Q1. (a) State the changes which occur in a normal eye when

(i) the eye changes from focussing on a distant object to focussing on a near object, both objects being viewed in bright light

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(2)

(ii) the eye changes from viewing an object in very dim light to viewing the same object in bright light.

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(2)

(b) State **two** differences in the perceived image of a coloured object viewed in bright white light compared to the perceived image of the same object viewed in very dim white light.

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(2)

(c) (i) A patient's eye is astigmatic. State the effect of astigmatism on the image produced by the defective eye.

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(1)

(ii) State the usual cause of astigmatism.

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(1)

(iii) State the shape of lens used to correct astigmatism.

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(1)
(Total 9 marks)

Q2. (a) A sound source of constant output power is used to generate a sound which is measured using a sound meter. When set to the dB scale, the sound meter displayed 60 dB as the reading when the frequency of the sound was 1 kHz.

(i) State and explain what the reading would be for a sound of frequency 1 kHz if the meter was changed to the dBA scale.

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(1)

(ii) State and explain what would happen to the reading on **each** scale if the frequency of the sound was changed to 500 Hz.

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(2)

(b) A drill is operated in an otherwise silent room. The drill produces sound of power 2.0 W which is given out equally in all directions. A sound meter is placed 5.0 m from the drill and is set to the dB scale.
Calculate the reading on the sound meter.

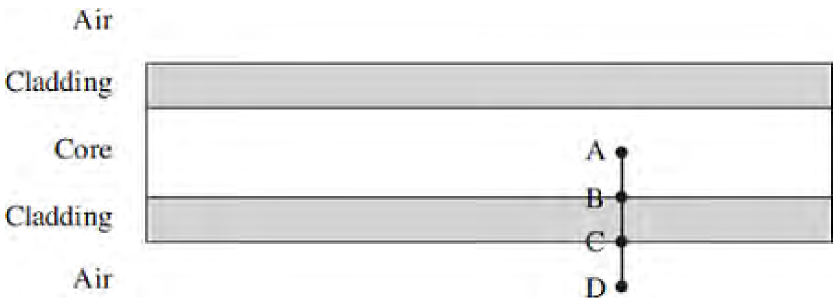
$I_0 = 1.0 \times 10^{-12}$ Wm^{-2}

answer = ... dB

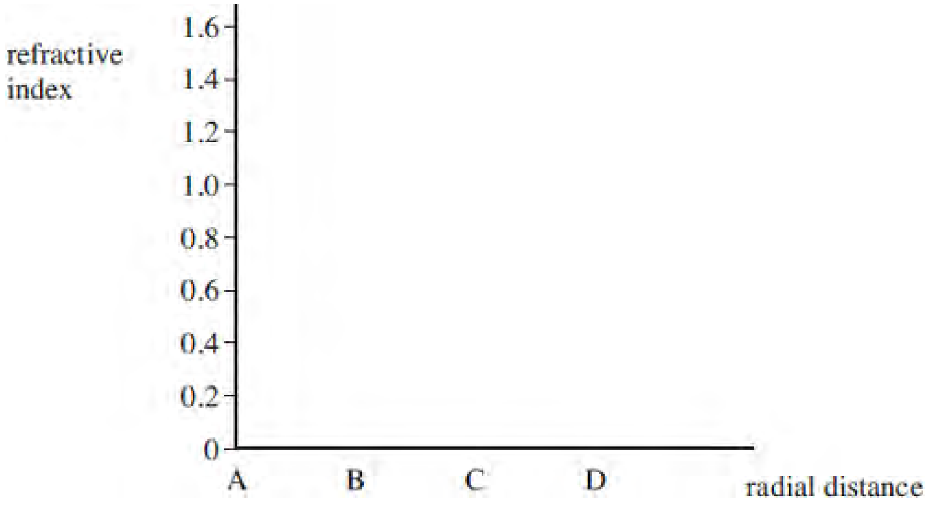
(3)

(Total 6 marks)

Q3. (a) The figure below shows the cross-section through a clad optical fibre which has a core of refractive index 1.50.



Complete the graph below to show how the refractive index changes with the radial distance along the line ABCD in the figure above.



(3)

(b) In the optical system of a flexible endoscope there are two types of fibre bundles, coherent and non-coherent. Explain the purpose of each of these two types of bundle.

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(2)
(Total 5 marks)

Q4. (a) Explain how and why ultrasound is used to obtain an image of an unborn foetus. You might consider the following points in your answer

- the method of obtaining the image
- practical considerations for the scan
- safety issues.

The quality of your written communication will be assessed in this question.

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(6)

(b) Explain why the pulses of ultrasound used in medical imaging must be of short duration.

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(2)
(Total 8 marks)

Q5. (a) In an X-ray tube, electrons are accelerated from rest through a pd of 72.4 kV before they hit the target anode.

(i) Calculate the kinetic energy of an electron as it reaches the anode. Give your answer to an appropriate number of significant figures.

answer = ... J

(2)

(ii) Assuming that the electron gives up all this energy to form an X-ray photon, calculate the wavelength of the photon.

answer = ... m

(2)

(b) X-rays are used in a CT scanner. Describe briefly how a CT scanner produces an image.

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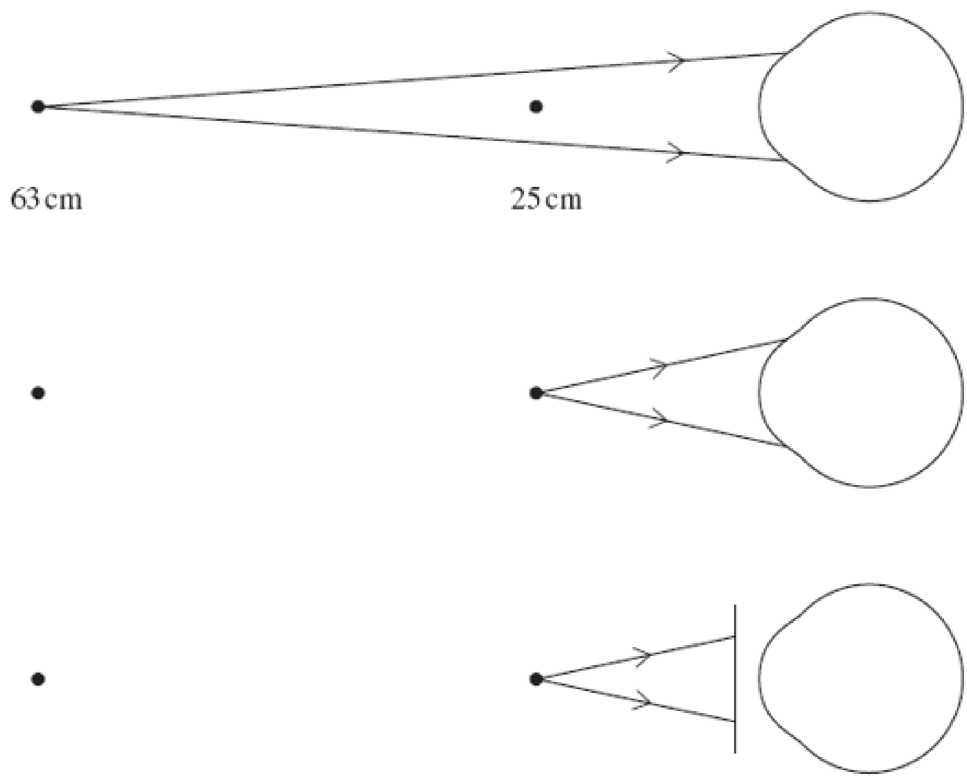
(3)
(Total 7 marks)

Q6. (a) A person suffering from long sight has an unaided near point 63 cm from the eye. The figure below shows three diagrams not drawn to scale. The first two diagrams show rays incident on the unaided eye. The third diagram shows rays incident on the correcting lens which will allow the person to have an aided near point 25 cm from the eye. Complete the diagrams to show the passage of the rays to the retina. You may assume that for the eye there is only a single refraction at the cornea of the eye.



(2)

(b) Calculate the focal length of the correcting lens, stating the answer to the appropriate number of significant figures.

answer = ... m

(3)

(c) Explain what is meant by persistence of vision and state a practical situation where it is important.

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(2)
(Total 7 marks)

Q7. (a) Define the threshold of hearing, I_0.

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(2)

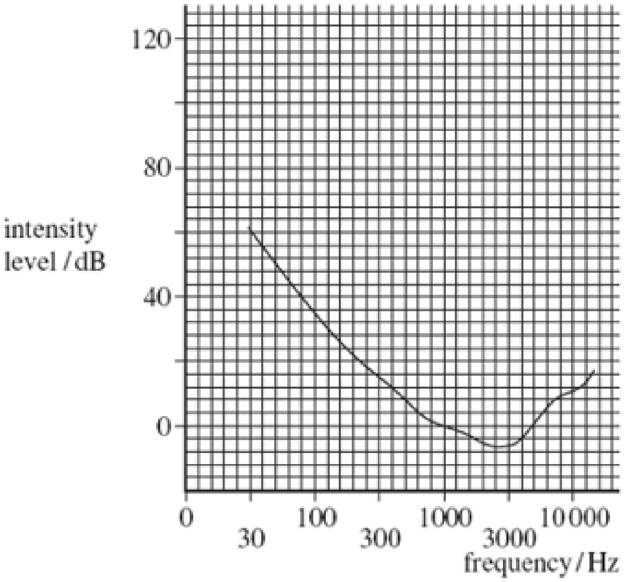
(b) A hearing test was used to obtain threshold hearing audiograms for several people. The audiogram shown in the figure below was obtained for a person with normal hearing.

On the same axes:

(i) sketch a curve, labelled **A**, for a person suffering hearing loss due to old age

(1)

(ii) sketch a curve, labelled **B**, for a person suffering hearing loss due to excessive noise.



(2)
(Total 5 marks)

Q8. An endoscope contains two bundles of optical fibres.

(a) Name the two bundles. For each bundle state clearly the arrangement of the fibres and explain its purpose in the operation of the endoscope.

Bundle 1 ....

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Bundle 2 ....

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(4)

(b) Each fibre has a core surrounded by cladding. Calculate the critical angle at the core – cladding interface of a fibre.

refractive index of core = 1.60

refractive index of cladding = 1.55

answer = ... degree

(1)

(Total 5 marks)

Q9. (a) An ECG trace is to be obtained for a patient. State and explain the procedure and some design features of the equipment needed to ensure a good trace is obtained.

The quality of your written communication will be assessed in this question.

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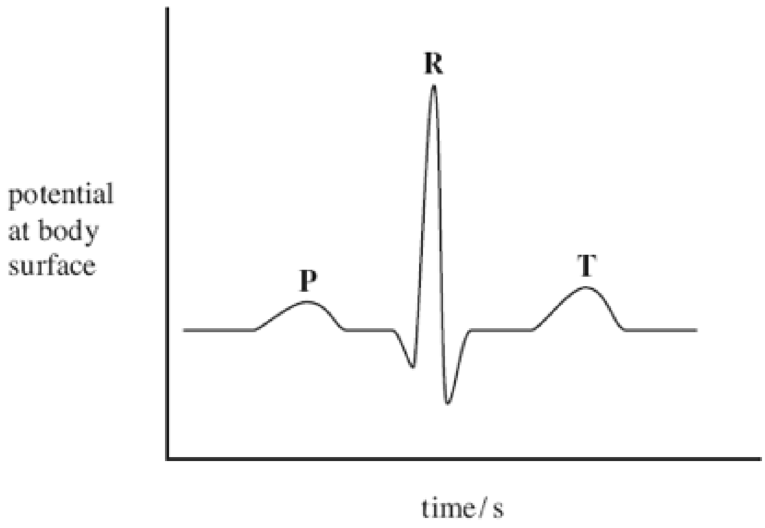
(6)

(b) The figure below shows an ECG trace for a healthy person.



(i) Add a suitable scale and unit to the potential axis.

(2)

(ii) Add a suitable scale to the time axis.

(1)

(iii) State the electrical events which give rise to the points:

P ....

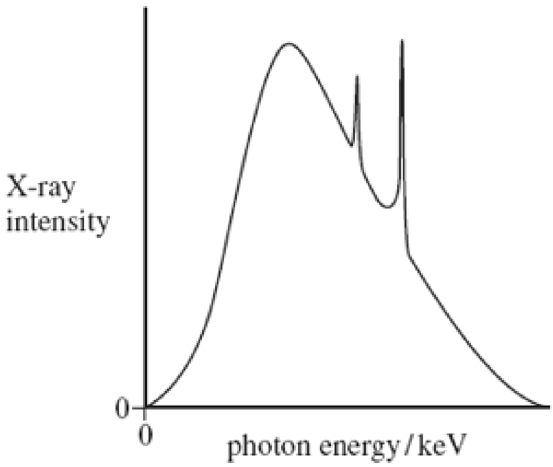
R ....

T ....

(3)
(Total 12 marks)

Q10. (a) The X-ray spectrum for a certain X-ray tube target is shown in **Figure 1**. Explain the process which gives rise to spikes at certain photon energies.

Figure 1



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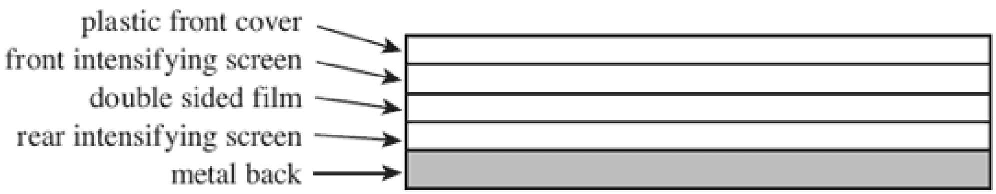
(3)

(b) A film cassette, placed under a patient being X-rayed, is shown in **Figure 2**.

Figure 2



Explain how the intensifying screens in the film cassette achieve their purpose and state their benefit to the patient.

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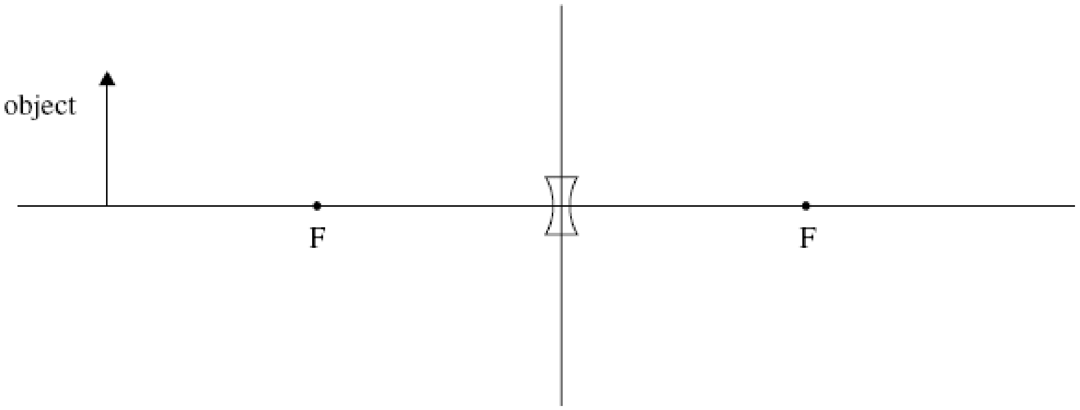
(3)
(Total 6 marks)

Q11. (a) Complete the ray diagram to show the formation of the image of a real object by a diverging lens.



(2)

(b) Define the power of a lens.

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(1)

(c) A lens of focal length –0.56 m is used to correct a defect of vision of an eye.

(i) Name this defect of vision.

....

(1)

(ii) The defective eye has an unaided near point at 0.15 m from the eye.
Calculate the aided near point distance, giving your answer to an appropriate number of significant figures.

answer = ... m

(3)

(d) Another person was found to suffer from astigmatism. State the format of the prescription to correct this defect.

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(1)
(Total 8 marks)

Q12. (a) (i) Describe how the vibrations of a sound wave are received by the outer ear and transmitted to the inner ear.

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(3)

(ii) Explain how the pressure changes due to the sound wave are amplified by the ear.

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(2)

(b) An intensity meter, set to the dB scale, measures the intensity level of a sound as 46 dB. Calculate the intensity of the sound at the meter, giving an appropriate unit.

answer = ...

(3)

(c) The scale on the intensity meter is changed to the dBA scale and the new reading, for the same sound, is found to be 50 dBA. Explain this change.

