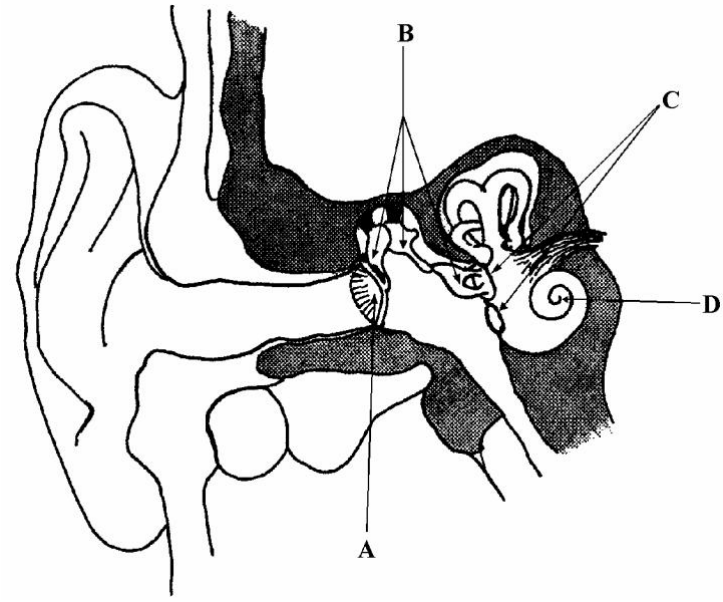
1. The diagram shows a vertical section through the human ear. Solid bone is shaded grey.



Name and state the function of the parts labelled A, B, C and D.

A name .....

function .....

.....

B name .....

function .....

.....

C name .....

function .....

.....

D name .....

function .....

.....

(Total 8 marks)

2. Bundles of optical fibres are described as either *coherent* or *non-coherent.*

(a) Describe how the fibres are arranged in each type of bundle and explain how the different designs determine their optical characteristics.

.....

.....

.....

.....

.....

.....

.....

(2)

(b) State an application for each type of bundle.

application of *coherent* bundle .....

.....

application of *non-coherent* bundle .....

.....

(2)

(c) (i) Give **two** advantages of a bundle consisting of fibres of very small diameter over a bundle consisting of larger fibres.

advantage 1 .....

.....

advantage 2 .....

.....

(ii) Give **two** reasons why a glass cladding is used around the central core of each fibre in a coherent bundle.

reason 1 .....

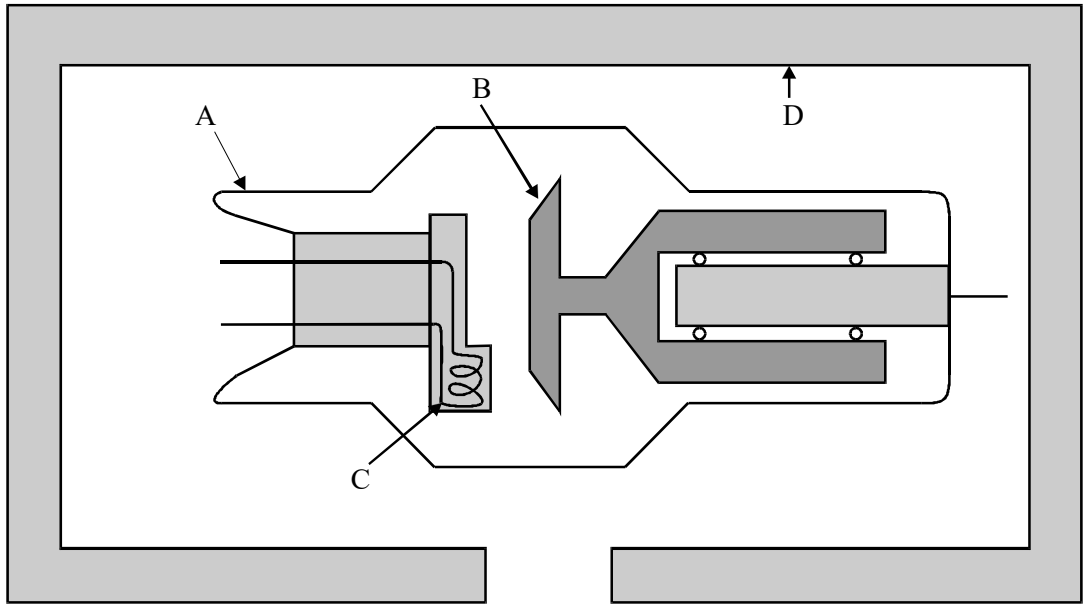
.....

reason 2 .....

.....

(4)
(Total 8 marks)

3. The simplified diagram shows a modern X-ray tube.



(a) For each of the labelled parts, state what it is and explain its purpose.

A name .....

purpose .....

.....

B name .....

purpose .....

.....

C name .....

purpose .....

.....

D name .....

purpose .....

.....

(8)

(b) On the diagram draw and label

(i) the direction of the electron beam,

(ii) the direction of the useful X-ray beam.

(2)
(Total 10 marks)

4. (a) The *threshold of hearing* is quoted as 1.0×10^{-12} W m^{-2}. Explain what is meant by the *threshold of hearing* and state the frequency at which the threshold has this value.

.....

.....

(2)

(b) Sound intensity levels are usually measured in decibels. Give **two** reasons why this *logarithmic* scale is used.

.....

.....

.....

.....

(2)

(c) Why was it necessary to introduce an adapted scale referred to as the dBA scale, which is used on some sound level matters?

.....

.....

.....

(1)

(d) Modern hi-fi equipment and televisions often have volume controls which allow the sound volume to be increased in steps. If each of these steps produces an increase in the sound intensity level of 2.0 dB, calculate

(i) the ratio by which the sound intensity is increased for each step up in volume,

.....

.....

.....

.....

(ii) the ratio by which the sound intensity is increased for a total of 10 identical steps up in the volume.

.....

.....

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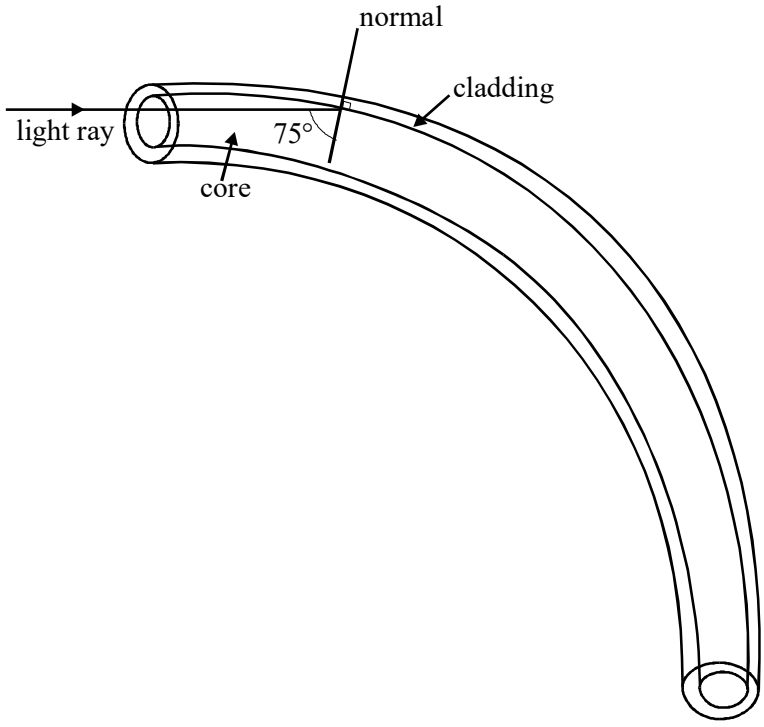
.....

(4)
(Total 9 marks)

5. The diagram shows a glass optical fibre with a central core of refractive index 1.55 and a surrounding cladding of refractive index 1.40.



(a) Calculate the critical angle, *C*, for the boundary between these two types of glass.

.....

.....

.....

.....

.....

(3)

(b) Complete the path of the light ray shown in the diagram.

(2)

(c) State and explain whether the following changes in the optical fibre would increase or decrease the probability of light escaping from the fibre.

(i) increasing the refractive index of the cladding

.....

.....

(ii) bending the fibre into a tighter curve

.....

.....

(3)
(Total 8 marks)

6. (a) Explain how a piezoelectric crystal is caused to generate waves of ultrasound.

.....

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.....

.....

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.....

(4)

(b) In medical applications of ultrasound a short pulse of duration about 1 μs is often used.

(i) Explain why the pulse of ultrasound must be short.

.....

.....

.....

(ii) Short voltage pulses applied to the piezoelectric crystal make it vibrate and emit *short* pulses only if the crystal assembly is modified. Explain the modification which is necessary.

.....

.....

.....

