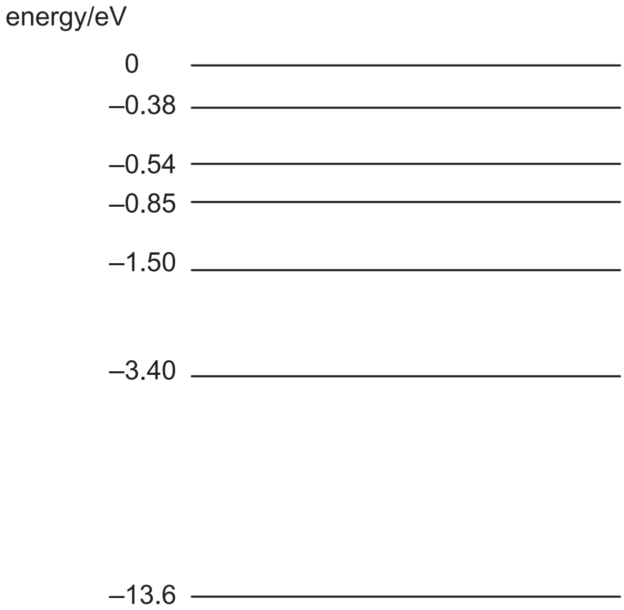

Fig. 7.2

One wavelength in the visible emission spectrum of hydrogen was measured as 488 nm with an associated photon energy of 2.55 eV.

(i) Identify the energy levels between which an electron transition would result in the *emission* of a photon of this energy.

Transition between ___________ eV and ___________ eV. [1]

(ii) On **Fig.7.2** mark the transition using a line with an arrowhead to indicate the direction of the transition. [1]

8 The wave properties of electrons can be demonstrated using electron diffraction.

(a) (i) Describe the arrangement used to show electron diffraction.

____

____

____ [2]

(ii) Sketch the diffraction pattern obtained in the above experiment.

[1]

(iii) Describe and explain why the observed pattern changes as the velocity of the electrons is increased.

____

____

____ [2]

Examiner Only	
Marks	Remark

(b) Electrons are accelerated in a vacuum through a potential difference which causes them to acquire a kinetic energy of 4.00×10^{-17} J.

Examiner Only	
Marks	Remark

(i) Calculate the resultant velocity of the electrons.

Velocity = ____________________ $m\,s^{-1}$ [2]

(ii) Hence find the associated wavelength of these electrons.

Wavelength = ____________________ m [2]

THIS IS THE END OF THE QUESTION PAPER

113606

GCE (Advanced Subsidiary) Physics

Data and Formulae Sheet

Values of constants

speed of light in a vacuum	$c = 3.00 \times 10^{8}$ m s^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
acceleration of free fall on the Earth's surface	$g = 9.81$ m s^{-2}
electron volt	1 eV $= 1.60 \times 10^{-19}$ J

Useful formulae

The following equations may be useful in answering some of the questions in the examination:

Mechanics

Conservation of energy	$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = Fs$ for a constant force
Hooke's Law	$F = kx$ (spring constant k)

Sound

Sound intensity level/dB	$= 10 \lg_{10} \frac{I}{I_0}$

Waves

Two-source interference	$\lambda = \frac{ay}{d}$

Light

Lens formula	$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$
Magnification	$m = \frac{v}{u}$

Electricity

Terminal potential difference	$V = E - Ir$ (e.m.f. E; Internal Resistance r)
Potential divider	$V_{out} = \frac{R_1 V_{in}}{R_1 + R_2}$

Particles and photons

de Broglie formula	$\lambda = \frac{h}{p}$