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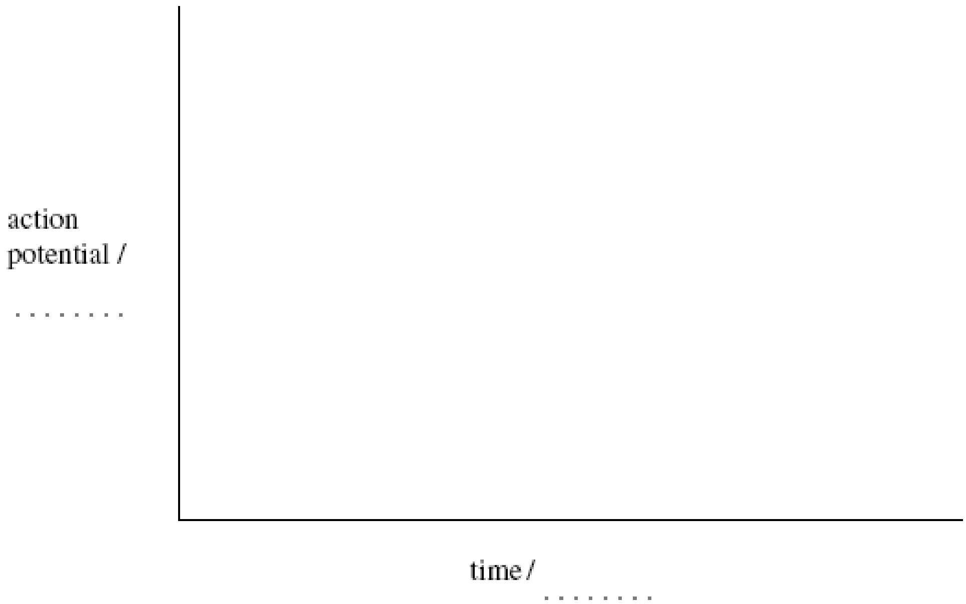
(2)
(Total 10 marks)

Q13. (a) On the axes below, sketch the action potential of a nerve cell. Indicate units and scales on both axes.



(3)

(b) Explain in terms of ion movement, starting at resting potential, how bioelectrical signals are produced in muscle fibres.
The quality of your written answer will be assessed in this question.

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(7)
(Total 10 marks)

Q14. (a) Outline the basic principles of a magnetic resonance (MR) scanner used to scan a patient's brain.

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(3)

(b) State and explain **two** advantages of using an **MR** scanner to scan a patient's brain compared with a CT scanner.

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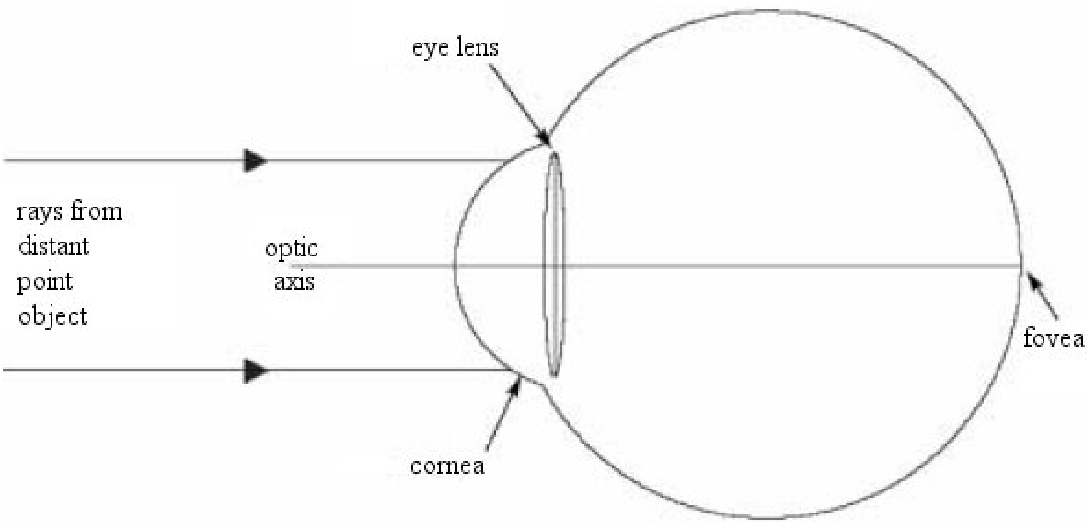
(4)
(Total 7 marks)

Q15. The diagram represents a simplified version of a normal eye, with no sight defects, looking at a distant point object.

Complete the paths of the two rays.



(2)

(b) Describe the distribution of receptors over the retina.

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(2)

(c) (i) State the purpose of the iris.

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(ii) Describe how this purpose is achieved when the eye is exposed to bright light.

....

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(2)

(d) (i) State what is meant by *accommodation*.

....

....

(ii) Describe how accommodation is achieved.

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(2)
(Total 8 marks)

Q16. Electrodes are attached to the chest of a healthy person and a normal ECG waveform is obtained.

(a) State **two** ways of ensuring good electrical contact between the electrodes and the person.

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(2)

(b) State **two** properties of the amplifier needed to amplify the signal from the electrodes.

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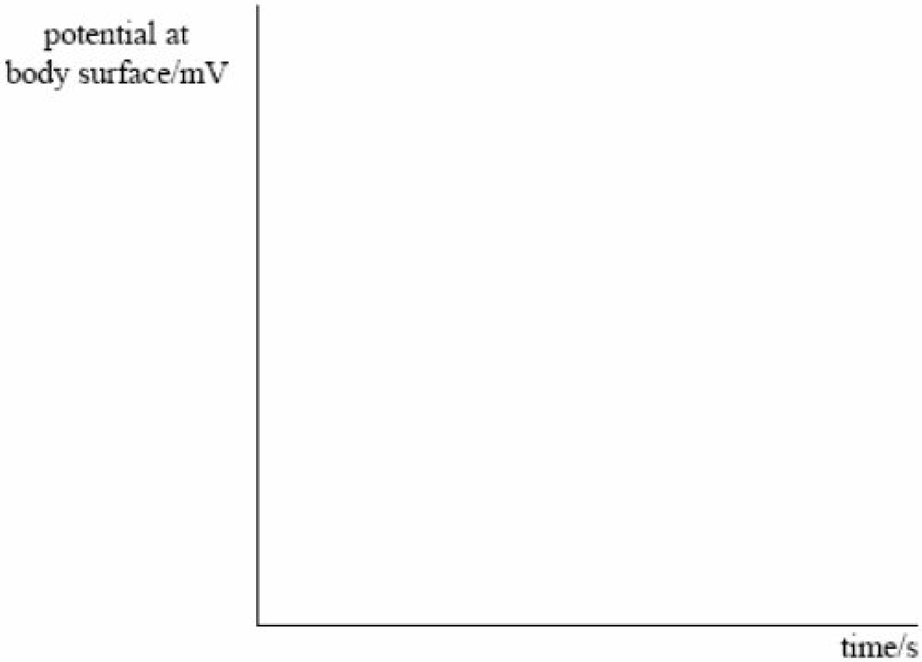
(2)

(c) Sketch, on the axes below, the waveform that you would expect to obtain. Label the axes with appropriate scales.



Mark on the waveform where the following occur:

(i) atrial depolarisation

(ii) ventricular depolarisation

(iii) ventricular repolarisation

(5)
(Total 9 marks)

Q17. (a) State the frequency of sound at which the normal ear is most sensitive.

....

(1)

(b) State the main features of hearing loss in terms of frequency response for

(i) age related hearing loss,

....

....

(ii) noise related hearing loss.

....

....

(2)

(c) At the site of a machine in a factory, a sound meter was used to measure the sound level. The relative intensity level with the machine operating was 86 dB. The sound intensity reaching the meter when the machine was not operating was 7.0×10^{-5} Wm^{-2}.

(i) Show that with the machine operating, the sound intensity reaching the meter was about 4×10^{-4} Wm^{-2}.

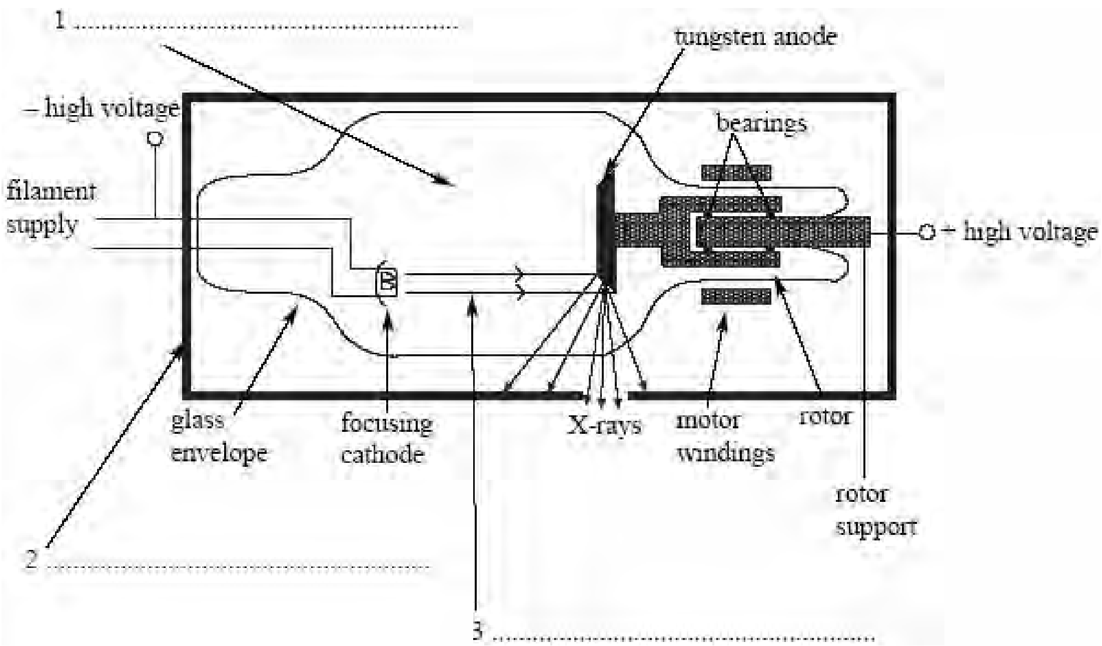
(ii) Calculate the relative intensity level due to the machine alone.

Relative intensity level = ...

(4)

(Total 7 marks)

Q18. (a) The diagram shows a rotating-anode X-ray tube. Complete the labelling of the **three** numbered arrows in the diagram.



(3)

(b) Explain why the anode

(i) is rotated,

....

....

....

(ii) has a bevelled edge.

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(3)

(c) Define for a material,

(i) the linear attenuation coefficient, μ,

....

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(ii) the half thickness.

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(2)

(d) A monochromatic X-ray beam of intensity 6.0 Wm^{-2} is incident on an aluminium sheet of thickness 2.0 mm. For these X-rays, the half-value thickness of aluminium is 3.2 mm. Calculate the intensity of the transmitted beam.

Intensity = ...

(3)
(Total 11 marks)

Q19. (a) State and explain **two** physical properties of the light produced by a laser which makes it different from the light produced by a filament lamp.

property 1..

....

....

property 2..

....

....

(3)

(b) An endoscope may use light from a filament lamp and light from a laser.

State

(i) the use of the light from a filament lamp,

....

....

....

(ii) a use of the light from a laser.

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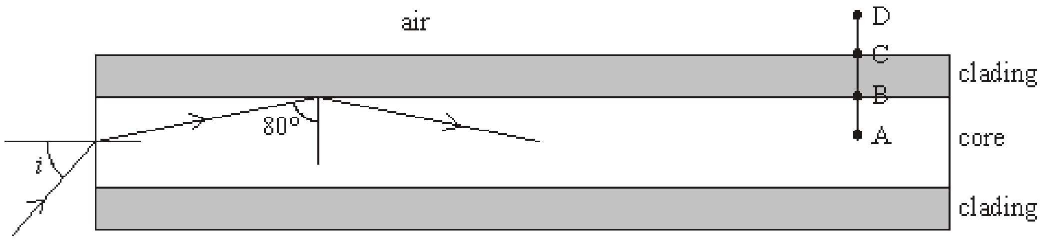
....

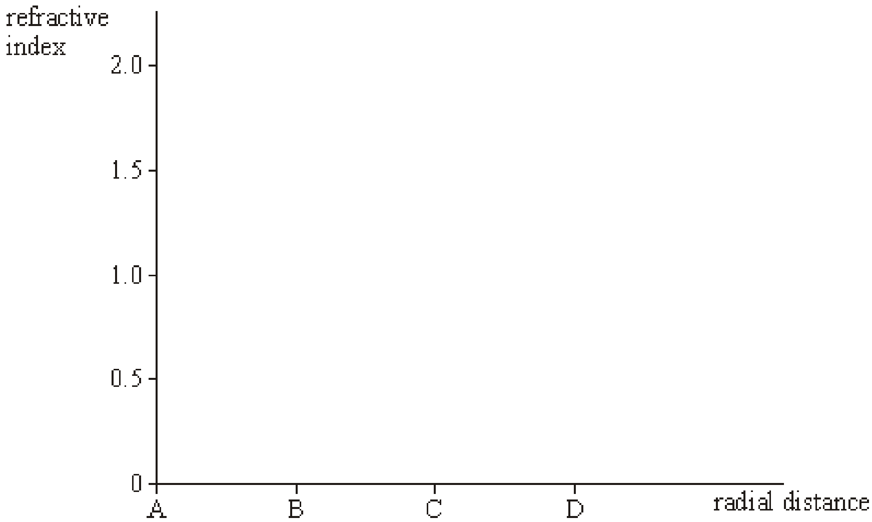
....

(2)

(c) The figure below shows a cross-section through an optical fibre used in an endoscope. The core is made from glass of refractive index 1.5.



(i) Complete the graph below to show how the refractive index changes with radial distance along the line ABCD in the figure above.



(ii) Calculate the value of the angle of incidence, *i*, shown in the figure above.

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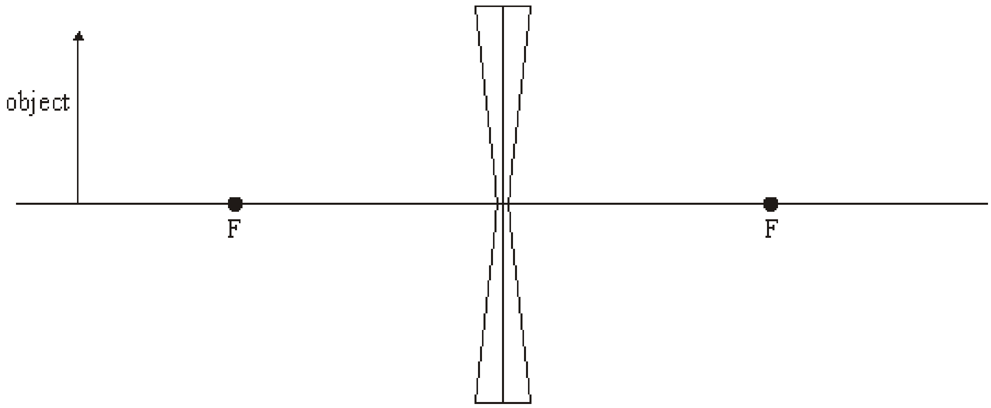
(4)
(Total 9 marks)

Q20. (a) The diverging lens in the figure below forms an image of the object. Complete the figure by drawing a ray diagram to show the formation of the image. Label the image.



(2)

(b) A diverging spectacle lens of power –3.0 D is used to correct a defect of vision. When used to view a real object, the image is formed 0.21 m from the lens.

(i) State the defect of vision.

....

(ii) Calculate the distance of the object from the lens.

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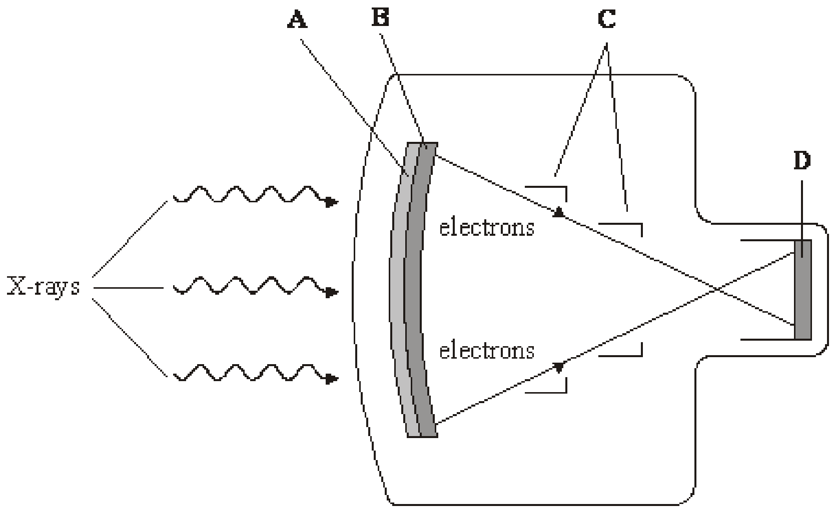
(3)
(Total 5 marks)

Q21. The figure below shows the design of an X-ray image intensifier.



