**1.** A ear drum [or tympanic membrane] **(1)**
transfers sound waves from the outer ear to the
ossicles of the middle ear **(1)**

B ossicles [or bones of the middle ear] **(1)**
system of levers with a mechanical advantage (of 1.5) [or amplification]
[or which links two membranes (ear drum and oval window)
or transmits sound vibrations from outer to inner ear] **(1)**

C windows: oval and round **(1)**
allow sound vibrations to enter the fluid of the inner ear
[or allows sound vibrations to be transmitted around the cochlea
or contain the inner ear's fluid while allowing the fluid to move] **(1)**

D cochlea **(1)**
convert (pressure) waves [or vibrations] in the fluid into electrical signals
[or stimulates (auditory) nerves to send signals to the brain] **(1)**

**[8]**

**2.** (a) *coherent bundle:*
fibres maintained in fixed positions relative to each other **(1)**
*non-coherent bundle:*
fibres have no fixed relative positions **(1)** 2

(b) coherent bundles of fibres transmit images (of internal organs
of the body) **(1)**
non-coherent bundles transmit (or conduct) light
(to inside the human body for illumination) **(1)** 2

(c) (i) high resolution [or fine detail can be seen] (*)
very flexible bundle (*)
finer fibres allow bending round tighter curves without
escape of light (*)
(*) any two **(1)(1)**

(ii) so that scratches on the outer surface do not allow light to
escape **(1)**
so that close contact between adjacent fibres
[or liquid penetrating between fibres]
does not allow light to pass from one fibre to
another to ensure that image is not confused
(*alternatives* :corrupted, scrambled) as a result of
light passing between individual fibres
[or to prevent (mechanical) damage to surface of core
e.g scratches]) **(1)** 4

**[8]**

**3.** (a) A glass tube **(1)**
(sealed), evacuated, allows electrons to travel unimpeded **(1)**

B rotating anode [or target] **(1)**
rotation of anode [or target] to spread heated area **(1)**
target which emits X-rays when hit by (energetic) electrons **(1)**

C filament [or cathode] **(1)**
heat source to release electrons from surface of cathode by thermionic emission **(1)**

D lead housing **(1)**
prevent X-rays from escaping in unwanted directions **(1)** max 8

(b) path of electrons shown from filament (C) to anode (B) **(1)**
path of X-rays shown starting at anode (B)
and emerging through window in lead housing (D) **(1)** 2

**[10]**

**4.** (a) lowest level of sound (intensity) which the ear can detect **(1)**
1 kHz **(1)** 2

(b) ear has a logarithmic response
[or log scale chosen to match (perceived) response of the ear] (*)
to accommodate very wide range of sound intensities to which ear can respond (*)
perceived change in loudness is proportional to fractional change in intensity (*)
10- fold increases in intensity are perceived as steps of equal increase in loudness (*)
log scale means that numerical values on the scale represent ratios of two sounds, expressed as the log of that ratio (*)
(*) any two **(1)** **(1)** 2

(c) the dBA scale takes account of the frequency dependence of the sensitivity of the ear
[or to match the ear's frequency response
or meters calibrated on a dBA scale give frequency-weighted readings] **(1)** 1

(d) (i) $2.0 = 10\log\left(\frac{I_2}{I_1}\right)$ **(1)**

$\frac{I_2}{I_1} = 1.58$ **(1)**

(ii) 10 steps = 10 × 2dB = 20dB **(1)**

$\frac{I_2}{I_1}$ = 100 **(1)**

[$1.58^{10}$ **(1)** = 100 **(1)**] 4

**[9]**

**5.** (a) $\frac{\sin i}{\sin r} = \frac{\sin C}{l}$ **(1)** = $\frac{1.40}{1.55}$ = 0.903 **(1)**

angle $C$ = 64.6° **(1)** 3

(b) on outer edge only of core **(1)**
two to four reflections **(1)**
[no marks for zig-zag] 2

(c) (i) smaller difference between the core index and cladding index makes critical angle larger **(1)**
therefore increases the chance of light escaping **(1)**

(ii) makes internal angle of incidence at core-cladding interface more likely to be less than the critical angle **(1)**
therefore increases the chance of light escaping **(1)** max 3

**[8]**

**6.** (a) two faces of a thin slice of crystal (coated with a thin layer of silver) act as electrodes **(1)**
electrodes connected to high frequency (several MHz) source of e.m.f. **(1)**
as applied e.m.f. alternates it applies alternating (rapidly reversing direction) electric field across the slice of crystal between the electrodes **(1)**
crystal expands and contracts at the same frequency as the applied e.m.f. **(1)**
the vibrations of the faces of the crystal slice produce ultrasound pressure waves **(1)** max 4

(b) (i) pulse short compared with the transit time **(1)**
pulses are used for timing echoes which give measurements of depth in the body **(1)**
pulse must be short enough to ensure the leading edge returns after the trailing edge departs **(1)**

(ii) behind the crystal a vibration-absorbing backing material is attached **(1)**
this stops the vibrations quickly after the electrical signal is stopped, ensuring that the pulse is short **(1)** max 3

(c) (i) when there is a large difference in acoustic impedance [or significant change in density or significant change in elasticity or texture of tissue] **(1)**