(3)

(c) (i) Under what conditions is ultrasound reflected strongly at boundaries between two types of material?

.....

.....

(ii) State **two** physical properties of the materials which determine the proportion of ultrasound which is reflected at a boundary.

.....

.....

(iii) Explain what a coupling medium or gel is and why, and where, it is used.

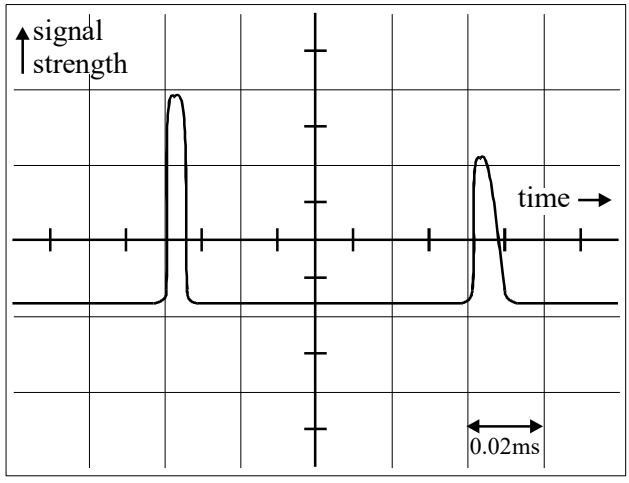
.....

.....

.....

(5)
(Total 12 marks)

7. An ultrasound transducer is used to obtain an A-scan of an internal organ. The A-scan pulses shown on the diagram were identified as coming from the front and rear surfaces of the organ.



(a) Describe the practical process, including details of the use of the transducer and the adjustment of the oscilloscope, required to produce this A-scan.

.....

.....

.....

.....

.....

(3)

(b) From the A-scan, estimate

(i) the thickness of the organ if the speed of ultrasound in the tissue is 1500 m s^{-1} (the horizontal scale is 0.02 ms/cm),

.....

.....

.....

(ii) the duration of the first ultrasound pulse.

.....

(3)

(c) Give **two** reasons why the height of the second pulse is smaller than that of the first pulse.

.....

.....

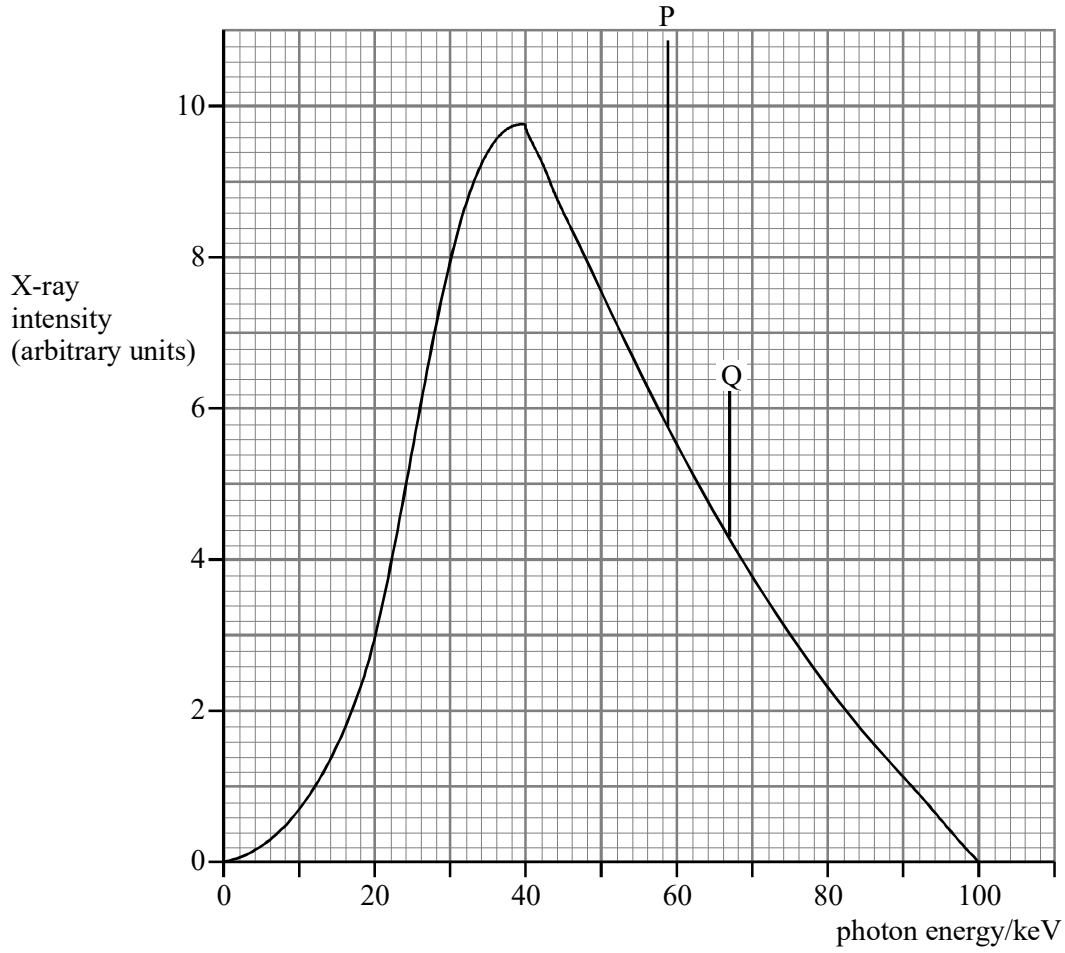
.....

.....

(2)

(Total 8 marks)

8. The X-ray spectrum, produced by an X-ray tube used to produce diagnostic images, has the features on the diagram.



(a) Explain why the spectrum has

(i) a maximum photon energy and state the circumstances in which a photon of this energy is produced,

.....

.....

(ii) two lines, P and Q.

.....

.....

.....

(4)

(b) (i) From the graph, estimate the accelerating voltage of the tube.

.....

(ii) Calculate the frequency of the line Q.

.....

.....

.....

.....

(3)

(c) On the X-ray spectrum draw an intensity curve which shows the output you would expect from the same tube when operated at 55 kV.

(3)

(d) For diagnostic purposes it is important to minimise the X-ray dose which patients receive. State **two** steps taken to reduce the dose and briefly explain how each is effective in reducing patient dose.

step1 .....

.....

.....

step 2 .....

.....

.....

(4)

(Total 14 marks)

9. (a) State what is meant by the *threshold of hearing* and state the frequency at which the reference threshold is quoted.

.....

.....

.....

(2)

(b) Sketch a curve on the axes to show how the threshold of hearing varies with frequency across the full range audible to a normal human ear. Add a suitable frequency scale to the frequency axis.

(5)

(c) (i) Calculate the intensity of a sound which is found to have an intensity level of 60 Db above the threshold of hearing. The intensity of the threshold of hearing is 1.0×10^{-12} W m^{-2}.

.....

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.....

.....

(ii) The smallest increase in sound intensity which the human ear can detect is about 12%. Express this change in decibels.

.....

.....

.....

(4)
(Total 11 marks)

10. (a) For the eye defect astigmatism, complete each of the following.

(i) Astigmatism is caused by .....

.....

.....

.....

(ii) The image seen by a person with astigmatism is .....

.....

.....

.....

(iii) Astigmatism is corrected using .....

.....

(3)

(b) A person has a myopic eye with a range of clear vision at distances from his eye of 0.15 m to 0.80m.

(i) Calculate the power of the correcting lens which would allow this eye to produce focused images of distant objects.

.....

.....

.....

.....

(ii) Calculate the new near point position for the eye when using the correcting lens.

.....

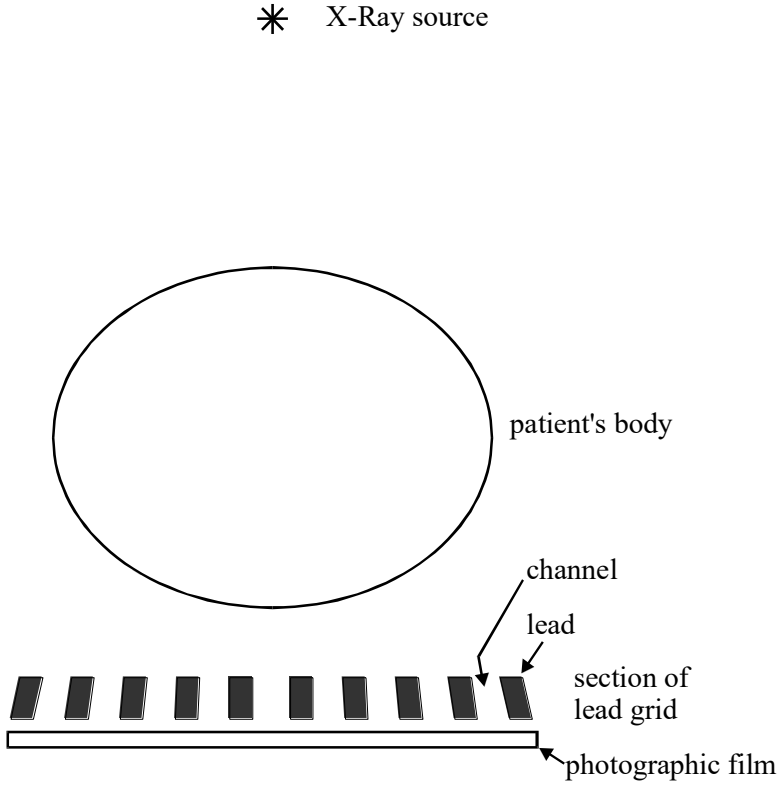
.....