The main components are labelled **A** to **D**. Name each component and state its purpose in the process of image intensification.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

A..

....

....

B..

....

....

C..

....

....

D..

....

....

(Total 8 marks)

Q22. (i) State the **two** physical properties of a material which determine its acoustic impedance.

....

(ii) Under what condition is ultrasound strongly reflected at a boundary between two types of material?

....

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....

(iii) State where a coupling medium or gel is used in an ultrasound scan and explain why it is necessary.

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(Total 6 marks)

Q23. (a) A detailed, coloured object is illuminated by white light. Compare what is seen under high intensity light with that seen under low intensity light by an observer with normal eyesight.

Your explanation should refer to rods and cones.

You may be awarded marks for the quality of written communication in your answer.

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(3)

(b) A person suffering from a defect of vision has an unaided far point of 2.0 m.

(i) Name this defect of vision.

....

(ii) Calculate the power of the correcting lens needed to allow the person to see distant objects clearly.

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(iii) The person has an unaided near point at 0.22 m. Calculate the aided near point of the person when using the correcting lens.

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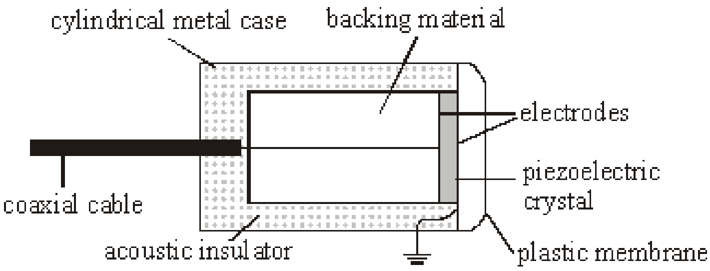
(4)
(Total 7 marks)

Q24. The figure below shows a transducer used in an ultrasound A scan.



(a) Describe how pulses of ultrasound are produced by the transducer.

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(3)

(b) In an ultrasound A scan

(i) explain how the received signals are detected,

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....

(ii) state why it is essential to use short pulses of ultrasound.

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(3)
(Total 6 marks)

Q25. (a) State the frequency of sound at which the normal ear is most sensitive.

....

(1)

(b) State the main features of hearing loss in terms of frequency response for

(i) age-related hearing loss,

....

....

(ii) noise-related hearing loss.

....

....

(2)

(c) At the site of a machine in a factory, a sound meter was used to measure the sound level. The relative intensity level with the machine operating was 86 dB. The sound intensity reaching the meter when the machine was not operating was 7.0×10^{-5} Wm^{-2}.

(i) Show that with the machine operating, the sound intensity reaching the meter was about 4×10^{-4} Wm^{-2}.

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(ii) Calculate the relative intensity level due to the machine alone.

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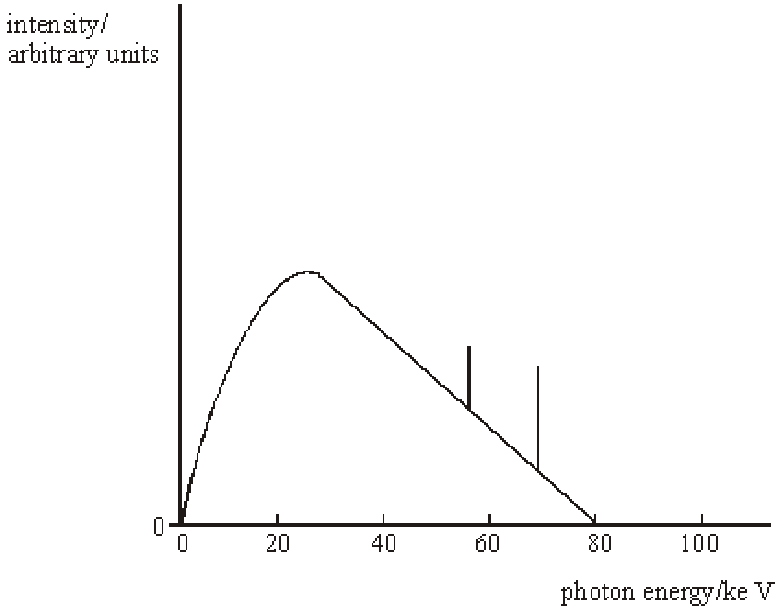
(4)
(Total 7 marks)

Q26.



(a) An X-ray tube operates with a pd across the tube of 80 kV. The figure above shows the X-ray spectrum emitted. Explain why the spectrum has spikes at specific photon energies.

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(2)

(b) The pd across the tube is increased to 90 kV. Sketch on the figure above the X-ray spectrum produced at this new pd.

(3)

(c) At the working pd of 80 kV, the anode current was 120 mA. The X-ray tube has an efficiency of 0.70 %. Calculate the rate of production of heat at the anode.

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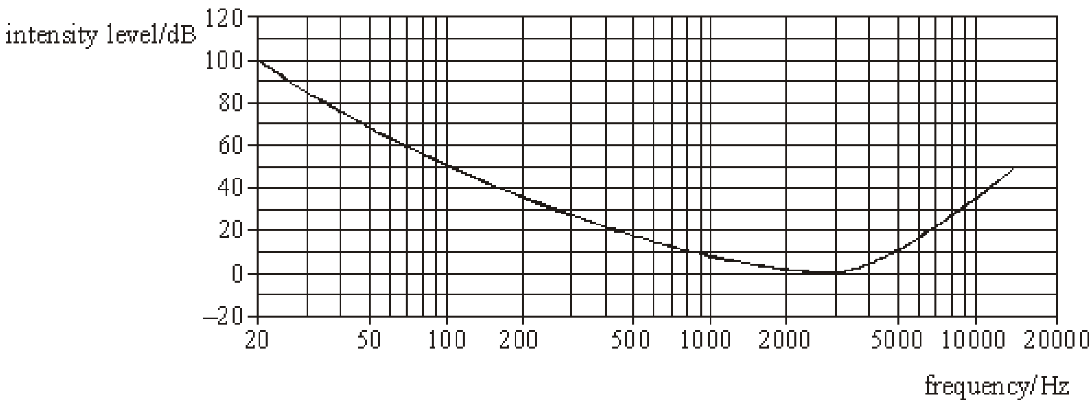
(3)
(Total 8 marks)

Q27. A patient has a hearing test to obtain an equal loudness curve at a level above the threshold of hearing. The curve obtained is shown in the diagram below.



(a) (i) Describe how such a curve is obtained.

You may be awarded marks for the quality of written communication in your answer.

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(ii) On the diagram draw an equal loudness curve which passes through 100 dB at a frequency of 1 kHz.

(5)

(b) (i) Define the threshold of hearing, I_0.

....

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(ii) A drill is heard by a passer-by. The intensity of the sound reaching the passer-by is 1.3×10^{-3} W m^{-2}. Calculate the intensity level of the sound heard.

$I_0 = 1.0 \times 10^{-12}$ W m^{-2}

....

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....

(4)
(Total 9 marks)

Q28. (a) State

(i) the cause of astigmatism,

....

(ii) the effect of astigmatism on vision,

....

....

....

(iii) the type of lens needed to correct astigmatism,

....

(iv) **two** parameters that must be determined for the correcting lens.

....

....

(4)

(b) A defective eye has an unaided near point at 0.65 m and an unaided far point at infinity.

Calculate

(i) the power of the correcting lens needed to allow the eye to see clearly an object 0.25 m from the eye,

....

....

....

....

(ii) the furthest distance from the eye that an object can be seen clearly when the correcting lens is used.

....

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(3)
(Total 7 marks)

Q29. (a) Sketch a graph of the ECG trace for a healthy heart. Label each axis with appropriate units and scales.

(4)

(b) When obtaining such a trace, electrodes are attached to the patient. State and explain **two** precautions which should be taken when attaching the electrodes to ensure reception of the best signal.

precaution 1:

....

....

....

....

precaution 2:

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....

(2)
(Total 6 marks)

Q30. (i) Explain what is meant by the *half-value thickness* of lead for X-rays.

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(ii) Calculate the linear attenuation coefficient of lead for 90 keV X-ray photons.

half value thickness of lead for 90 keV X-ray photons = 12mm.

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(iii) Calculate the thickness of lead needed to reduce the intensity of a beam of 90 keV X-ray photons to 5.0 % of the intensity incident on the lead.

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(Total 6 marks)

Q31. In the course of diagnosis and treatment of a child's broken arm, several images of the arm are required. Similarly, to check the progress of a woman's pregnancy, several images of the foetus are required. **In each case,** state which imaging technique would probably be used and give **two** reasons for the choice.

Broken arm:

technique used ....

reason 1 ....

....

reason 2 ....

....

Foetus:

technique used ....

reason 1 ....

....

reason 2 ....

....

(Total 4 marks)

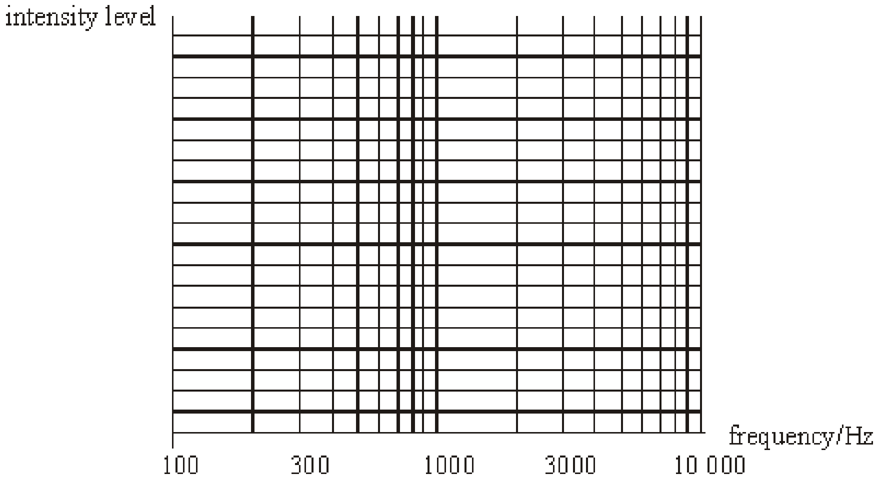
Q32 (a) (i) State the main difference between the dB cale and the adapted dBA cale used to measure sound intensity levels.

....

....

(ii) A variable frequency sound source produces sound of equal intensity at all frequencies. Two sound meters are placed equidistant from the source. One meter is switched to the dB scale. The other meter is switched to the dBA scale.

On the axes below sketch the response of the two sound meters as the frequency varies from 100 Hz to 10 000 Hz. Label each curve dB or dBA.



(5)

(b) A sound of intensity level 85 dB is incident on a human ear. The cross-sectional area of the ear canal is 65×10^{-6} m^2. Calculate the power incident on the ear-drum.

threshold intensity level, $I_0 = 1.0 \times 10^{-12}$ W m^{-2}

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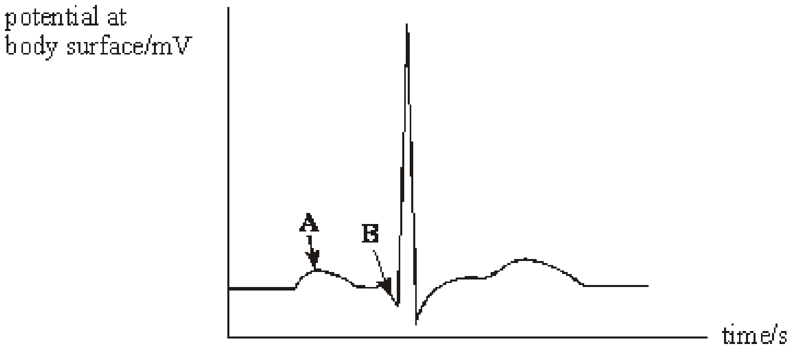
(3)
(Total 8 marks)

Q33. Electrodes are placed on the surface of a body to record an ECG trace for a healthy person.
The trace obtained for one heartbeat is shown.



(a) (i) Label approximate scales on each axis.

(ii) State what electrical event happens at points **A** and **B** and the physical change that results.

Position **A**:

electrical event ....

....

physical change ....

....

Position **B**:

electrical event ....

physical change ....

....

(6)

(b) State, giving a reason, **one** precaution you would take when attaching the electrodes to the surface of the skin to ensure a good signal is obtained.

....

....

(2)

(c) The amplifier used must have a high gain. State **two** other properties of the amplifier.

property 1 ....

property 2 ....

....

(2)
(Total 10 marks)

Q34. An endoscope uses coherent and non-coherent optical fibre bundles.

(i) Describe the difference in structure between coherent and non-coherent bundles.

You may be awarded marks for the quality of written communication in your answer.

....

....

....

....

....

(ii) State the use of:

the coherent bundle ....

the non-coherent bundle ....

(iii) The fibres in the coherent bundle have very small diameters. State **two** advantages of using small diameter fibres.

advantage 1 ....

....

....

advantage 2 ....

....

....

(Total 6 marks)

Q35. A convex lens is placed 0.25 m from an object. The focused image produced is virtual and is 0.60 m from the lens.

(a) Calculate

(i) the power of the lens,

....

....

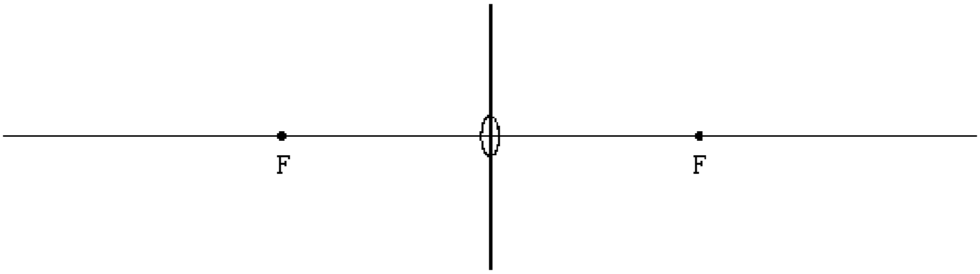
(ii) the magnification produced.

....

....

(3)

(b) Draw a ray diagram to show the formation of the image produced by this lens. The diagram does not have to be to scale, but relevant distances must be marked.



(3)

(c) (i) What defect of vision is this lens used to correct?

....

(ii) A person has an unaided near point at 0.60 m and an unaided far point at infinity. Calculate the range of vision of the person when using this lens.

....

....

....

....

(4)
(Total 10 marks)

Q36. A ship sounds its foghorn. A person on a cliff hears the sound which has an *intensity* of $0.13\ \text{mW m}^{-2}$.
The sound suffered *attenuation* in travelling between the ship and the person.

(a) (i) Define intensity.

....

....

(ii) State what is meant by attenuation and what causes it.

....

....

....

....

(3)

(b) Calculate the intensity level of the sound heard by the person described above.

threshold of hearing $I_0 = 1.0 \times 10^{-12}$ W m^{-2}

....

....

....

....

(2)
(Total 5 marks)

Q37. (a) Describe the response of the heart to the action potential originating at the sino-atrial node.

You may be awarded marks for the quality of written communication in your answer.

....

....

....

....

....

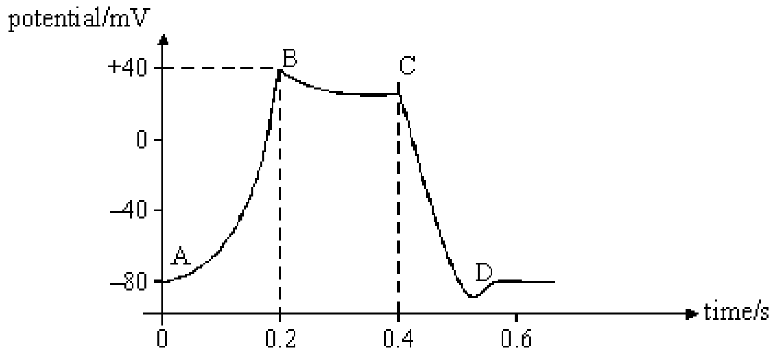
....

....

....

(4)

(b) The cell membrane action potential changes with time as shown.



The change in action potential results from ion movement in the same way as does the change of action potential across a nerve membrane. AB is a region of depolarisation. CD is a region of repolarisation.

(i) Describe the ion movement which produces depolarisation.

....

....

(ii) Describe the ion movement which produces repolarisation.

....

....

(3)
(Total 7 marks)

Q38. (a) When an X-ray image is obtained of certain organs, *image contrast enhancement* is necessary. Explain why image contrast enhancement is needed and describe how this might be achieved.

....

....

....

....

....

(3)

(b) A monochromatic X-ray beam of intensity 3.2×10^{-2} W m^{-2} is incident on an aluminium sheet. Calculate the thickness of aluminium required to reduce the intensity of the X-ray beam to 1.2×10^{-2} W m^{-2}.

mass attenuation coefficient of aluminium, $\mu_m = 0.012$ m^2 kg^{-1}

density of aluminium, $\rho = 2700$ kg m^{-3}

....

....

....

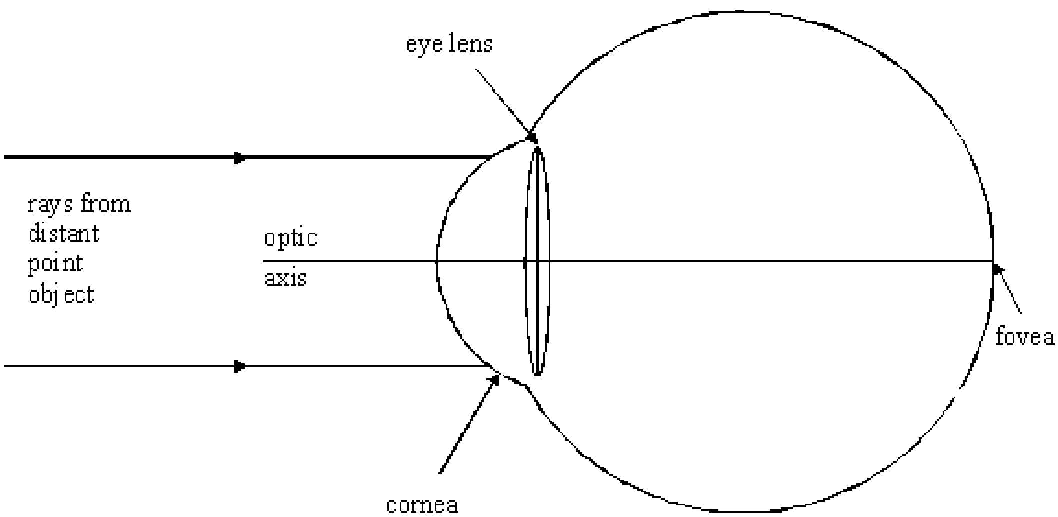
....

....

(3)
(Total 6 marks)

Q39. (a) The diagram represents a simplified version of a normal eye, with no sight defects, looking at a distant point object.

Complete the path of the two ray



(2)

(b) Describe the distribution of receptors over the retina.

....

....

....

....

(2)

(c) (i) State the purpose of the iris.

....

....

(ii) Describe how this purpose is achieved when the eye is exposed to bright light.

....

....

(2)

(d) (i) State what is meant by *accommodation*.

....

....

(ii) Describe how accommodation is achieved.

....

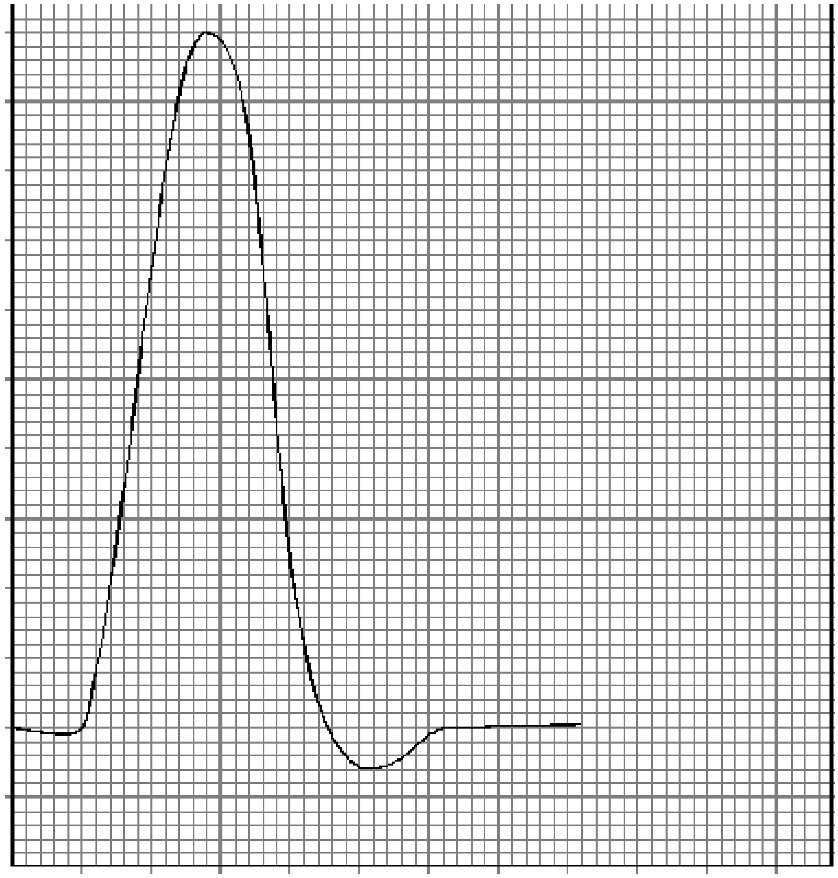
....

....

....

(2)
(Total 8 marks)

Q40. The graph shows the variation of membrane potential difference with time of a nerve fibre, known as an action potential.



(a) Complete the graph by adding suitable axes, units and scales.

(3)

(b) Describe the processes involved in the production of such an action potential when a nerve is stimulated.

You may be awarded marks for the quality of written communication in your answer.

....

....

....

....

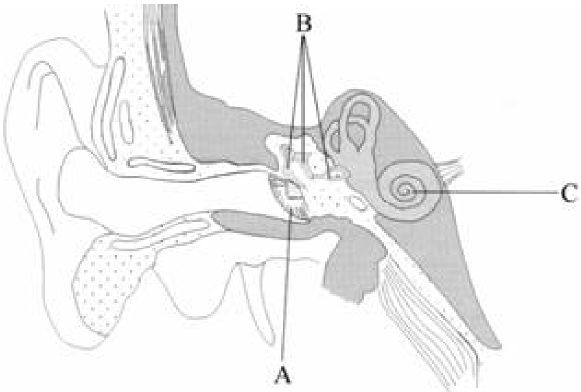
....

....

....

(3)
(Total 6 marks)

Q41. The diagram shows a vertical section through a human ear.



(a) Name and state the functions of the parts labelled A, B and C in the diagram.

A name ....

function ……..

....

B name ....

function ....

....

C name ....

function ....

....

(6)

(b) An ear has a threshold of hearing at a particular frequency at an intensity level of 42 dB. Calculate the intensity of sound incident on the ear.

$I_0 = 1.0 \times 10^{-12}$ W m^{-2}

....

....

....

(2)
(Total 8 marks)

Q42. Diagnostic X-rays are produced using a rotating anode X-ray tube.

(a) (i) State **two** methods which can be used to increase the intensity of the X-ray beam produced by the tube.

method 1 ....

method 2 ....

(ii) For each method of increasing intensity, state the effect on the maximum X-ray photon energy.

method 1 ....

method 2 ....

(3)

(b) Before taking an X-ray photograph, the X-ray beam emerging from the tube is passed through an aluminium filter. State and explain the reason for filtering the X-rays.

....

....

....

....

....

(3)
(Total 6 marks)

Q43. (a) A converging lens of focal length 4.0 cm is used to form an inverted image of a small upright object. The image produced is the same size as the object.

(i) State the distance of the lens from the object for this image to be formed.

....

(ii) Draw a ray diagram to show how the image is formed. Mark the positions of the object, image and the principal foci of the lens.

(3)

(b) (i) The lens in part (a) is replaced by another converging lens of focal length 12.0 cm, the distance between the lens and object staying the same. Calculate the distance between the image formed and the lens.

....

....

....

(ii) State **three** properties of this image.

....

....

....

(3)
(Total 6 marks)

Q44. A defective eye has an unaided far point of 2.5 m and an unaided near point of 0.20 m. A correcting lens is used to produce an aided far point at infinity.

(a) (i) Name the defect of vision affecting the eye.

....

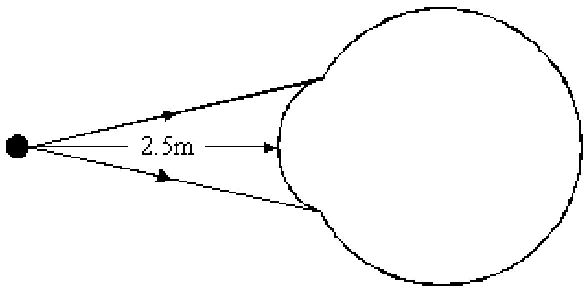
(ii) State **one** possible cause of this defect of vision.

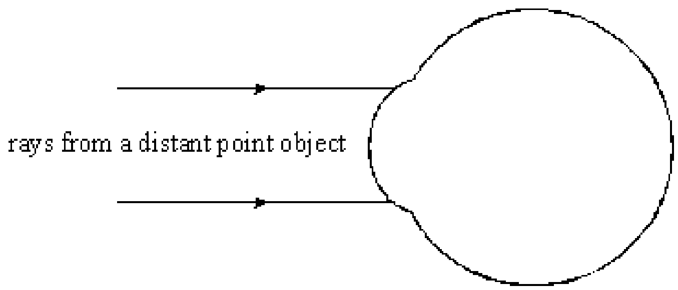
....

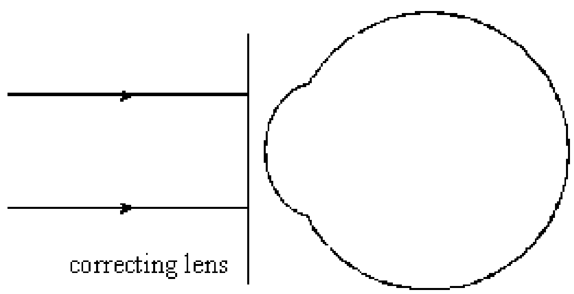
....

(2)

(b) Complete the ray diagrams below for the defective eye.







(3)

(c) (i) Calculate the power of the correcting lens.

....

....

....

(ii) Calculate the aided near point when wearing the correcting lens.

....

....

....

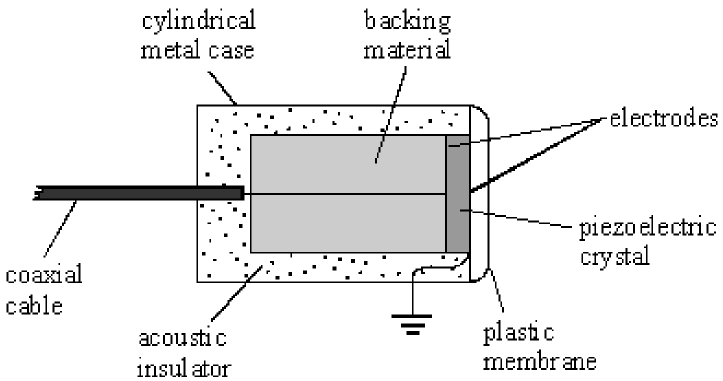
....

....

....

(4)
(Total 9 marks)

Q45. The diagram shows an ultrasound transducer as used in A-scans. The transducer produces short pulses of ultrasound.



(a) (i) Why is it necessary for the pulse to be short?

....

....

....

(ii) Explain, with reference to the diagram, the process by which the transducer produces short pulses.

You may be awarded marks for the quality of written communication provided in your answer.

....

....

....

....

....

(5)

(b) State **one** advantage and **one** disadvantage of ultrasound compared with X-rays in medical imaging.

advantage: ....

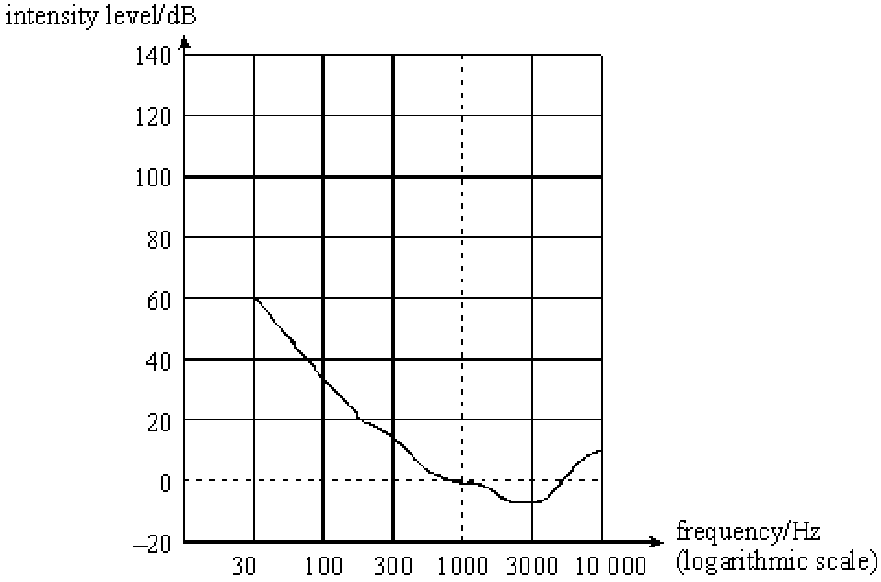
....

disadvantage: ....

....

(2)
(Total 7 marks)

Q46. (a) The graph shows the equal loudness curve for the threshold of hearing.



(i) On the diagram sketch the equal loudness curve which has an intensity level of 120 dB at a frequency of 1000 Hz. (120 phon)

(ii) What is the main similarity between the two curves?

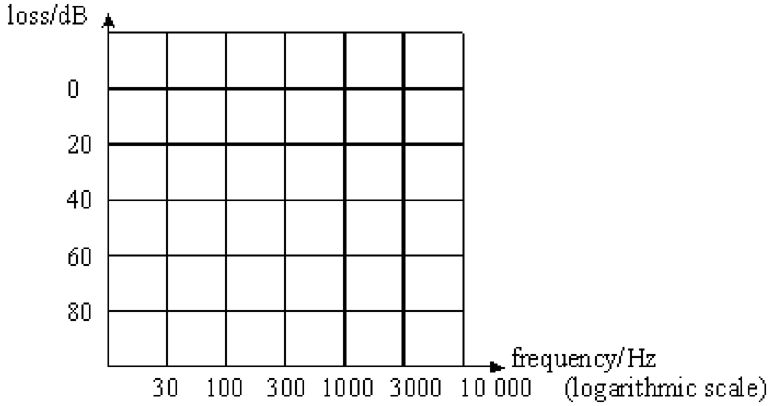
....

(2)

(b) On the axes below draw the curves for:

(i) age-related hearing loss and label it A,

(ii) noise-induced hearing loss and label it B.



(iii) What is the main difference between the two types of hearing loss?

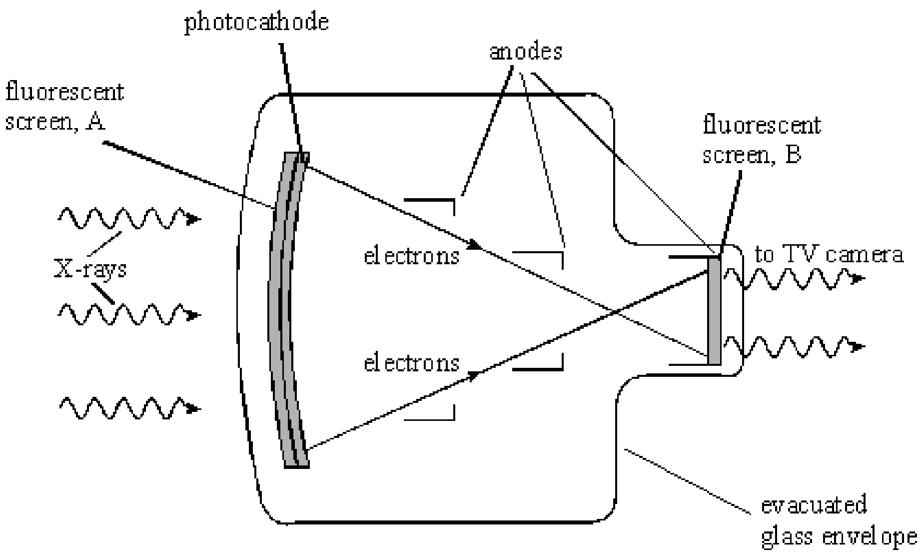
....