.....

.....

(4)
(Total 7 marks)

11. When using an X-ray source to produce an image of part of a patient a lead grid is sometimes placed between the patient and the photographic film, as shown in the diagram. The channels in the grid diverge from the X-ray source.



(a) (i) Why is the grid made of lead? .....

.....

(ii) By drawing the paths of about 10 rays from the X-ray source to illustrate your answer, explain how the use of the grid improves the clarity of the X-ray image.

.....

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.....

.....

(5)

(b) Explain why it is important to use a *point source* of X-rays for imaging purposes.

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.....

.....

(1)
(Total 6 marks)

12. (a) A lens is used as shown in figure 1 to enable a person with an eye defect to see distant objects clearly.

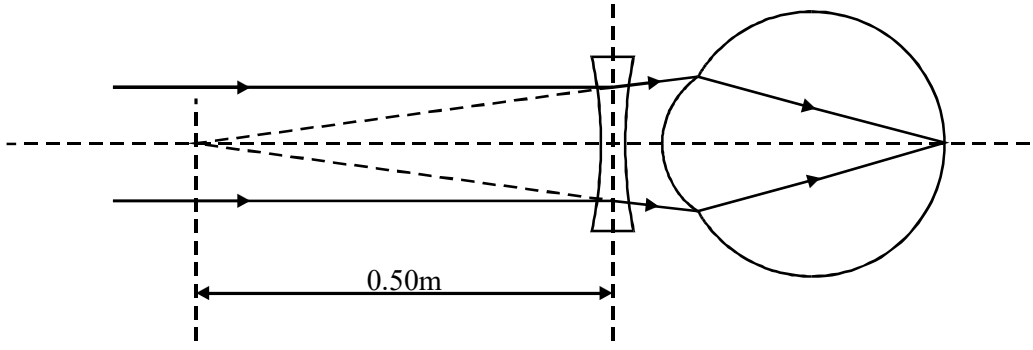


figure 1

(i) Name the defect corrected by this lens.

.....

(ii) Determine the power of the lens.

.....

.....

.....

(iii) Draw a ray diagram on figure 2 to show the path through the eye of rays from a distant object when a correcting lens is not being used.

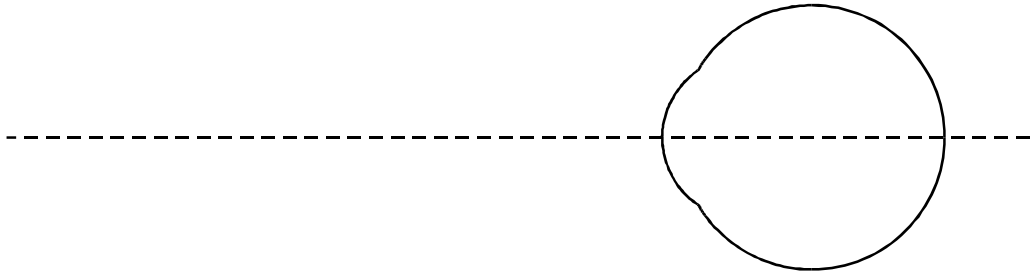


figure 2

(iv) Draw a ray diagram on figure 3 to show the path through the eye of rays from an object positioned at the uncorrected far-point.

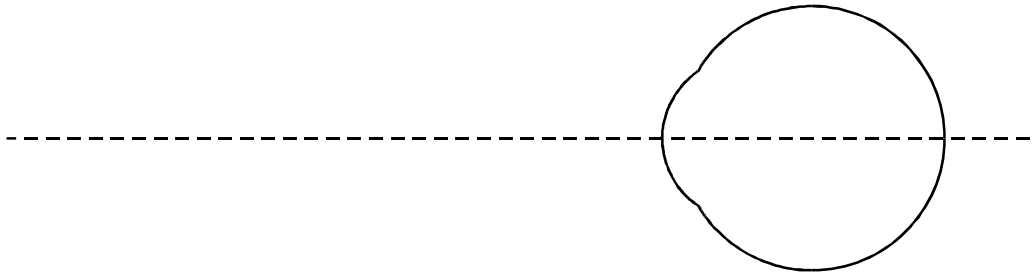


figure 3

(v) State one cause of the defect you have named in part (i).

.....

(6)

(b) When a camera is focused on a near object at a point P, the distance from lens to film is 36.4 mm. In order to refocus on a very distant object, the lens has to be moved a distance of 1.2 mm.

(i) State the direction in which the lens must be moved.

.....

(ii) Calculate the focal length of the lens.

.....

.....

(iii) Calculate the distance from the lens to P.

.....

.....

.....

(iv) One frame of the film in the camera has a height of 24mm. Determine whether or not the image of an object of height 0.60 m placed at P will fit into this frame.

.....

.....

.....

.....

(7)

(c) A photographic plate can be used with an astronomical telescope in order to photograph the night sky. State where the plate should be positioned in the telescope and give **one** advantage which photography has over direct observation when using telescopes.

.....

.....

.....

(2)
(Total 15 marks)

13. (a) State **two** applications of laser radiation in medicine.

1 .....

2 .....

(2)

(b) For **one** of the applications which you have given, describe how the laser radiation is applied and state any safety features needed.

method of application .....

.....

.....

.....

safety features .....

.....

.....

.....

(4)
(Total 6 marks)

14. 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.

.....

.....

.....

.....

(2)

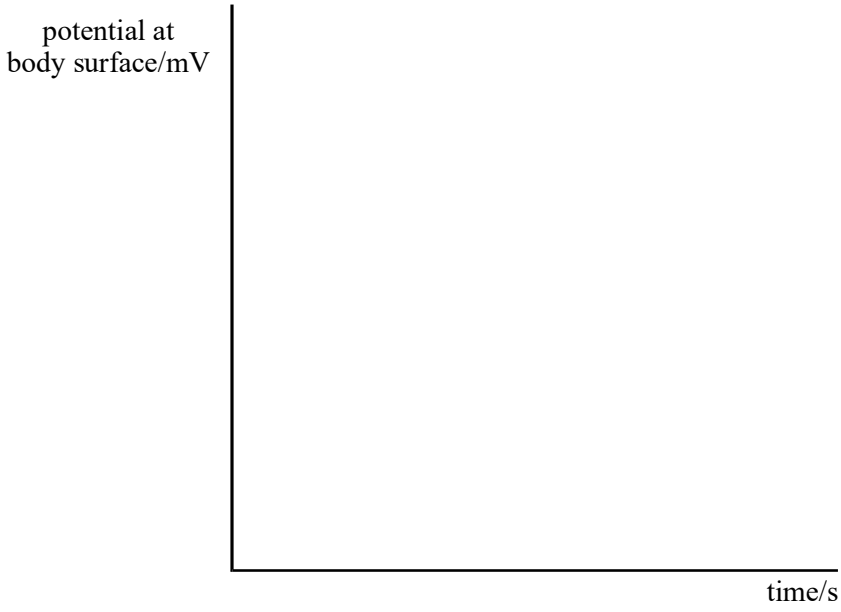
(b) State **two** properties of the amplifier needed to amplify the signal from the electrodes.

.....

.....

(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)

15. An eye test shows that a person suffers from astigmatism.

(i) Give the main cause of astigmatism.

.....

.....

(ii) State the effect of astigmatism on the image seen.

.....

.....

(iii) State the type of lens needed to correct this defect of vision.

.....

(iv) Give **two** quantities which must be known in order to manufacture the correcting lens.

1 .....

2 .....

(Total 5 marks)

16. (a) State **two** reasons why the *logarithmic* dB scale is used to compare sounds of different intensities.

.....

.....

.....

.....

(2)

(b) Another scale used to compare sounds of different intensities is the dBA scale. What are the main differences between the dBA and the dB scales?

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.....

(3)

(c) A reading of 94 dB is obtained on a sound meter placed near a drill. Calculate the intensity of the sound incident on the meter.

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

.....