....

....

(4)
(Total 6 marks)

Q47 The diagram how a fluoro copic image inten ifier



(a) State the purpose of:

(i) the fluorescent screen, A,

....

(ii) the photocathode,

....

....

(iii) the anodes,

....

....

(iv) the fluorescent screen, B.

....

....

(4)

(b) Give **one** example of a medical application for which an image intensifier might be used. Explain why the use of an image intensifier is required.

....

....

....

....

....

(2)
(Total 6 marks)

M1. (a) (i) Ciliary muscles contract / suspensory ligaments relax Producing a lens of greater power / shorter focal length

2

(ii) (Iris circular muscles contract and /or radial muscles relax produces) constricted pupil /pupil becomes smaller

Cones turn on and rods become inactive

2

(b) Colours seen in bright light, but black and white in very dim light Good detail in bright light, but much less detail in very dim light

2

(c) (i) Image is focussed in a given plane and out of focus in **<u>perpendicular</u>** plane

1

(ii) non-spherical cornea

1

(iii) cylindrical lens

1

[9]

M2. (a) (i) Reading would be 60 dBA as 1 kHz is the reference frequency (at the threshold of hearing).

1

(ii) dB reading would be 60 dB as power is the same/not frequency dependent.

dBA reading would be less than 60 as 500 Hz has a higher threshold intensity / ear is less sensitive.

2

(b) Intensity at meter = $2/(4 \times \pi \times 5 \times 5)$ (= 6.37×10^{-3})

Intensity reading = $10 \log((2/(4 \times \pi \times 5 \times 5))/1.0 \times 10^{-12})$

Intensity reading = 98 dB

Allow ecf here from intensity calc. to get a ‘correct’ answer:

Use of 2 as intensity gains 0 for 123 dB

Use of 2/5 as intensity gains 1 for 116 dB or any use of 2 and a power of 5 **multiplied** also for 1 mark.

Use of $2/5^2$ as intensity gains 2 for 109 dB or use of $2/\pi 5^2$ gains 2 marks

3

[6]

M3. (a) horizontal line from A to B at 1.5

Vertical line at B from 1.5 to value between 1.5 and 1.4 and then horizontal line from B to C

Vertical line at C from value to 1.0 (if possible) and then horizontal line from C to D

3

(b) Use of non-coherent to transmit light into body/ provide illumination

Use of coherent to transmit image/ light to form an image (from inside to viewer /camera)

2

[5]

M4. (a) **The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.**

The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.

High Level (Good to excellent): 5 or 6 marks

The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.

The answer will discuss the multi-array of transducers in a linear formation and the use of gel between the skin and the probe will be explained. There will be mention of the transducers acting as receivers and why ultra sound echoes occur. There will be some discussion of the processing of the received signal to produce an image. The fact that this is non-ionising and thus has no known side effects will be included.

Intermediate Level (Modest to adequate): 3 or 4 marks

The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.

The answer will contain at least one property of the probe and either the use of gel or the transducer acting as a receiver should be discussed. The processing of the signal will be sketchy, but the reason that ultrasound is safe is likely to be mentioned.

Low Level (Poor to limited): 1 or 2 marks

The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate.

There will be a few of the guidance points mentioned, but there will be little cohesion in the writing.

The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case.

Method of obtaining the image

Ultra sound reflected at interface between two different acoustic impedances

Each transducer emits pulse in turn and receives the echoes from the interfaces directly in line with it

Each echo displayed as a bright spot on screen

The brightness is determined by the intensity of the echo

The y position is determined by the time taken from transmission to the time of the echo

The x position is determined by the position of the transducer

Images are produced at about 25 per second and thus appear as a real time moving image

Practical considerations

Probe has line of transducers (approx 100)

High frequency ac pulse applied to each transducer in turn

Each transducer has piezoelectric crystal to generate ultra sound

Use of gel between probe and skin to eliminate air

Transducer acts as receiver

Safety

No harmful side effects known – does not use ionising radiation.

Always allow details of other correct probes.

6

(b) The transducer to be damped/stop oscillating before the echo returns to allow the transducer to act as a receiver.

(This time is very short) as distances travelled are short

Emitted pulse must cease before echo arrives so that there is no overlapping at the transducer/ no interference

3

[9]

M5. (a) (i) $1.60 \times 10^{-19} \times 72.5 \times 10^{3} = 1.16 \times 10^{-14}$ (J)

Sig Fig mark for 3sf

2

(ii) $\lambda = (6.63 \times 10^{-34} \times 3.00 \times 10^{8})/1.16 \times 10^{-14}$

$= 1.71 \times 10^{-11}$ (m)

2

(b) Narrow beam of X–rays

X ray generator rotated (in circular path) around patient

Detectors arranged around outside of the path

Detector opposite generator registers transmitted intensity

Detectors connected to computer which (over time) produces cross sectional image

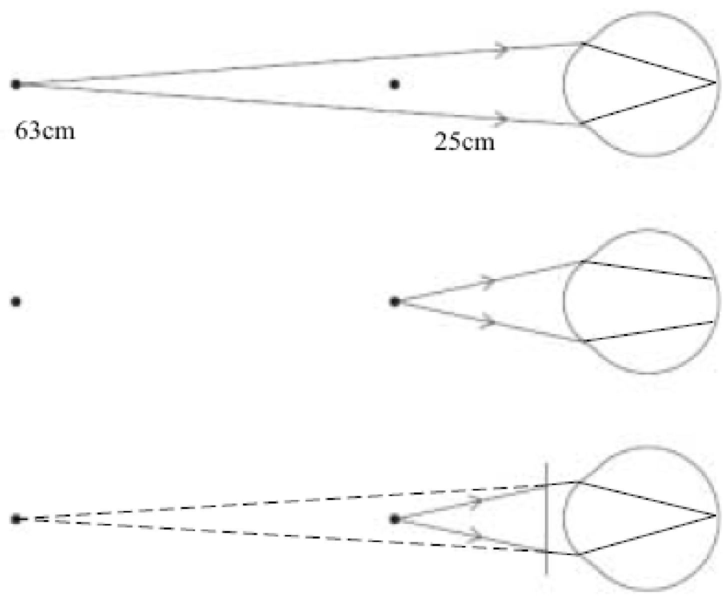
Any **three** relevant point

3

[7]

M6. (a) first two diagrams correct ✓

third diagram correct ✓



2

(b) 1/f = 1/u + 1/v = 1/0.25 – 1/0.63 ✓

f = 0.41 m ✓

correct sfs (independent mark) ✓

3

(c) image remains after stimulus is removed ✓

eg cinema pictures, television, fluorescent lights, optical illusions ✓

2

[7]

M7. (a) **minimum** intensity heard by a **normal** ear ✓

at 1 kHz ✓

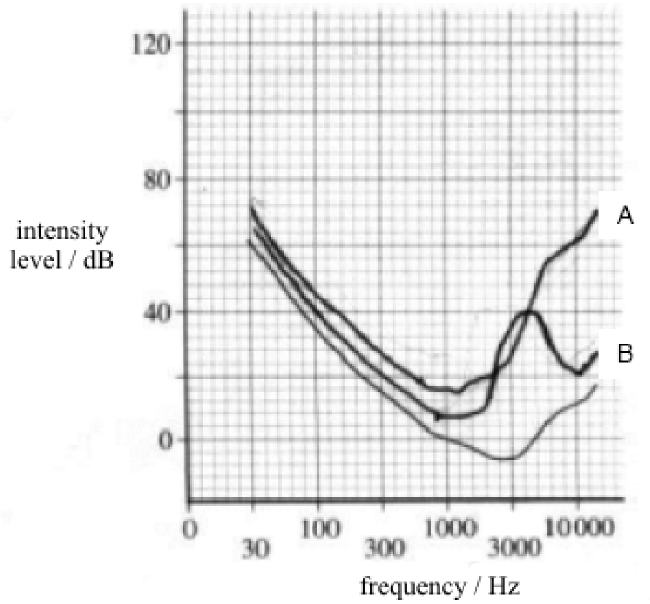
2

(b) (i) increased loss with increased frequency ✓

1

(ii) increased loss followed by decreased loss ✓

max loss at 4 kHz ✓



2

[5]

M8. (a) coherent same relative position of fibres at both ends ✓

coherent transfers picture from inside of body to viewer ✓

non-coherent no relative order to the fibres ✓

non-coherent carries light into body/for illumination ✓

4

(b) sin θ_c = 1.55/1.60 θ_c = 76 (75.6) (degree) ✓

1

[5]

M9. (a) **The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.**

The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.

High Level (Good to excellent): 5 or 6 marks

The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.

The candidate accurately describes measures to ensure good contact between the electrodes and the skin including the use of conducting gel. The candidate will mention the need for more than one electrode and the need for the patient to remain relaxed and still. They will need at least one property of the amplifier.

Intermediate Level (Modest to adequate): 3 or 4 marks

The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.

The candidate will include mo t mea ure to en ure good contact between electrodes and the skin. They might give a property of the amplifier or mention the need for the patient to remain relaxed and still.

Low Level (Poor to limited): 1 or 2 marks

The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate.

The candidate will mention electrodes connected to the skin and might make another sensible comment on the arrangement.

Statements expected in a competent answer should include some of the following marking points.

To reduce contact resistance

- sandpaper skin to remove hairs and some dead skin
- apply conducing gel
- securely attach more than one electrode

To remove unwanted signals

- electrodes should be non-reactive
- patient to remain relaxed and still
- shielded leads/reducing interference from ac sources

Properties of amplifier

- amplifier has large input impedance/high gain/low noise

max 6

(b) (i) 0 marked where line meets axis with maximum value of 1 ✓

unit mark mV ✓

2

(ii) uniform scale starts at 0 and has value 0.7 (0.9 to 0.5) at end of T wave ✓

1

(iii) P depolarisation of atria ✓

R depolarisation of ventricles (and repolarisation of atria) ✓

T repolarisation of ventricles ✓

3

[12]

M10. (a) electrons strike anode and ionise/excite the target **atoms** ✓

excited/higher electrons fall to **inner** energy level ✓

fixed energy gaps produce fixed energy photons ✓

3

(b) convert X-ray (photons) to light (photons) ✓

light photons expose film in correct place due to closeness of the screens to the film ✓

reduces radiation dose to the patient/the exposure time is shorter ✓

3

[6]

M11. (a) first correct diverging ray **(1)**

second correct ray and image labelled or clearly shown (also CE mark) **(1)**

2

(b) reciprocal of the focal length **(1)**

1

(c) (i) myopia or shortsight **(1)**

1

(ii) $1/u + 1/(-0.15) = 1/(-0.56)$ **(1)**

$u = 0.2049$ (m) **(1)**

correct sig figs – 2 sig figs correct answer 0.20 (m) **(1)**

3

(d) **power** and **axis** of the **cylindrical** lens – any 2 bold terms to get the mark **(1)**

1

[8]

M12. (a) (i) longitudinal/pressure waves in the ear canal **(1)**

forces eardrum into mechanical vibrations **(1)**

(mechanical) vibrations (passed through middle ear) by a lever system/series of bones/named bones to the oval window **(1)**

sets up pressure waves in fluid in cochlea **(1)**

max 3

(ii) force increased by the action of the lever system/series of bones/named bones; value $F \times 1.5$ **(1)**

area of oval window << area of the eardrum ; value $A/20$ **(1)**

effect of pinna in increasing intensity in ear canal **(1)**

max 2

(b) $46 = 10 \times \log (I/(1.0 \times 10^{-12}))$ **(1)**

$I = 4.0 \times 10^{-8}$ **(1)**

$W\ m^{-2}$ **(1)**

3

(c) dBA scale is frequency dependent to match the response of the ear **(1)**
ear more sensitive (than I_o) for a range of frequencies between 1 and about 2 6 kHz **(1)**

2

[10]

M13. (a) general shape, must be both positive and negative values **(1)**

action potential axis scale and unit – allow –70 to +30,
or –90 to +20 mV
(these values will be consistent in part a and part b)
minimum –90 maximum +45 **(1)**

time scale and unit 0 to 6 ms – this will depend on curve drawn, pulse lasting no less than 1 ms and no more than 6 ms **(1)**

3

(b) **The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.**

The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.

High Level (Good to excellent): 5 or 6 marks

The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.

The candidate provides a correct and detailed description of the movement of ions into and out of the fibre. They include the terms depolarisation and repolarisation with reference to change in potential. Final mention is made to the slower process to restore the equilibrium concentrations.

Intermediate Level (Modest to adequate): 3 or 4 marks

The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.

The description of ion movement and the terms depolarisation and repolarisation might not be clearly named, but the candidate refers to the change in potential, although actual values might not be included. There may be mention of a final movement restoring equilibrium.

Low Level (Poor to limited): 1 or 2 marks

The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate.

Some reference to ion movement and a resulting change in potential. One of the terms depolarisation or repolarisation might be included.

The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case.

Points which can be used to support the explanation:

- at resting potential, high concentration of K^+ ions inside and Na^+ outside
- when stimulated, membrane becomes permeable to Na^+ ions entering the core increasing membrane potential
- good answer will say depolarisation from –70 mV to 0 mV and reverse polarisation from 0 mV to +30 mV; but allow depolarisation from –70 mV to +30 mV
- membrane becomes impermeable to Na^+ ions and permeable to K^+ ions leaving the core
- reducing membrane potential to –70 mV, repolarisation
- after this, a much slower process returns the axon to its initial state with Na^+ ions outside and K^+ ions inside

max 7

[10]

M14. (a) (head) placed in strong/high intensity/super conducting magnets magnetic field **(1)**

supplied radio pulse excite H nuclei **(1)**

when H nuclei de-excite/change spin/change alignment they emit radio signal/em radiation/photons **(1)**

these signals are detected and passed to computer **(1)**

gradient in static field to allow location to be determined/magnetic field aligns H nuclei **(1)**

max 3

(b) example answers:

MR non-ionising radiation – ionising radiation in CT more danger to living cells **(1)**

MR can give multi-plane images from same scan – CT needs new scan for each image **(1)**

MR gives better resolution between tissue types, better resolution picture **(1)**

MR gives real time image CT scan needs to rotate to produce final image **(1)**

4

[7]

M15. (a) diagram to show rays refracted inwards at cornea **(1)**

rays refracted inwards at lens **(1)**

rays focused at optic axis on retina **(1)**

max 2

(b) only cones at fovea **(1)**

moving away from fovea, more rods, less cones **(1)**

2

(c) (i) to control the intensity of light reaching retina **(1)**

(ii) forms a small pupil **(1)**

2

(d) (i) accommodation: ability of the eye/lens to (change and) focus on different object distances **(1)**

[adjustment of the eye/lens to form a clearly focused image on the retina]

(ii) changing the shape of the lens

[or using the cillary muscles] **(1)**

2

[8]

M16. (a) electrodes made from a material which does not become polarised

electrodes coated with conductive gel

hair and dead skin removed

any two **(1)(1)**

2

(b) high gain

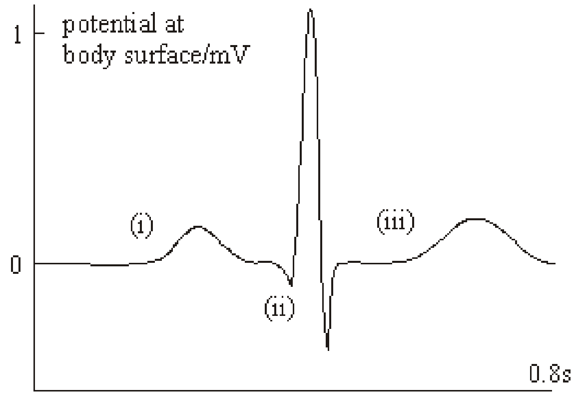
high input impedance

low noise

any two **(1)(1)**

2

(c)



for waveform:
*suitable scales **(1)***
*correct shape **(1)***

for marking in correct position on waveform:
atrial depolarisation (i) **(1)**
ventricular depolarisation (ii) **(1)**
ventricular repolarisation (iii) **(1)**

5

[9]

M17. (a) 3kHz **(1)**

1

(b) (i) (age related) as *f* increases, loss increases **(1)**

(ii) (noise related) loss is maximum at 4 kHz **(1)**

2

(c) (i) (use of *intensity level* = 10 log $\frac{I}{I_0}$ gives)

$I = 1.0 \times 10^{-12} \times 10^{86/10}$ **(1)**

$= 3.98 \times 10^{-4}$ W m^{-2}

(ii) (use of same equation gives)

intensity level = 10 log$\left(\frac{3.98 \times 10^{-4} - 7.0 \times 10^{-5}}{1.0 \times 10^{-12}}\right)$ **(1)**

= 85(.2) dB **(1)**

(allow CE for incorrect *I* from (i))

4

[7]

M18. (a) 1: vacuum/evacuated (tube) **(1)**

2: lead (lined shield) **(1)**

3: electrons (beam) **(1)**

3

(b) (i) heat is spread over a greater volume/area/section **(1)**

thus allows more energetic X-rays to be produced

[or allows X-rays to be generated for longer] **(1)**

(ii) (bevelled edge) gives larger target area **(1)**

but small source area (to produce sharp image) **(1)**

max 3

(c) (i) the fraction of X-rays removed per unit thickness of the material **(1)**

(ii) the thickness of the material which will reduce the intensity to half its original level **(1)**

for a specified energy of the X-rays (in either (i) or (ii)) **(1)**

max 2

(d) (use of $\mu = \frac{\ln 2}{X_{1/2}}$ gives) $\mu = \frac{\ln 2}{3.2}$ = 0.22 mm^{-1} (0.217mm^{-1}) **(1)**

(use of $I = I_0 e^{-\mu x}$ gives) $I = 6.0 \times e^{-0217 \times 2}$ **(1)**
(allow CE for value of μ)

= 3.9 W m^{-2} **(1)**

3

[11]

M19. (a) **property** **explanation**

monochromatic waves of single frequency/wavelength

collimated produces an approximately parallel beam

coherent waves produced are in constant phase with each other

two correct properties **(1)**
each correct explanation **(1)(1)**

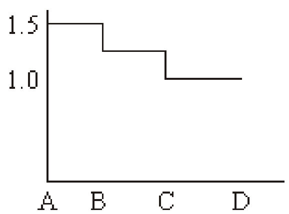
3

(b) (i) illuminate the inside of a body **(1)**

(ii) stopping bleeding/cutting tissue/treatment of tumours **(1)**

2

(c) (i)



n (constant) = 1.5 from A to B, slight decrease and
constant from B to C **(1)**
at C, n decreases to 1, remains at 1 from C to D **(1)**

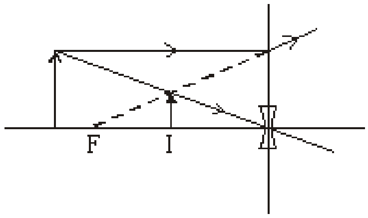
$1.5 = \frac{\sin i}{\sin 10}$ **(1)**

i = 15(.1)° **(1)**

4

[9]

M20. (a)



ray diverging from F **(1)**
ray through centre of lens to form marked image **(1)**

2

(b) (i) myopia/short sight **(1)**

(ii) (use of $P = \frac{1}{u} + \frac{1}{v}$ gives) $-3.0 = \frac{1}{u} + \frac{1}{(-0.21)}$ **(1)**

u = 0.57 m **(1)**
(0.568 m)

3

[5]

M21. A scintillator crystal(s)/fluorescent screen **(1)**
convert X-ray photons into light **(1)**

B photocathode **(1)**
light energy releases electrons **(1)**
number of electrons released proportional to X-ray intensity **(1)**

C anodes **(1)**
increase energy of the electrons **(1)**
focus the electrons to form an image **(1)**

D fluorescent screen **(1)**
converts electron energy into light photons **(1)**

[8]

M22. (i) density of the material **(1)**
speed of sound in the material **(1)**

(ii) large difference in acoustic impedance **(1)**

(iii) (position) between probe and skin **(1)**

(reason for gel): without it, trapped air gives large difference in acoustic impedance **(1)**
gel has similar acoustic impedance to tissue **(1)**
air excluded and maximum transmission **(1)**

max 3 for (iii)

[6]

M23. (a) (both answers, for bright light and dim light, are required to gain a mark)

bright light	**dim light**
cones	rods **(1)**
colour	black and white **(1)**
detail seen	lack of detail **(1)**
optic axis	periphery **(1)**

Max 3

(b) (i) short sight/myopia **(1)**

(ii) $P = \dfrac{1}{-2.0} = -0.5$ D **(1)**

$0.5 = \dfrac{1}{u} - \dfrac{1}{0.22}$ **(1)**

$u = 0.25$ m **(1)** (0.247 m)

(allow C.E. for value of *P* from (ii))

4

[7]

M24. (a) electrodes connected to **alternating/high frequency** emf/voltage/pd **(1)**
crystal expands and contracts at frequency of emf **(1)**
[or resonates at same frequency]
vibration of faces produces ultrasound/pressure waves **(1)**
backing material damps oscillations of crystal **(1)**
to stop crystal oscillating between end of transmitted pulse
and start of reflective pulse **(1)**

Max 3
QWC 1

(b) (i) (probe acts as receiver and) received signal causes crystal to vibrate **(1)**
vibration of crystal produces alternating pd **(1)**

(ii) transmission must stop so that reflected pulse can be received **(1)**

3

[6]

M25. (a) 3 kHz **(1)**

1

(b) (i) (age related) as *f* increases, loss increases **(1)**

(ii) (noise related) loss is maximum at 4 kHz **(1)**

2

(c) (i) (use of *intensity level* = 10 log $\frac{I}{I_0}$ gives)

$I = 1.0 \times 10^{-12} \times 10^{86/10}$ **(1)**
$= 3.98 \times 10^{-4}$ W m^{-2} **(1)**

(ii) (use of same equation gives)

intensity level = 10 log$\left(\frac{3.98 \times 10^{-4} - 7.0 \times 10^{-5}}{1.0 \times 10^{-12}}\right)$
= 85(.2) dB **(1)**

(allow C.E. for incorrect *I* from (i)) **(1)**

4

[7]

M26. (a) specific to anode element/target atoms/material **(1)**
energy level transition **(1)**

2

(b) new curve to show:
entire curve has more intensity **(1)**
stops at 90 kV **(1)**
spikes in same position **(1)**

3

(c) % into heat = (100 – 0.70) = 99.3 **(1)**

rate of heat produced = $\frac{99.3}{100} \times 80 \times 10^{3} \times 120 \times 10^{-3}$ **(1)**

= 9.5 kW **(1)** (9.53 kW)

3

[8]

M27. (a) (i) listen to sound at f = 1 kHz and intensity level 10 dB **(1)**
listen to sound at different f and loudness and alter loudness **(1)**
switch between 1 kHz, 10 dB and new f and loudness until same loudness is perceived **(1)**
repeat for f between 20 Hz and 14 – 20 kHz **(1)**

QWC 1

(ii) equal loudness curve to show:
line almost flat at 100 dB **(1)**
with dip at 3 kHz **(1)**

max 5

(b) (i) minimum of intensity of sound heard by normal ear **(1)**
at frequency of 1 kHz **(1)**

(ii) intensity level = 10 log $\left(\frac{1.3 \times 10^{-3}}{1.0 \times 10^{-12}}\right)$ **(1)**

= 91(.1) dB **(1)**

4

[9]

M28. (a) (i) non-spherical cornea **(1)**

(ii) when one plane is in focus, plane at 90° is out of focus **(1)**

(iii) cylindrical (lens) **(1)**

(iv) power and angle of alignment/orientation **(1)**

4

(b) (i) $P = \frac{1}{f} = \frac{1}{0.25} - \frac{1}{0.65}$ **(1)**

$= 2.5$ D **(1)** (2.46 D)

(ii) $u = \frac{1}{P} = 0.41$ m **(1)** (0.406 m)

(allow C.E. for value of *P* from (i))

3

[7]

M29. (a) ECG trace to show:
sec on *x*-axis and mV on *y*-axis **(1)**
correct value on *x* axis (0.7 s to end of trace) **(1)**
correct values on *y* axis (start at 0, highest point at 1 mV) **(1)**
shape of curve **(1)**

4

(b)

precaution	**+**	*explanation*
attach firmly		stop noise
remove dead skin/hair		reduce contact resistance
use conducting gel		remove air for better electrical contact
positioning of electrodes		to get largest pd

any two pairs **(1)** **(1)**

2

[6]

M30. (i) thickness needed to reduce intensity by half **(1)**
for X-rays of specific energy **(1)**

(ii) $\mu = \frac{\ln 2}{x}$ **(1)**

$= 58\ \text{m}^{-1}$ (1) ($57.8\ \text{m}^{-1}$)

(iii) (use of $I = I_0 e^{-\mu x}$ gives) $0.05 = e^{-57.8x}$ **(1)**

$x = 0.052$ m (or 52 mm) **(1)** (51.8 mm)
(allow C.E. for value of μ from (ii))

[6]

M31. technique: broken arm – X-ray, foetus – ultrasound **(1)**

reasons: (X-ray) good contrast
sharp image
good resolution any two **(1) (1)**

(ultrasound) non-ionising (safe)
detects change in tissue type
allows real-time image any two **(1) (1)**

[4]

M32. (a) (i) dBA scale is frequency dependent (dB scale is not) **(1)**

(ii) dB graph: flat - same response at all frequencies **(1)**
dBA graph: correct general shape **(1)**
most sensitive at 3 kHz **(1)**
slightly higher than dB curve at 3 kHz **(1)**
crosses dB line at 1 kHz **(1)**

max 5

(b) (use of *intensity level* = 10 log $\frac{I}{I_0}$ gives) 85 = 10 log $\frac{I}{1.0 \times 10^{-12}}$ **(1)**

$I = 3.2 \times 10^{-4}$ (W m^{-2}) **(1)** (3.16×10^{-4} (W m^{-2}))

P (= IA) = $3.16 \times 10^{-4} \times 65 \times 10^{-6} = 2.1 \times 10^{-8}$ W **(1)** (2.06×10^{-8} W)

(allow C.E. for value of I)

3

[8]

M33. (a) (i) y-scale: +1 to –0.2 V **(1)**
x-scale: 0 to 0.8 s **(1)**

(ii) position A: *event* - sino atrial node fires **(1)**
result - atria contracts **(1)**

position B: *event* - ventricular node fires **(1)**
result - ventricles contract **(1)**

6

(b) precaution: remove dead skin
[or use conducting/electrode gel] **(1)**
reason: to give best possible contact between person and electrode **(1)**

2

(c) low noise **(1)**
high input impedance **(1)**
[or any other suitable property]

2
QWC 1
[10]

M34. (i) coherent: fibres maintain positions at both ends **(1)**
non-coherent: fibres have random positions **(1)**

(ii) carry images **(1)**
carry light into the body **(1)**

(iii) more flexible **(1)**
image has better definition **(1)**

[6]

M35. (a) (i) (use of $f = \frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ gives) $\frac{1}{f} = \frac{1}{0.25} - \frac{1}{0.60}$ **(1)** (= 2.33)

(use of $P = \frac{1}{f}$ gives) P = (+)2.3 D **(1)**

(ii) $m\left(= \frac{0.60}{0.25}\right) = 2.4$ **(1)**

3

(b) diagram to show: two correct rays to locate image **(1)**
correct (virtual) image **(1)**
two distances shown **(1)**

3

(c) (i) long sight **(1)**

(ii) aided far point at focal length of lens **(1)**

$f = \frac{1}{2.33}$ = 0.43 m **(1)**

aided near point is 0.25 m **(1)**

4
[10]

M36. (a) (i) intensity : power per unit cross-sectional area (in path of wave) **(1)**

(ii) attenuation : reduction in intensity/energy/power as wave travels through a medium **(1)**
due to absorption/scattering/diffraction **(1)**

3

(b) (use of intensity level = 10 log $\frac{I}{I_0}$ gives)

intensity = 10 log $\left(\frac{1.3 \times 10^{-4}}{1.0 \times 10^{-12}}\right)$ **(1)**

= 81 dB **(1)**

2

[5]

M37. (a) pulse causes atria muscles to contract **(1)**
blood forced into ventricles **(1)**
pulse delayed before firing ventricular node **(1)**
ventricles contract **(1)**
forces blood out of heart to lungs and body **(1)**

max 4
QWC 2

(b) (i) Na^+ **(1)**
from outside to inside **(1)**

(ii) K^+ from inside to outside **(1)**

3

[7]

M38. (a) for clear image need large difference in densities between part being investigated and parts around it **(1)**
when this is not natural, add material to part under investigation **(1)**
which has high density to provide good attenuation of X-rays **(1)**
barium meal use barium sulphate **(1)**

max 3

(b) μ (= $\rho\mu$m) = 2700 – 0.012 = 32.4 **(1)**

(use of $I = I_0 e^{-\mu x}$ gives) $1.2 \times 10^{-2} = 3.2 \times 10^{-2} \times e^{-32.4x}$ **(1)**

(allow C E for value of μ)

x = 0.03(0) m **(1)**

3

[6]

M39. (a) diagram to show: rays reflected inwards at cornea **(1)**
rays reflected at lens **(1)**
rays focused at optic axis on retina **(1)**

max 2

(b) only cones at fovea **(1)**
moving away from fovea, more rods, less cones **(1)**

2

(c) (i) to control the intensity of light reaching retina **(1)**

(ii) forms a small pupil **(1)**

2

(d) (i) accommodation: ability of the eye/lens to (change and) focus on different object distances **(1)**
[adjustment of the eye/lens to form a clearly focused image on the retina]

(ii) changing the shape of the lens
[or using the cillary muscles] **(1)**

2

[8]

M40. (a) axes: time/ms, action potential/mV **(1)**
time scale from 1 → 5 (approx) **(1)**
action potential scale + 20 → –80 or +30 → –70 **(1)**

3

(b) Na^+ ions move into cell **(1)**
pd rises (from –70 to 0) (or +30), called depolarisation **(1)**
K^+ ions move out of nerve **(1)**
pd returns/falls to –70/resting potential, called repolarisation **(1)**
Na^+ moving from 0 to +30 called reverse polarisation **(1)**
to restore starting equilibrium of ions, the Na/K pump operates **(1)**

max 3
QWC2

[6]

M41. (a) A ear drum or tympanic membrane **(1)**
transfers vibration of sound waves into mechanical oscillations

B ossicles **(1)**
system of levers to multiply the force **(1)**
[or system of levers to link outer and inner ear]

C cochlea **(1)**
converts pressure wave in fluid into electrical signal **(1)**

6

(b) (use of *intensity level* = 10 log $\frac{I}{I_o}$ gives) $42 = 10 \log \frac{I}{1.0 \times 10^{-12}}$ **(1)**
$I = 1.6 \times 10^{-8}$ W m^{-2} **(1)**

2

[8]

M42. (a) (i) method 1: increasing pd across the tube **(1)**
method 2: increasing tube current or increasing filament temperature **(1)**

(ii) method 1: will increase the maximum photon energy **(1)**
method 2: will not change the maximum photon energy **(1)**

max 3

(b) reduces intensity of low energy photons **(1)**
hardly changes intensity of high energy photons **(1)**
need high energy for picture
[or low energy no good for picture] **(1)**
reducing low energy reduces dose received by patient **(1)**

max 3

[6]

M43. (a) (i) 8.0 cm **(1)**

(ii) diagram to show:
ray parallel to axis through labelled F **(1)**
ray through centre of lens to produce correct image **(1)**

3

(b) (i) (use of $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ gives) $\frac{1}{0.12} = \frac{1}{0.08} + \frac{1}{v}$ **(1)**

$\left(\frac{1}{v} = -4.2\right)$ and v = –0.24 m **(1)**

(ii) magnified, upright, virtual (three correct **(1)** **(1)**

two correct **(1)**)

max3

[6]

M44. (a) (i) myopia or short sight **(1)**

(ii) eyeball too long

[or cornea too curved/powerful] **(1)**

(allow C.E. if (i) is incorrect)