.....

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.....

.....

.....

(3)

(d) An identical drill is now placed next to the first drill and both are switched on. Calculate the new reading on the sound meter.

.....

.....

.....

.....

(2)

(Total 10 marks)

17. (a) Sketch, on the axes below, the response curves for the colour cones of the eye. Label the wavelength axis with a scale appropriate for your curves.

(4)

(b) In terms of receptors,

(i) give the condition for two different images to be resolved by the eye,

.....

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.....

.....

(ii) explain why finer detail can be seen in bright light than in dim light.

.....

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.....

.....

(3)

(c) (i) State what is meant by *persistence of vision.*

.....

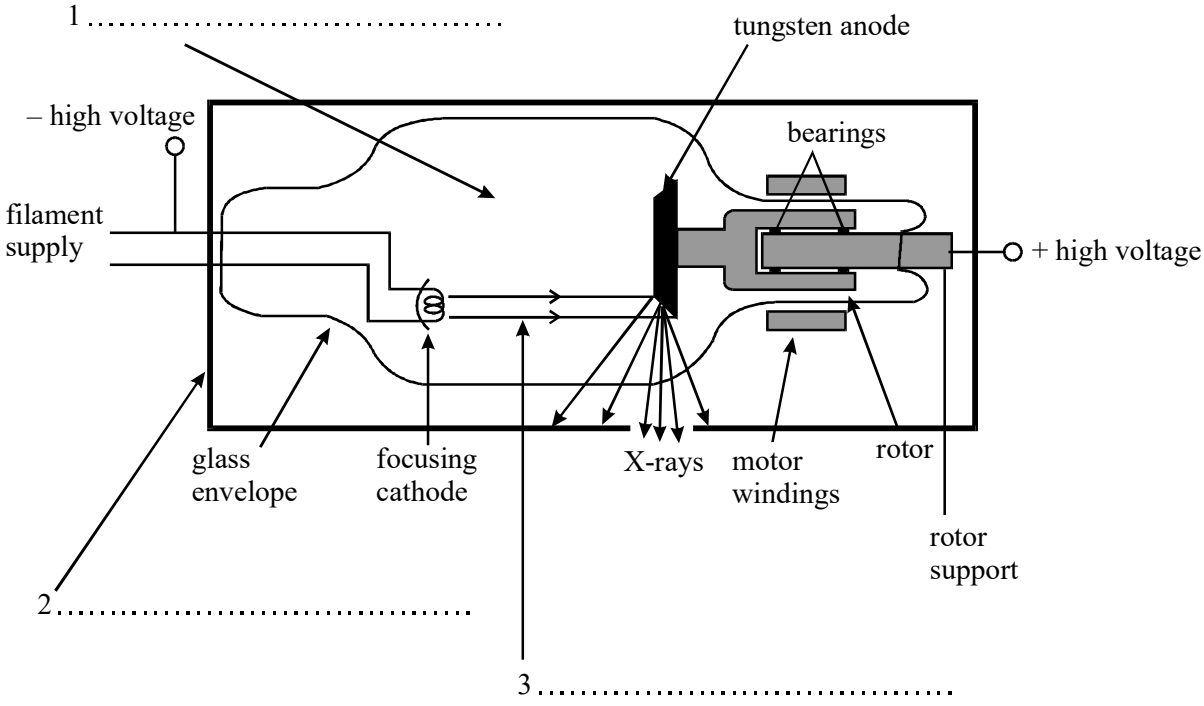
.....

(ii) Give an example of a practical situation where persistence of vision is used to advantage.

.....

(2)
(Total 9 marks)

18. (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.

.....

.....

.....

(3)

(c) Define for a material,

(i) the linear attenuation coefficient, μ,

.....

.....

.....

(ii) the half-value thickness.

.....

.....

.....

(2)

(d) A monochromatic X-ray beam of intensity 6.0 W m^{-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.

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.....

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(3)

(Total 11 marks)

19. (a) The acoustic impedance, Z, of a medium is equal to the product of the medium's density and the speed of sound in that medium. When sound is incident on the boundary between two media of acoustic impedances Z_1, and Z_2 respectively, some sound is reflected and some transmitted. The ratio of the reflected intensity, I_r, to the incident intensity, I_i, is given by the equation

$$\frac{I_r}{I_i} = \left[\frac{(Z_2 - Z_1)}{(Z_2 + Z_1)}\right]^2$$

speed of sound in air = 330 m s^{-1}
speed of sound in tissue = 1540 m s^{-1}
density of air = 1.3 kg m^{-3}
density of tissue = 1100 kg m^{-3}

(i) Calculate, giving the appropriate unit, the acoustic impedance of air.

.....

.....

(ii) Calculate the acoustic impedance of tissue.

.....

.....

(iii) Show that the ratio $\frac{I_r}{I_i}$ at an air/tissue boundary is approximately 1.

.....

.....

.....

(3)

(b) Use your answer to part (a)(iii) to explain why a coupling gel is needed between an ultrasound probe and a patient's skin. State and explain what the ideal value of the acoustic impedance would be for such a gel.

.....

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.....

.....

.....

(3)

(c) An A-scan is used to find information about the depth and size of organs within a patient's body. Explain

(i) the basic physical principles behind the A-scan,

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.....

.....

.....

.....

.....

(ii) how the results are used to find the size of an organ.

.....

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.....

.....

(4)

(Total 10 marks)

20. 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.

.....

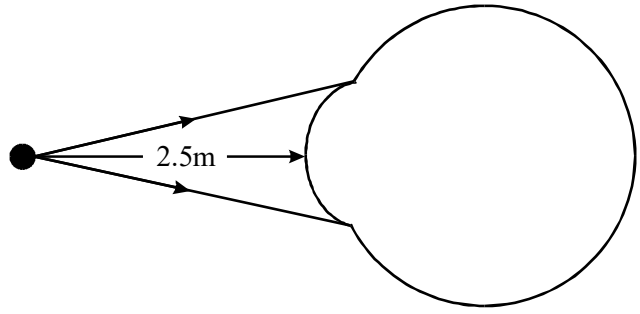
(ii) State **one** possible cause of this defect of vision.

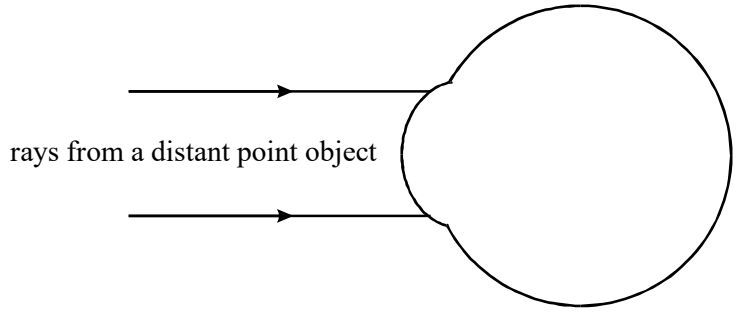
.....

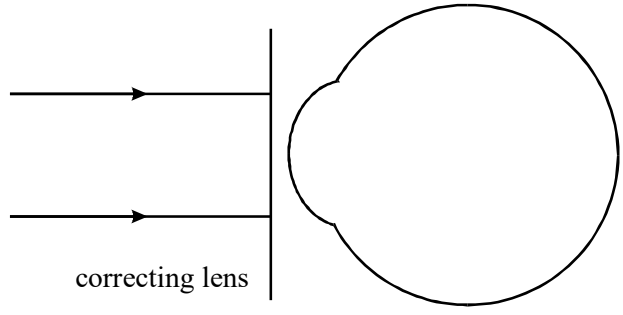
.....

(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.

.....

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.....

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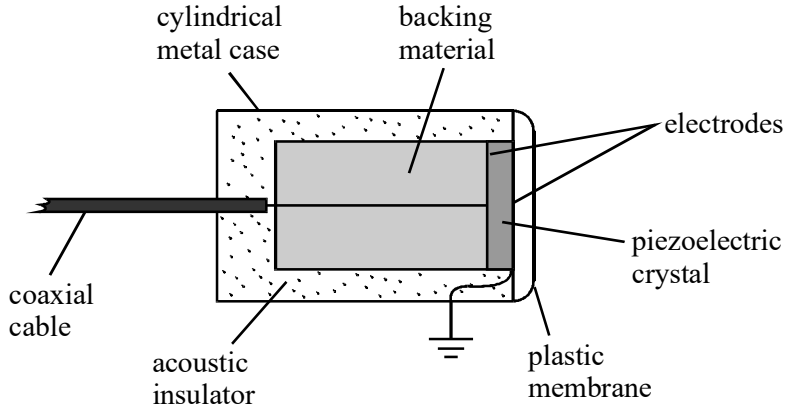
.....

.....

(4)
(Total 9 marks)

21. 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: .....

.....

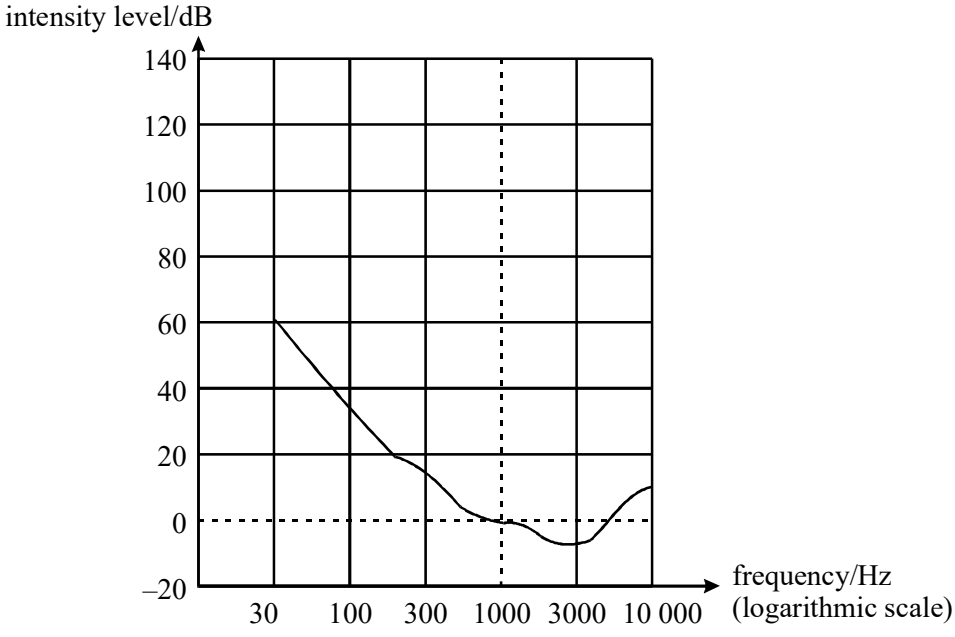
disadvantage: .....

.....

(2)

(Total 7 marks)

22. (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?

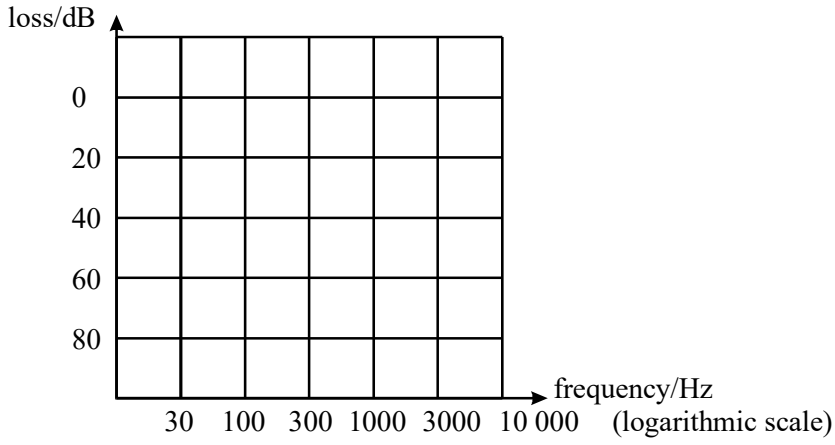
.....

(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?

.....

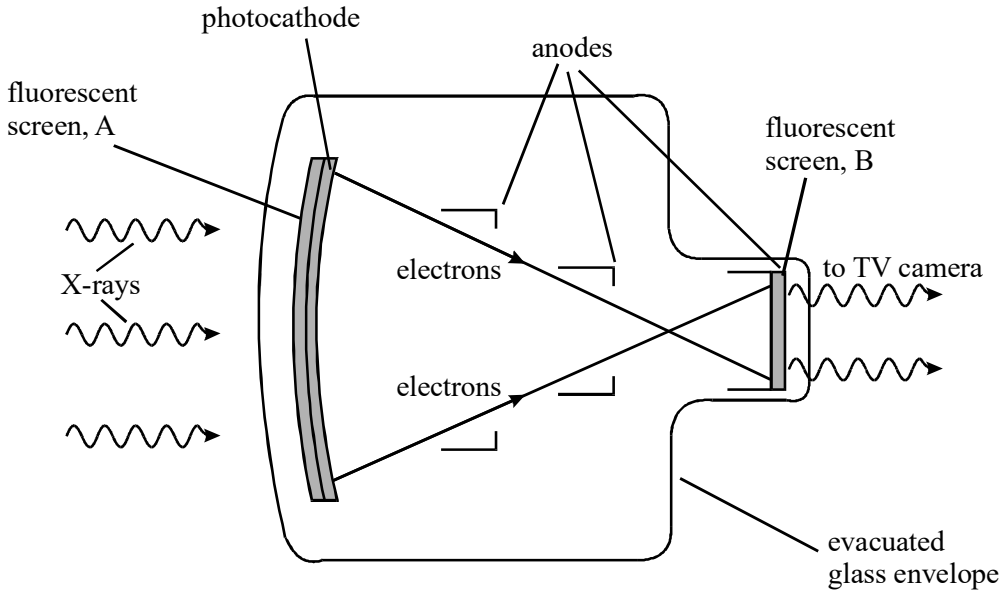
.....

.....

(4)

(Total 6 marks)

23. The diagram shows a fluoroscopic image intensifier.



(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.

.....

.....

.....

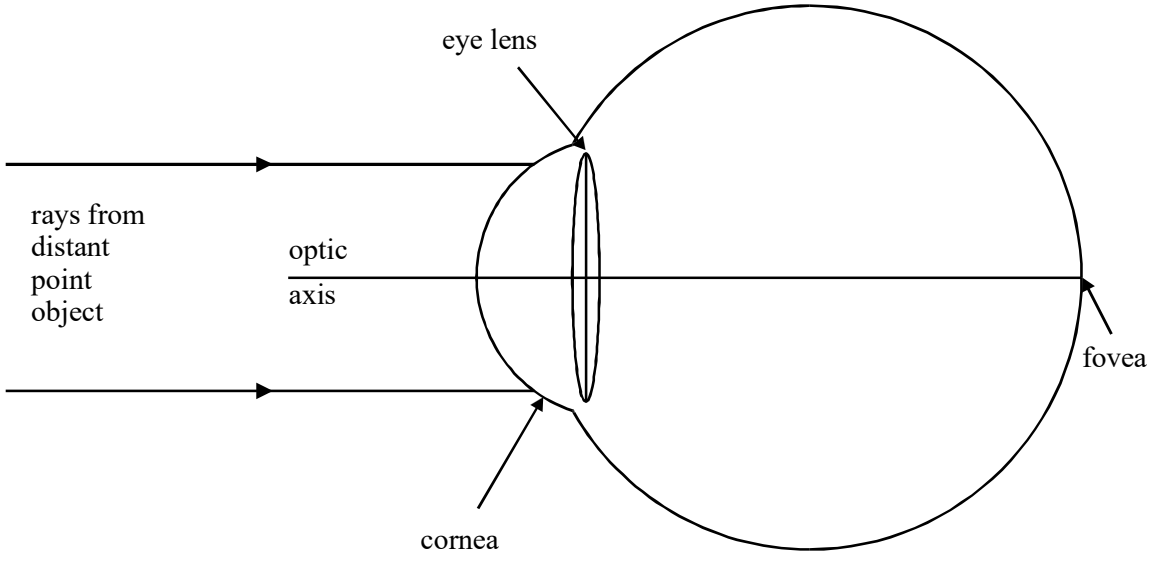
.....

.....

(2)
(Total 6 marks)

24. (a) 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.

.....

.....

.....

.....

(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.

.....

.....