2

(b) 1st diagram: rays focused on retina **(1)**

2nd diagram: rays focussed before retina **(1)**

3rd diagram: rays diverging from lens and appear
to come from point 2.5m away **(1)**
rays (after diverging) focused on retina

max 3

(c) (i) (use of $P = \frac{1}{f}$ gives) $P = \frac{1}{(-)2.5}$ **(1)**

= –0.4 D **(1)**

(ii) (use of $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ gives) $\frac{1}{-2.5} = \frac{1}{u} + \frac{1}{-0.2}$ **(1)**

$\left(\frac{1}{u} = \frac{23}{5}\right)$ and u = 0.22 m **(1)**

4

[9]

M45. (a) (i) probe is used as a generator and receiver **(1)**

(ii) electrodes connected to (high frequency/alternating) emf **(1)**
crystal expands and contracts at frequency of emf **(1)**
vibration of faces produce ultrasound (pressure) waves **(1)**
backing material damps oscillation of crystal **(1)**
to stop crystal oscillating between end of transmitted pulse and start of received pulse **(1)**

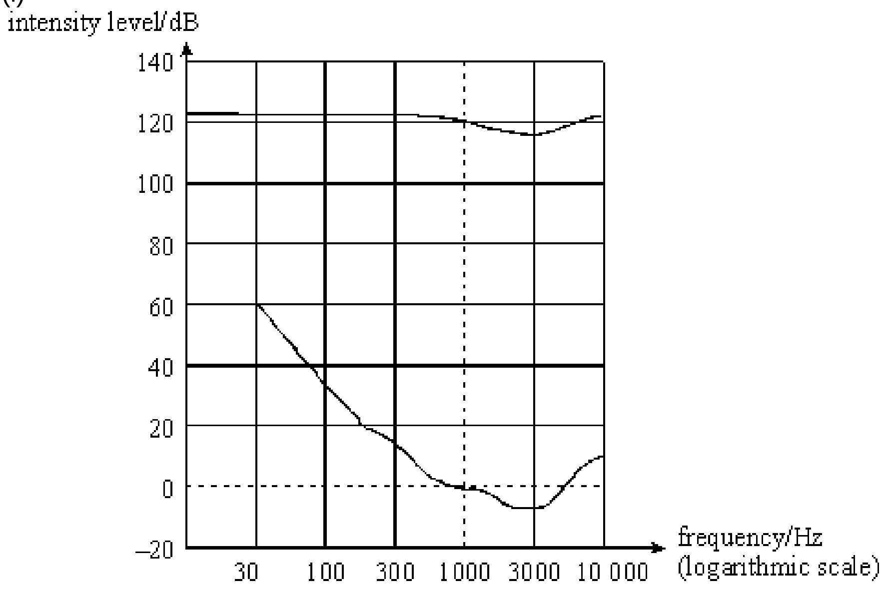
max 5
QWC 2

(b) advantage: e.g. not harmful to living cells or soft tissue **(1)**
disadvantage: e.g. cannot penetrate bone or low resolution **(1)**

2

[7]

M46. (a) (i)

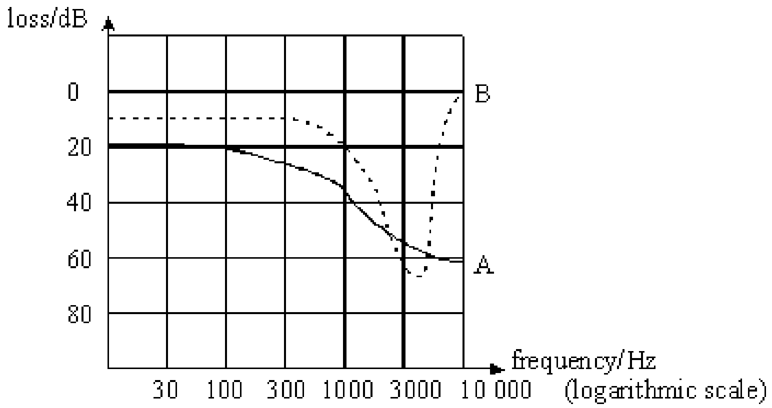


general shape flatter and passing through 120, 1000 **(1)**

(ii) both most sensitive at ≈ 3000 Hz **(1)**

2

(b)



(i) trace A (——), basic shape correct **(1)**

(ii) trace B (------), basic shape correct **(1)**

(iii) loss due to age increases with frequency **(1)**
loss due to noise is maximum at 4000 Hz **(1)**

4

[6]

M47. (a) (i) converts X rays to visible photons **(1)**

(ii) converts photons to emission of electrons **(1)**

(iii) increases kinetic energy of electrons travelling from cathode to anode **(1)**
focuses rays of electrons to produce faithful image **(1)**

(iv) converts (increased) electron <u>energy</u> into light photons

max 4

(b) dynamic process such as fluid flow **(1)**
cuts radiation dose whilst still providing good image
[or allows multiple or continuous use of X ray] **(1)**

2

[6]

E1. This question was related to the eye and allowed most students to attempt all parts. Part (a) (i) required a knowledge of accommodation and produced some good answers. However, there were too many vague answers such as ‘ciliary muscles change shape to adjust the power of the lens’ or ‘the lens becomes short and wide’ and the lens becomes thicker’. In part (a)(ii) many answers only scored 1 mark as only one change was mentioned. A significant number of students confused the iris with the pupil, suggesting ‘the iris opens wider in dim light and will get smaller in bright light’. A noticeable number thought that the cilliary muscles controlled the iris. Other students wrongly suggested that the pupil was reduced in size as less light was needed. Part (b) brought more confused statements such as ‘the colour is less bright in dim light’ rather than grayscale images are seen in very dim light, and ‘the image is less focussed in dim light’ rather than the resolution of the image is poorer in very dim light. In part (c)(i) we were looking for reference to perpendicular planes, but this was often missing. Part (c)(ii) was again a part where some student missed the mark writing ‘the eyeball is not spherical’ or ‘irregular shaped lens or cornea’ rather than relating the answer only to the surface of the cornea not being spherical. Part (c) (iii) produced the highest percentage of correct answers.

E2. This question was related to the ear and the two relative intensity scales, dB and dBA. In part (a)(i) many students failed to gain the mark as they were unable to explain why the reading would be 60 dBA, failing to express clearly that the frequency of 1 kHz was the reference frequency at the threshold of hearing. Part (a)(ii) had the most blanks of any question on the paper. Those students who attempted this part could clearly be seen as those who had a good idea of what was happening and those who were guessing. Part (b)(ii) brought its own problem with the initial calculation of intensity 5m from the source. There were a significant number of students who said that the intensity was $2/5^2$. Those who failed to get this calculation correct were given some credit for using their value in a further calculation.

E3. This question was related to the use of optical fibres in an endoscope. Part (a) looked at the refractive indices of the fibre and surrounding air and was poorly answered. There were very few students who recognised the small difference in refractive index between the core and the cladding. Poor answers showing continually varying values in all regions including air were common. This was very disappointing as it is related to A/S work. Part (b) produced better answers with many students gaining two marks. Poor expression such as ‘non-coherent bundles transfer light’ or ‘coherent bundles form an image’ was again responsible for some students losing marks.

E4. This question was related to ultrasound scans. Part (a) was the part where written communication was examined and related to prenatal scans. This was felt to be a topic that the students would be able to write on in a logical manner, but most answers were lacking in detail and coherence, with poor spelling and sentence construction. The use of a multi-array probe in a B-scan was very poorly described and very few answers could be graded in the high level as good to excellent. Many students still refer to the gel used in ultrasound as 'Conducting' confusing this with the gel used in an ecg examination, even suggesting that the patients stomach should be rubbed with sandpaper to remove unwanted hairs. Many students suggested that the ultrasound was diffracted or scattered at boundaries. The reasons for the partial reflections were not often given. The use of the gel to eliminate air was often not discussed. Students often referred to the scan being safer than using X-rays, but failed to state that this was because ultrasound is non-ionising. Part (b) provided many students with a single mark. Very few students related the length of pulse to the short distances travelled and thus the short time available between the start of the transmitted and reflected pulses. Several students gave incorrect answers suggesting that the short pulses were used to allow the reflected pulse to be received before the next pulse was transmitted.

E5. This question was related to X–ray production and use. Part (a) (i) and (ii) were related to A/S work and although there were good answers which showed a clear understanding of the principle needed in part (i), there were far more answers which had students trying to use the general equation for kinetic energy with random values being substituted for the electron's speed. A wrong answer in (i) was carried forward to (ii) where students were able to gain both marks on offer. There were better answers in part (ii), but random equations such as that for the deBroglie wavelength were often seen. Part (b) was to do with a simple description of a CT scan. Good answers were seen where students were able to express clearly and concisely the main points of the scan. However, too many students again failed to score high marks by either contradicting themselves or by being too vague in what they were writing. Answers such as 'the CT scanner rotates' rather than the X–ray source rotates. From some answers it seemed that students hadn't covered this topic, and instead of describing the CT scan, they thought they would make up for it by describing how X–rays are produced, or how images are obtained by fluoroscopy.

E6. The first question was about the eye. Part (a) asked the candidates to complete three ray diagrams to explain long sight. The majority of candidates got the first two diagrams correct however, the third diagram showing the use of the correcting lens was done very poorly. Of those that did score the mark, few showed clearly that after refraction at the correcting lens the rays should appear to be coming from the unaided near point. Only a handful actually produced dotted lines back in line with those rays. It was also noticeable how many candidates did not use a ruler to draw the rays, even though it is clearly stated on the front of the paper that they should have a ruler in the exam.

In part (b) there were less than a quarter of the candidates who gained full marks, the majority of the candidates only scoring one mark for expressing their final answer to the correct number of significant figures. It had been hoped that the third diagram in part (a) would have given the candidates the clue that the object was real and the image was virtual, but many candidates thought that both were real, using positive values in the equation, whilst a noticeable number of candidates used values suggesting that the image was real and the object was virtual.

In part (c) the use of the term ‘flicker fusion’ was common, but a direct explanation of persistence of vision was very rare. The second mark for stating a practical situation where it is important was well answered with most candidates mentioning cinema or television.

E7. Part (a) asked for a clear definition of I_0, but the majority of candidates did not include either the fact that this was for a person with normal hearing or that it was at a frequency of 1 kHz resulting in no marks being scored by over half of the candidates. This was disappointing as it is a standard definition.

In (b), the line for part (i) had to show an increasing loss with increasing frequency which was lost with careless drawing. There were a noticeable number of candidates who drew a new line parallel to the original line clearly not understanding the idea involved. The line for part (ii) should have shown an increase in loss followed by a decrease in loss as the frequency increased, with maximum loss at 4 kHz. Many candidates gained the first mark, but few drew a line which showed the maximum loss at 4 kHz. There were quite a number of candidates who tried to relate a loss of hearing with a new line drawn underneath the given line.

E8. This proved to be the easiest question, with nearly all candidates producing some correct facts and over half the candidates scoring four or five marks. In part (a), the majority of the marks were lost by candidates not answering both parts relating to fibre arrangement and use.

In part (b), most candidates got the equation and therefore the answer right, but some candidates lost the mark when they did not give their numeric answer correctly rounded to the number of significant figures which they wished to quote. This was not a penalty on significant figures, but on the rounding procedure.

E9. In part (a), much of what was written did not answer the question clearly. The impression often given was that this topic had been learnt parrot-fashion from a revision guide, or dictated notes, because candidates who clearly did not understand what was being measured could often quote ‘high gain, large input impedance, low noise’ impeccably, without relating it to an amplifier, often just to the ‘sensors’, or just the ECG machine. Many candidates, presumably confused by the use of a gel, were drawn into describing some features of an ultrasound scan. Coupling gel was often used to reduce impedance, matching that of the skin, and sometimes an A scan was received on the oscilloscope.

Generally, answers were so mixed up with actual features of an ECG scan that it was difficult to be sure what was being described. Features that seemed to have registered well were the shaving of the chest and the absolute requirement not to use the right leg. Sometimes it was clear from the answer that the candidate thought that the electrodes were being used to supply a voltage to the patient – which is why the leads needed to be screened so as not to shock or electrocute them. ‘Low noise’ was a giveaway to the poor understanding of other candidates when it was clear that it was being related to sound. The ECG machine had to be quiet, the room had not to be noisy either otherwise it would ‘spoil the trace’.

In (b)(i) many candidates gained the unit mark, mV, but the scale mark was often lost by either placing the zero in the wrong place or by confusing it with that for the nerve action potential.

In (b)(ii) the scale was generally well known, but sometimes it was drawn looking non-uniform because candidates were trying to relate peaks on the graph to remembered values.

In (b)(iii) there were many answers which gained full marks. Those that lost marks did so because they did not give the electrical events, but described the resulting movements of the heart.

E10. Part (a) highlighted the inability of many candidates to state their answers clearly and so marks were often lost by omission; omission to state the atoms of the target anode were excited or ionised, rather than just the target; omission to mention the inner electron shell is involved in this process if X-rays are produced; omission to relate the specific energy of the X-ray photon to the specific difference in energy due to the specific levels of the excited/de-excited atom.

Part (b) produced some good answers, but there was quite a lot of confusion between the intensifying cassette and the intensifier tube; some candidates had X-rays producing light photons then electrons drawn to an anode and a second fluorescent layer which they thought might be the rear intensifying screen. The point that the screens being in close contact with the film mean that the film is exposed by the light in the same place as it would have been exposed by the X-ray was missed by nearly all candidates.

E11. This question on lenses and defects of vision was expected to provide a straight forward introduction to the paper, but this was not the case for the majority of candidates. The ray diagram was completed correctly by a minority of candidates, many drawing the ray diagram for a converging lens. Most candidates were able to define the power of a lens and realised that a diverging lens was used to correct myopia or short-sight.

The lens calculation in part (c) (ii) was answered poorly. Candidates still find these eye defect calculations difficult, and correct answers were in the minority. Candidates can struggle to decide which is u and which is v in the lens formula, and many candidates had no idea the image was virtual and thus needed a negative value in the formula. However most candidates gave their answers to the correct number of significant figures and were awarded the maximum mark.

In part (d) most candidates gave the answer ‘use cylindrical lenses’. This response did not answer the question correctly. Candidates needed to refer to ‘the format of the prescription’ ie the power and the axis of correction for the lens.

E12. Part (a) was about the structure of the ear. In (a) (i) most candidates wrote about the ear drum vibrating and then passing a vibration through the bones to the oval window. Very few candidates talked about pressure waves for the sound at the start or the end. Of the candidates who did talk about pressure waves in the cochlea very few mentioned that it was in a liquid.

Many candidates did not appreciate the importance of saying the ear drum vibrates in order to transmit mechanical vibrations, not sound or pressure waves, through the middle ear.

In part (a) (ii) very few candidates said that the **force** was increased by the bones of the middle ear, and some who did lost the mark by saying the force was amplified by 50%. A significant number of candidates talked about the ear bones amplifying sound or pressure not force. The realisation that the oval window was much smaller than the tympanic membrane was the source of the majority of marks awarded for this part of the question.

In part (b) it was unfortunate that the value of I_0, the threshold of hearing, was not given in the question. However, this was not a problem for many candidates who were able to quote the value and core full mark There were quite a few candidate who could not olve the log part of the equation and a minority who did not know the difference between log base 10 and log base e.

Many candidates were awarded a mark for stating what was meant by the dBA scale in part (c), but a correct deduction about the frequency of the sound being tested was rarely seen.

E13. Part (a) was about the action potential of a nerve, but a significant number of candidates sketched the ecg trace, and a small number sketched the action potential of the heart. If the correct shape was drawn, then most candidates were able to score the marks for labelling the axes with the correct scale and unit.

In part (b) there were quite a few candidates who used about three quarters of the space available talking about the sodium potassium pump getting the muscle into equilibrium and then tried to squeeze the action potential into two lines at the end. There were some good descriptions of the ion movements, but the majority of candidates answers fell within the middle strand as shown in the mark scheme. The main faults were not using specific physics terms such as depolarisation, reverse polarisation and repolarisation, or not relating the ion movement with specified changes of potential.

E14. This question concerned the new part of the specification.

In part (a) most candidates had an idea of how the MR scanner worked but did not include enough detail Thing mi ed were the trength of the magnetic field, talking about the effect on hydrogen **nuclei** rather than atoms or molecules, and that the radio pulses emitted on relaxation had to be detected before they were passed on to be processed by a computer.

Part (b) was answered well on the whole with many candidates talking about safety issues to gain credit and some talking about the better detail produced in picturing soft tissues. The candidates who just stated ‘cheaper’ or ‘easier to use’ may have been running out of time on the last question. Quite a few candidates incorrectly seemed to think that MR scanning was less claustrophobic than CT scanning.