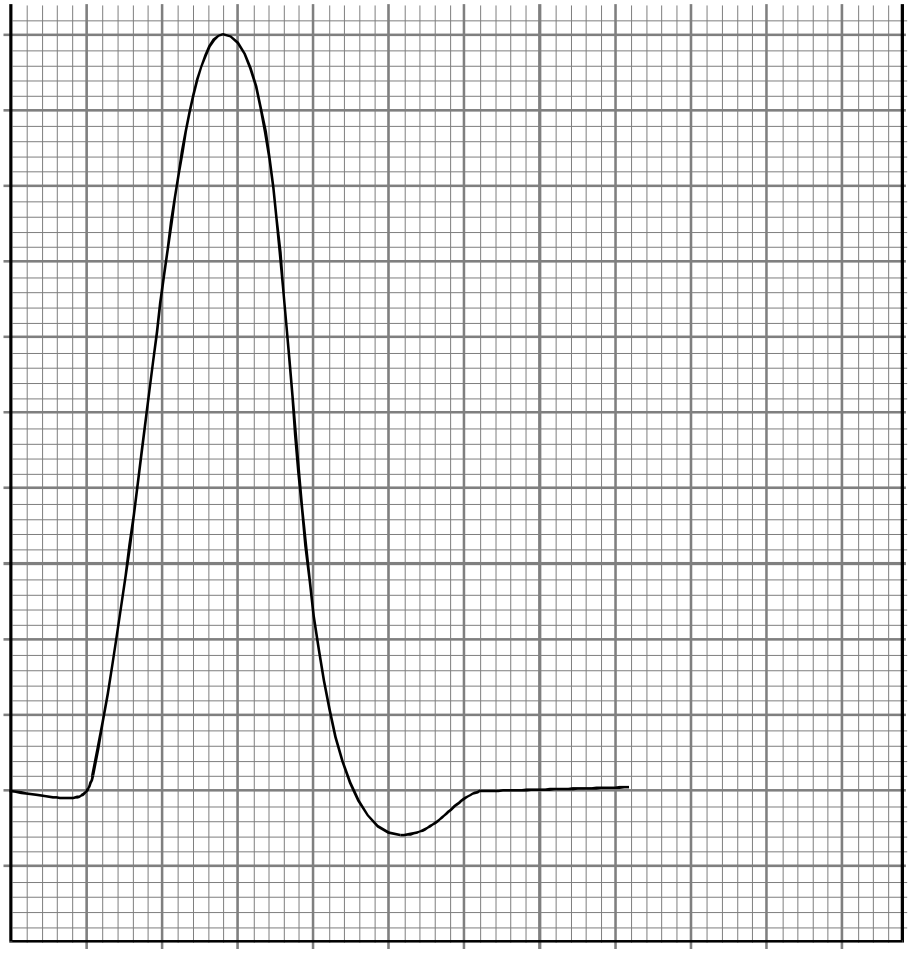
.....

.....

(2)

(Total 8 marks)

25. 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.

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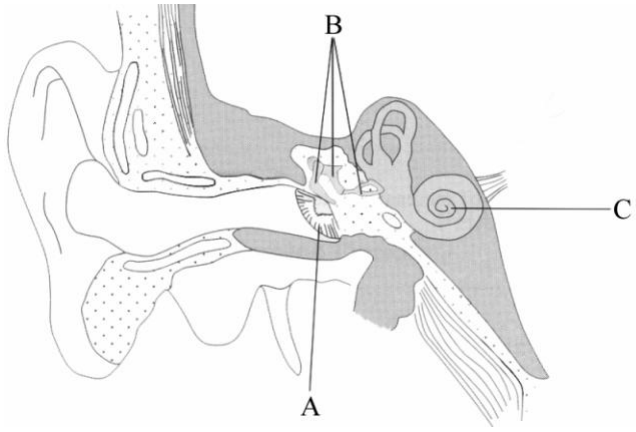
.....

.....

.....

(3)
(Total 6 marks)

26. 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)

27. 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.

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(3)
(Total 6 marks)

28. 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,

.....

.....

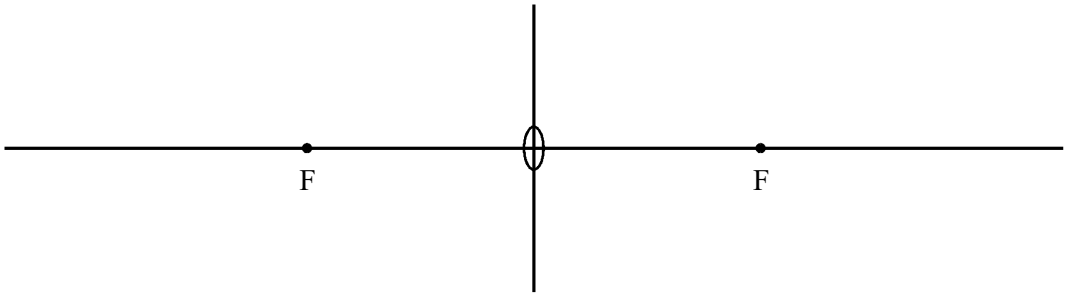
(ii) the magnification produced.

.....

.....

(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.

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(4)
(Total 10 marks)

29. A ship sounds its foghorn. A person on a cliff hears the sound which has an *intensity* of 0.13 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.

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(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}

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(2)
(Total 5 marks)

30. (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.

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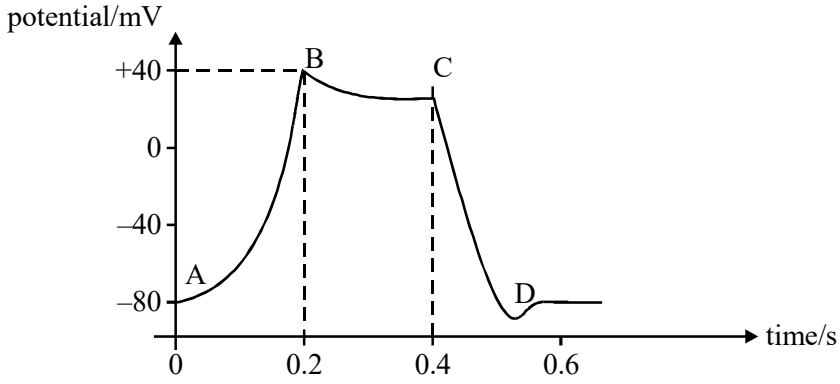
(4)

(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.

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(ii) Describe the ion movement which produces repolarisation.

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(3)

(Total 7 marks)

31. (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.

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(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}

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(3)
(Total 6 marks)

32. 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)

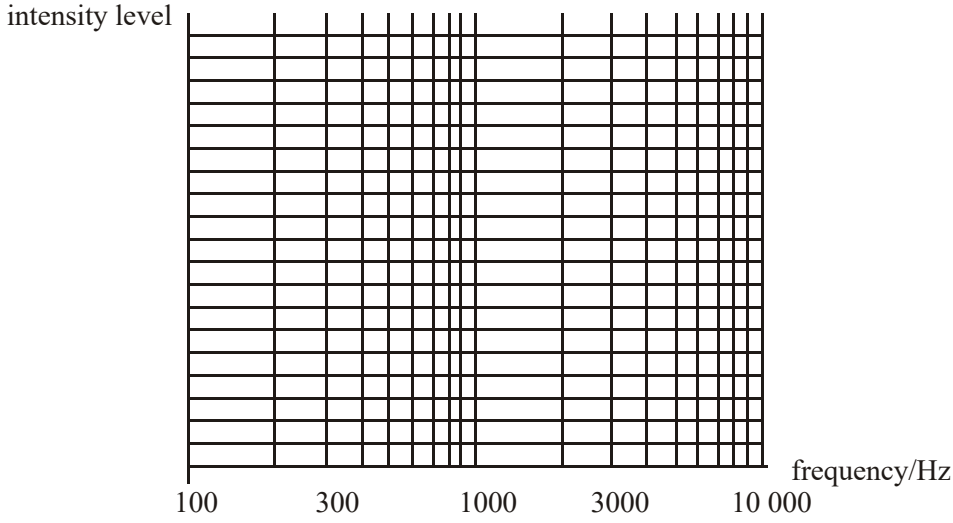
33. (a) (i) State the main difference between the dB scale and the adapted dBA scale used to measure sound intensity levels.

.....

.....

(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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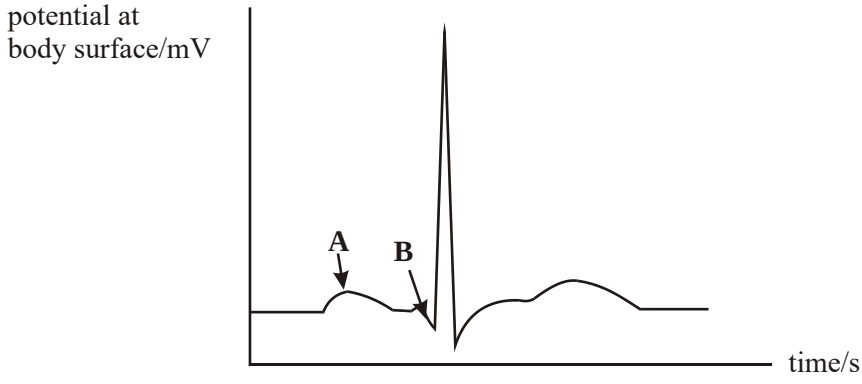
(3)

(Total 8 marks)

34. 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)

35. 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.

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.....

(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 ……

……

……

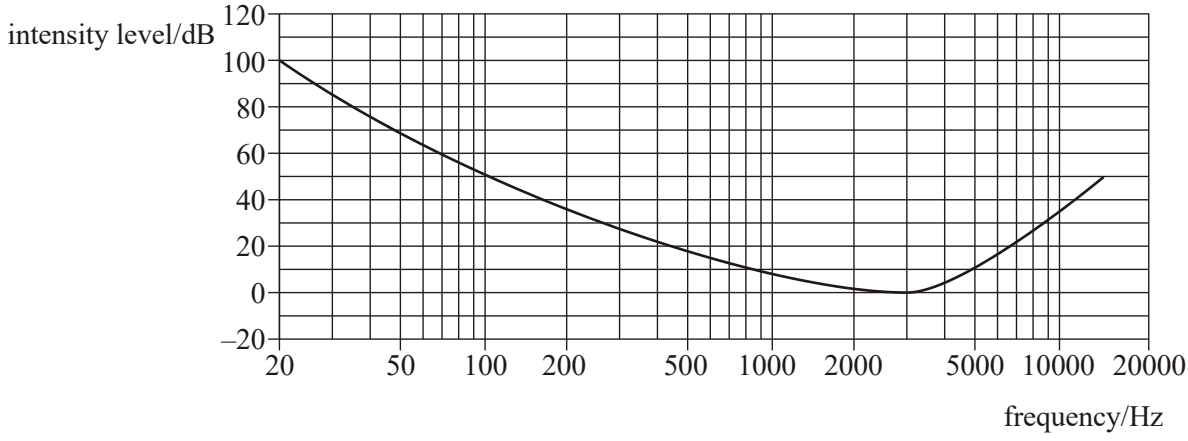
advantage 2 ……

……

……

(Total 6 marks)

36. 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)

37. (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,

.....

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.....

.....

(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)

38. (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)

39. (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)

40. (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)

41. (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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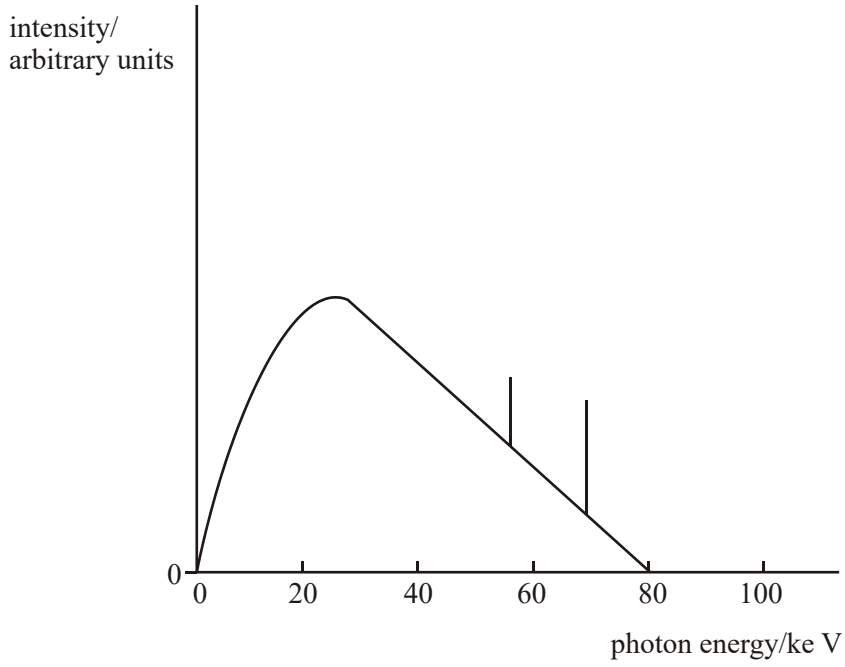
(4)

(Total 7 marks)

42.



(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)

43. (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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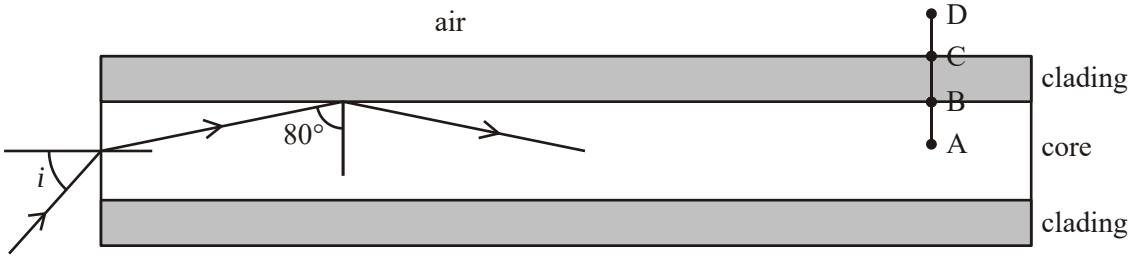
.....

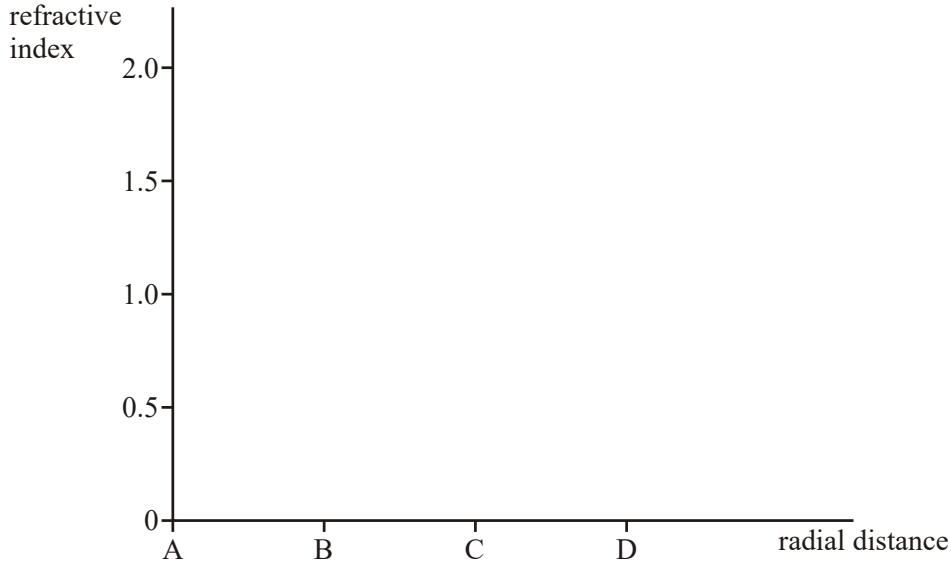
.....

(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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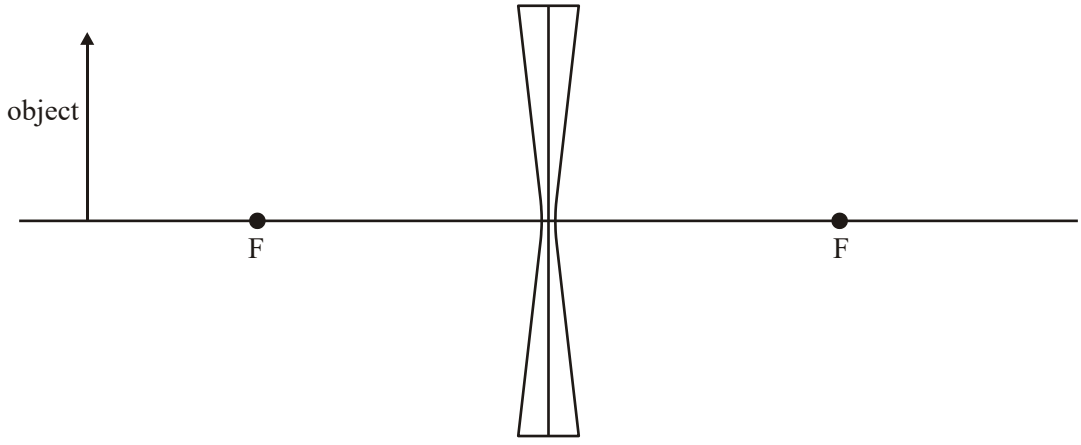
(4)
(Total 9 marks)