E19. Few candidates gained full marks in part (a). Confusion reigned about what was a property and what was an explanation. When a valid property was named, the explanation of that property was often wrong, e.g. monochromatic - all in phase, coherent - same frequency etc. Good answers were seen in part (b) with simple descriptions of the use of both kinds of light.

Part (c) (i) was answered very poorly. Mistakes were common; such as the cladding having a higher refractive index than the core, a gradual change occurring in the refractive index and the refractive index of air being zero. Part (c) (ii) realised better answers and overall it was answered fairly well. It was surprising though how many candidates thought the angle of refraction was 20°. The most common mistake, however, was in the actual calculation of the critical angle.

E20. Drawing the correct ray diagram in part (a) proved to be beyond the capabilities of most candidates with the majority of diagrams showing the formation of a real image. Part (b) (i) was probably the ea ie t mark on the paper and the an wer of myopia wa well known The an wer to the lens calculation in part (ii) proved to be as variable as ever, with candidates finding it difficult to allocate the correct signs in these calculations. A surprisingly common mistake was to use the power *P* as –1/3 instead of –3. Also several candidates were confused with the meaning of *u* and v in the lens equation.

E21. Some candidates were able to answer this question clearly and concisely, earning all eight marks. Quite a few lost two marks by turning electrons into photons, rather than the electron's energy into photons, and vice versa. The remainder, which was the majority, found the question difficult and guessed at many of the answers.

E22 On the whole, thi que tion wa done well In part (i), ome candidate lo t a mark by suggesting that the acoustic impedance depended on the speed of light. The mark in part (ii) was only awarded if the candidate indicated a large difference in the acoustic impedance. In part (iii), candidates usually gained some credit, but often their answers lacked sufficient clarity to be awarded full marks.

E23. There were some very good answers from candidates who stated clearly the different responses from cones and rods. On the other hand there were many candidates who failed to express their answers clearly and as a result lost marks. An example of this was 'more rods than cones in low intensity leading to very little colour'. Several candidates were clearly aware of the physics involved, but did not answer the question and compare what was seen in each case.

Parts (b) (i) and (ii) were answered well by most candidates, but some decided to remove the minus sign from the value of the power before completing the question. Part (b) (iii) raised quite a few problems. The use of v instead of *u* was often seen, but usually led to the right answer by some subtle changing of signs. This gained no credit and was treated as a physics error. Candidates who used the alternative method, i.e. using a real lens-to-retina image distance fared much better, because they did not become confused with distances or signs. Whole centres would use this method, and most of their candidates performed well on the question.

E24. This question was very well answered by a small number of candidates, but carelessly phrased answers led to most candidates losing marks unnecessarily. In part (a), many candidates started their answer by stating that a voltage was applied across the crystal, missing out the essential fact that it must be an alternating voltage. Other candidates wrote about alternating currents being passed through the crystal, or voltages passing through the crystal.

In part (b) (i), there were many candidates who went into great detail about reflection and acoustic impedance, timings and swept-gain amplifiers, but clearly did not understand what ‘detected’ meant. Those who did understand the situation, often gave answers which lacked clarity. In part (ii), most candidates knew that short pulses of ultrasound were used to avoid interference between the outgoing and incoming pulses, but either did not state where this would occur, or else suggested that there should be a time lapse between the reflected pulse being received and the next pulse going out, instead of between the generated pulse and its reflection being received.

E25. Part (a) was correctly answered by nearly all candidates. Many candidates gained the mark for part (b) (i), but fewer were able to state the main hearing loss being at 4 kHz in part (ii).

Part (c) (i) was also done well, and most candidates did show their working, ending up with an answer of 3.98×10^4 W m^{-2}. Contrary to this, part (ii) was, on the whole, answered poorly. Although most candidates tried to use the correct expression, entering the data seemed to be a random process.

E26. Very few candidates gained full marks for this question. In part (a), most candidates failed to state that the photon energies were specific to the target material. There were better answers to part (b), but many candidates tried to keep the areas under the graphs the same, which made them lose the mark for the 90 keV curve having greater intensity than the original curve. The new curve should have finished midway between the 80 and 100 keV marks, but this was too much for quite a few candidates. This was a careless error which could, and should, have been avoided.

For what was a relatively simple calculation in part (c), the answers were poor. Most candidates managed to obtain the input power, but then went on to work out 0.7% (or 70%, or 0.7) and gave that answer as the heat produced. Examiners would have hoped that an answer of 67W would have struck the candidates as being far too low for an X-ray tube. Many otherwise good answers were spoilt by the careless use of significant figures in the final answer.

E27. In part (a), when describing how an equal loudness curve was obtained, few candidates scored more than one mark. Most candidates treated the curve as the threshold curve, even though the stem of the question stated that it was not. Sketching the 100 dB curve was also poorly done with many curves missing the stated point and failing to show a minimum at 3 kHz.

In part (b) most candidates gained a mark for the definition of I_0, but failed to gain the second mark for stating that it was the intensity at 1 kHz. Nearly all candidates were able to calculate the intensity level of the sound, but too many candidates lost a mark because of a wrong unit.

E28. Overall, this was the best answered question in the paper, but errors, which have been highlighted in past reports, were still made. In part (a) most of the marks were lost because the statements were too vague. In part (i) the shape of the cornea was sometimes described as ‘being like a rugby ball’. This may be vaguely true, but a more scientific description, such as ‘non-spherical’ would have been more appropriate. Several candidates failed to give two parameters of the correcting lens in part (iv).

In part (b) (i), the most common error was failing to realise that the image produced was virtual, thus requiring any distances used in related calculations to be negative. Few candidates gained the allocated mark in part (ii), many losing the mark for giving the answer to too few significant figures.

E29. Few candidates gained full marks in part (a) for what was considered to be a straightforward question. Marks were lost in all aspects, with wrong units on axes, silly scales, a failure to realise where the zero was on the potential axis and in completing the curve to a reasonable degree of accuracy.

Marks were lost in part (b) because candidates failed to explain clearly why certain precautions were taken when attaching electrodes to the patient. A few candidates also failed to give precaution relating to the connection of the electrode and thu failed to gain any mark

E30. In part (i) many candidates stated that it was the reduction of intensity to half the original value that gave the half-value thickness, but only one candidate was able to complete the definition by relating this to a specific energy of an X-ray beam. Only half the candidates were able to quote the correct equation in part (ii), and again, many candidates lost a mark by failing to give a correct unit with their answer. It was evident that in part (iii) candidates failed to understand what the intensity of the beam meant. Very often they would start by suggesting that the initial intensity was 90 keV and the final intensity 4.5 keV. Such a basic error in Physics ensured that no further marks were awarded.

E31. This question proved to be an easy introduction to the Medical Physics section and many candidates scored well. The main errors came from the poor use of the word ”clear” to describe the image rather than discussing resolution or contrast. Several candidates lost marks because instead of giving the advantages of the method they had quoted they gave disadvantages of another method.

E32. Although attempted by all candidates, it proved to be the most difficult question on the paper as it relied on the candidates understanding the situation. In part (a) (i), many candidates gained the initial mark, stating that the dB scale was independent of frequency, but the dBA scale was frequency dependent. Having given the correct answer in part (i), nearly all candidates now chose to ignore it when it came to sketching the relevant lines on the graph in part (ii). The dB line was nearly always shown as the threshold of hearing line and the dBA line as a higher loudness line. The few candidates who drew the dB line as a straight line at a constant intensity level often drew the dBA line as a dipping threshold of hearing curve rather than the exact opposite, a curve which crossed the dB line at 1 kHz and peaked at 3 kHz.

In part (b), most candidates were able to calculate the sound intensity incident on the ear–drum, but were then unable to go beyond that and obtain the power simply by multiplying the intensity with the cross-sectional area. Many candidates gave an equation stating that *power = intensity*/*cross-sectional area*.

E33. Part (a) (i) proved to be a good introduction, answered correctly by most candidates, although some lost a mark by wrongly labelling the zero on the potential axis. Unfortunately, this part was not attempted by a number of candidates who may not have read the question completely. Some also confused the given trace with the *action potential* curve and thus lost both available marks. There were some excellent answers in part (ii), showing that the candidates had a good understanding of the situation. Some candidates lost marks due to their answers again lacking the clarity needed, e.g. referring just to ‘depolarisation’ rather than ‘depolarisation of ….’

In general there were poor answers to part (b). Many candidates confused the correct use of a conducting gel in this situation with the use of an acoustic gel in ultra-sound scans and answers often referred to ‘reducing the amount of reflection at the boundary’. There were many pot-shots at part (c), the answers suggesting that candidates had little idea of the other properties of the amplifier.

E34. On the whole this question was answered well, with many candidates scoring full marks. The main errors were in (i), confusing a coherent bundle with a coherent light source, and in (iii) stating that a bundle made from small diameter fibres was easier to insert into the patient, without discussing its flexibility. Again some candidates lost marks because they referred to ‘clear’ images instead of increased resolution of the image.

E35. This question produced the poorest answers in the whole paper and it was clear that many candidates had little real knowledge of the situation outlined in the question. In part (a) the large majority of candidates failed to appreciate that the image was virtual and did not apply the correct convention in the calculation involving the lens formula. More candidates worked out the magnification correctly, but a noticeable number wrongly used object distance divided by image distance.

In part (b) only two correct diagrams were seen. Candidates appeared to have very little idea of how to construct a ray diagram and of those that did they failed to realise the relevance of the virtual image.

The best answers appeared in part (c)(i). In part (ii), clear thinking was missing in most of the answers submitted. Even allowing for an incorrect answer in part (a)(i) to be carried forward, very few candidates produced a correct answer. Many were unable to even start the calculation and of those that did, the majority stated that the aided far point would still be at infinity.

E36. Several candidates gained full marks for this question. In part (a), many lost the first mark by defining intensity in terms of energy instead of energy per second or power. Many candidates gave a correct explanation of attenuation but a common misconception was that attenuation was cau ed by the preading of a wave from a point ource according to the inver e quare law

In part (b), although many candidates carried out the calculation correctly a common error arose from the fact that the units were not read carefully enough and watts was used as the unit of I0 instead of the given mW.

E37. Candidates provided good answers to this question and it earned the highest marks on the paper. In part (a) most candidates were able to describe the action of the heart and full marks were awarded quite often. Marks were lost when candidates were unable to express their ideas clearly and occasionally four steps were described as atrium to ventricule to atrium to ventricule.

Answers to part (b) also saw many full marks being awarded but marks were lost for including wrong answers alongside the correct ones, e.g. in part (i) stating that both potassium and sodium ions entered the membrane.

E38. Although a number of candidates gained full marks, this question proved to be difficult for some. Answers to part (a) often lacked the clarity needed to be awarded the allocated marks and usually candidates were only awarded one or two marks of the possible three. A number of candidates did not really understand what was required by the question and tried to answer in terms of an image intensifier or intensifying screens. Some candidates even discussed the use of a grid to enhance the picture by reducing scattered *x*-rays reaching the film.

It was very pleasing to find that the calculation in part (b) was carried out correctly in a number of ca e Some candidate failed to rearrange the e ponential equation correctly but they appeared to be fewer in number than in previous *y*ears.

E39. Most candidates found, in part (a), an easy introduction to the paper and were able to draw the path of the two rays correctly, thus scoring both marks. Some candidates however, showed the lens acting as a diverging lens and were subsequently penalised. Although it was considered to be an easy introduction, a significant number of candidates did not attempt it.

In order to give candidates a starting point to part (b), the fovea was marked on the diagram. This was picked up by many of the candidates who then proceeded to give the required answer. The recurring error in the answer was the statement that rods were found at the fovea.

Both parts (c) and (d) were answered well by nearly all the candidates, except that in part (d) many candidates thought that accommodation referred to dark adaptation.

E40. Answers to this question were, in general, the poorest on the paper. In part (a), for example, many candidates failed to score any marks. The most common errors for the potential difference axis was having the wrong units, which included V, μV and eV, and also the wrong scale, which should have been from –30 to + 70 in mV. A common fault for the time axis was the use of seconds rather than ms as the unit.

The answers to part (b) were better than those to part (a), but many candidates failed to obtain full marks because of poorly expressed answers. Several candidates referred to sodium ions moving out of the membrane and potassium ions moving in, rather than the other way around.

E41. The majority of candidates scored high marks on part (a); marks not awarded were usually due to a failing to describe the function of the ossicles clearly enough.

The calculation in part (b) proved difficult for the majority of the candidates. Some candidates treated 42 dB as the intensity and worked out an intensity level. Other candidates were able to insert the correct numbers into the relevant equation, but were then unable to calculate the final answer correctly. Several candidates worked out the final answer correctly, but lost a mark by failing to give the correct unit.

E42. This question was, in general, answered well, but many candidates wrote a great deal, especially in part (b) and gained no marks. In part (a) many wrong ideas were encountered, especially in part (i). These including "focussing the beam more", "increasing the distance between the beam and the patient" and "increasing the angle of the bevelled edge". In nearly all cases it was found that if a candidate was able to give a correct method in part (i) then the correct effect was given in part (ii).

Although many candidates failed on part (b), full marks were gained sometimes. The main error was a failure to use correct terminology. Several candidates referred to X-ray intensity when they meant X-ray photon energy. Other candidates wrongly based their answer on the use of the grid in front of the detector to stop scattered X-rays.

E43. It was disappointing in part (a) to find that many candidates were not aware of the simple arrangement needed to produce an image the same size as the object i.e. $v = u = 2f$. A common mistake on the ray diagram was incorrectly labelling the focal point as the point where the image was formed. Whilst this was clearly an error in many cases brought about by giving an answer of 4 cm to part (i), a good understanding of ray diagrams would have led candidates to draw the correct construction and amend their answer to part (i).

In part (b) a significant number of candidates did not read the question correctly and failed to realise that the lens in part (a) had been replaced by another. There was also some carelessness in the calculation in part (i) and many candidates did not include the negative sign in the answer. Answers to part (ii) showed that there was considerable confusion as to which three properties of the image were required. The required properties were size (magnified/diminished), orientation (upright/inverted) and type of image (real/virtual).

E44. There were many wrong answers to part (a)(i), some of which involved the correct term being included with an incorrect term such as “ myopia or long sight”. In part (ii) most answers showed a correct response to the answer given in (i), but several were too vague or gave wrong statements concerning the lens, such as “the lens is too big”.

In part (b) many candidate completed the fir t diagram correctly but were unable to follow through to give the correct second diagram and showed the rays coming to a focus behind instead of before the retina. This resulted in many poor answers to the third diagram.

Several candidates scored full marks in part (c), but in general, this part was poorly answered with most candidates using random numbers to get an answer. It was clear that some candidates were calculating the total power of the eye when unaided and aided, but failed to explain their working clearly.

E45. In their answers to part (a)(i) most candidates discussed interference between the incident wave and the reflected wave, and failed to realise that the use of the same probe as transmitter and receiver was the reason for the pulse to be short. Answers to part (ii) were often too vague to be awarded many marks. Reference to a pd being applied across the crystal without stating that the pd must be alternating or high frequency were common. There were many references to resonance without any further explanation.

Nearly all candidates were able to gain the allocated mark in part (b) for the advantage of using ultrasound but few gained the mark for the disadvantage because the answers were too vague such as “the image is not clear”.

E46. This question was the most poorly answered on the paper. Many candidates failed to gain any of the allocated six marks. In part (a)(i), although the candidates were told that the graph passed through 120 dB at a frequency of 1000 Hz, most answers ignored this point on the graph. Of the candidates who correctly identified this point, many then tried to draw the same curve as the one given, but at a higher level. There were very few correct curves seen. Part (ii) produced a few more correct answers, but again random statements were much in evidence.

In part (b) the sketches of the hearing loss curves were very disappointing and the answers showed a lack of understanding of the difference between the two types of hearing loss. Very few candidates gained any credit for clear statements relating the loss to frequency.

E47. In part (a)(i) most wrong answers stated that the fluorescent screen converted X-rays to electrons. Having answered part (i) wrongly, the candidates were then unable to give a sensible answer to part (ii). In part (iii) most candidates were able to gain one of the two marks available by stating that the anodes were used to accelerate the electrons or to focus the electron beam The most common error in part (iv) was again a poor use of language with candidates discussing electrons rather than electron energy being converted into light.

It was disappointing to find in part (b) that the use of the image intensifier was not well known. Many candidate confu ed the image inten ifier with inten ifying creen and thu produced a wrong answer.

Resource currently unavailable.