44. (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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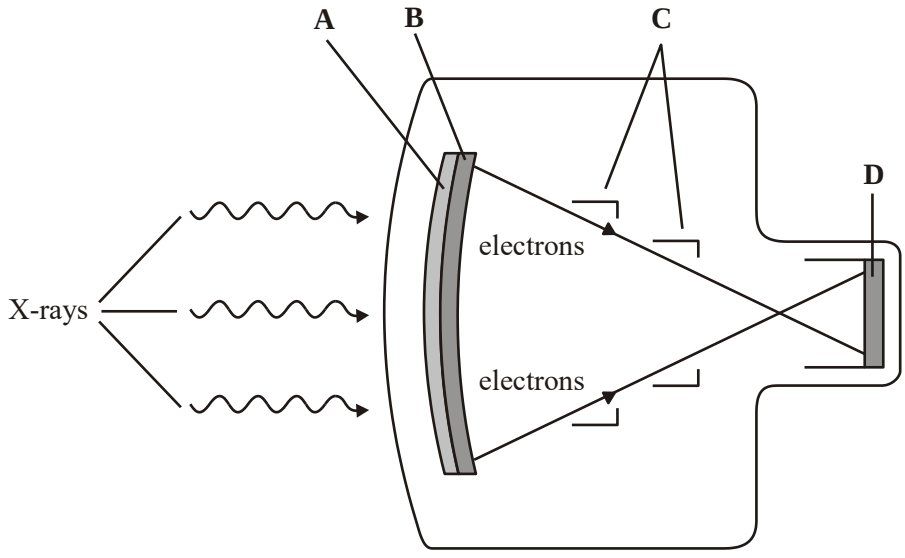
(3)
(Total 5 marks)

45. 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)

46. (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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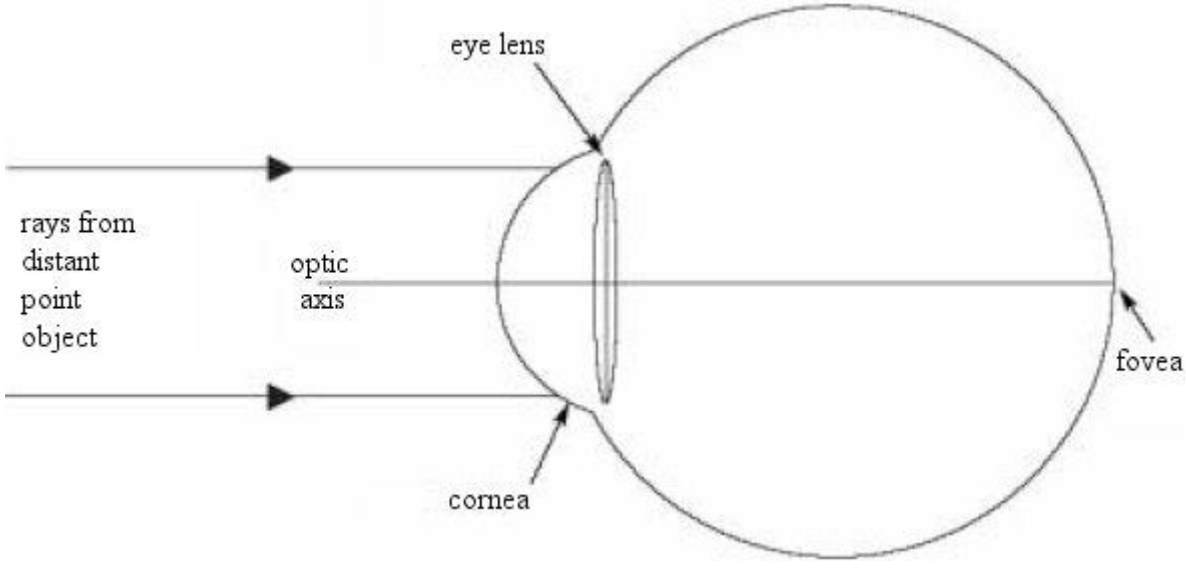
(Total 6 marks)

47. 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.

.....

.....

(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.

.....

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.....

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(2)

(Total 8 marks)

48. 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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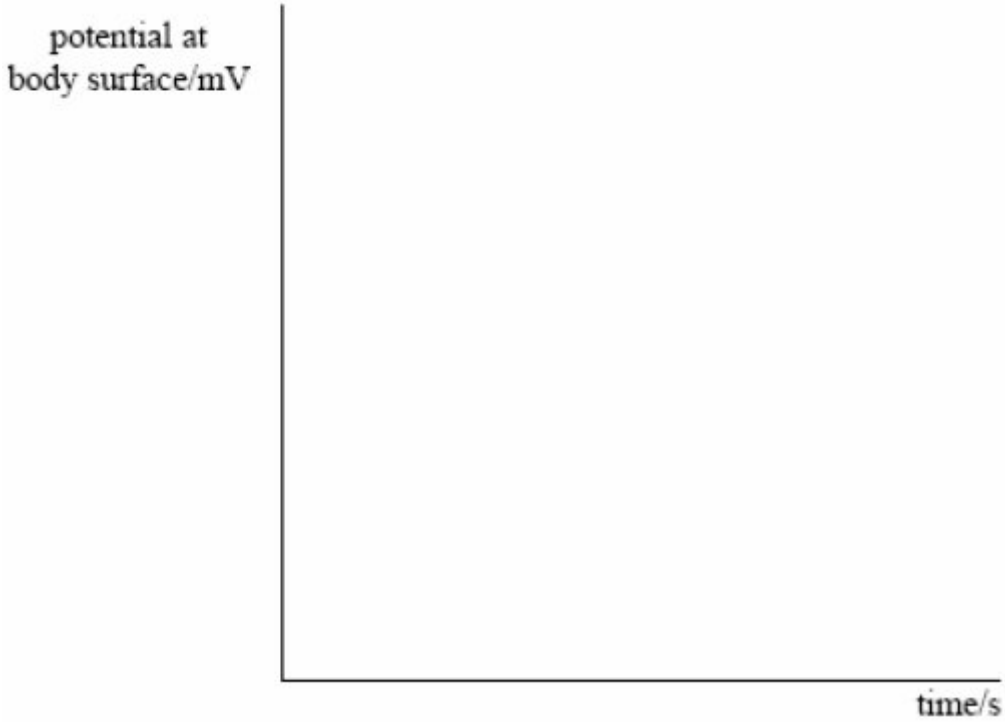
(2)

(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)

49. (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}.

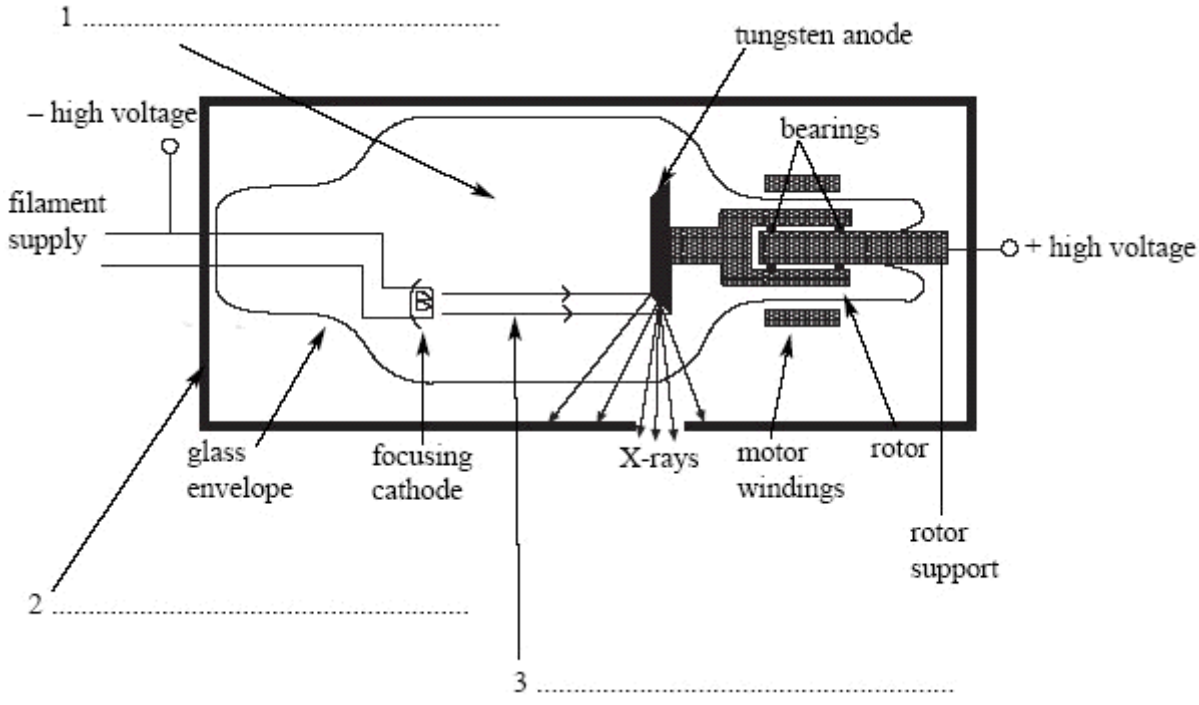
(ii) Calculate the relative intensity level due to the machine alone.

Relative intensity level = ...

(4)

(Total 7 marks)

50. (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.

.....

.....

.....

(3)

(c) Define for a material,

(i) the linear attenuation coefficient, μ,

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.....

.....

(ii) the half thickness.

.....

.....

.....

(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)