(ii) tissue density **(1)**
tissue elasticity/texture **(1)**

(iii) ultrasound is reflected back at boundaries with air
[or replacement of air prevents reflection] (*)
gel between transducer and skin
(prevents loss of signal due to boundary reflection) (*)

acoustically well -matched gel gives good transmission
(with minimum reflection at skin boundary) (*)
(*) any two **(1)** **(1)** 5

**[12]**

**7.** (a) surface of body covered with an oil to improve transmission from ultrasound transducer to body **(1)**
short ultrasound pulses sent into the body and echoes received from surfaces detected by the transducer **(1)**
oscilloscope sweep time synchronised with the ultrasound pulse frequency **(1)** 3

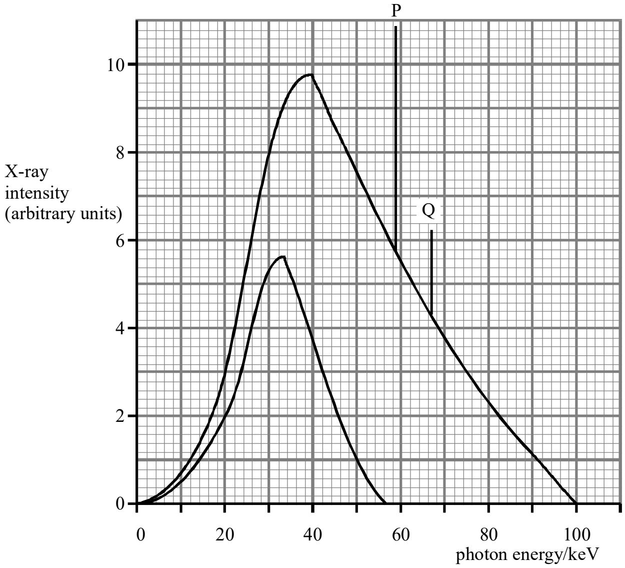
(b) (i) thickness $= \frac{1}{2} \upsilon \Delta t$ **(1)** $= \frac{1}{2} \times 1500 \times 0.08 \times 10^{-3}$ (m) **(1)**
$= 0.06$ m **(1)**

(ii) pulse duration $= 0.3 \times 0.02 = 0.006$ms **(1)** max 3

(c) extra distance in tissue results in more signal absorption (*)
smaller fraction of signal reflected at second surface (*)
pulse more spread over time (*)
signal is diffracted (*)
(*) any two **(1)** **(1)** 2

**[8]**

**8.** (a) (i)




maximum photon energy determined by accelerating voltage **(1)**

corresponds to all electron kinetic energy **(1)**

converted to single photon **(1)**

only one electron can contribute to production of X-ray photon **(1)**

(ii) line spectra characteristic of the target material **(1)**

frequencies (energies) correspond to allowed transitions of inner electrons of target atoms **(1)**

produced by de–excitation of excited electrons of target atoms **(1)** max 4

(b) (i) 100 kV **(1)**

(ii) 67keV = $67 \times 10^3 \times 1.6 \times 10^{-19}$ J′

$$f\left(=\frac{E}{h}\right) = \frac{67\times10^3 \times 1.6\times10^{-19}}{606\times10^{-34}} = 1.6 \times 10^{19}\ \text{Hz}\ \mathbf{(1)}$$ 3

(c) maximum intensity at lower photon energy **(1)**

maximum photon energy at 55keV **(1)**

no line spectrum **(1)** 3

(d) (i) use of image intensifier screen **(1)**

low intensity (dose of) X-rays can be used because image is enhanced

by conversion of X-ray photons into light photons by fluorescent

material [or use of image intensifier tube – signal electronically amplified] **(1)**

(ii) filters placed between source and patient **(1)**

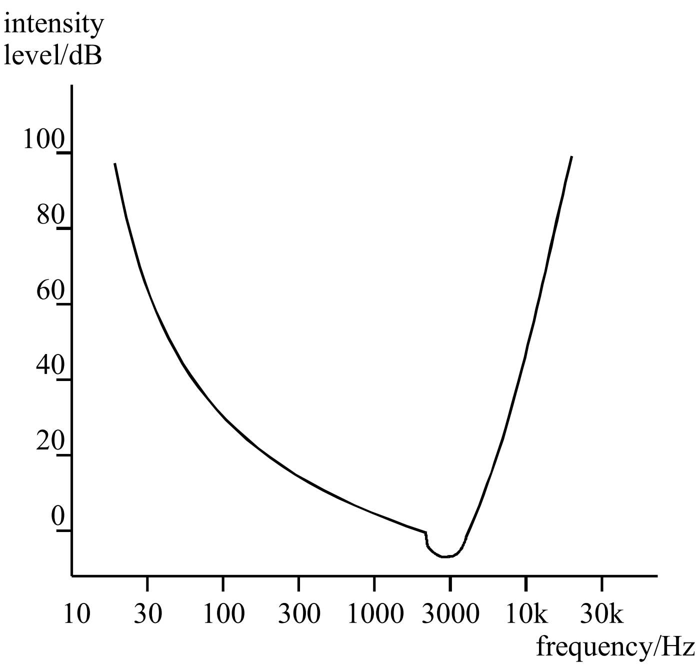
soft X-rays absorbed by filters instead of patient **(1)** 4

**[14]**

**9.** (a) threshold of hearing – lowest intensity of sound detected by human ear **(1)**
reference intensity ($1.0 \times 10^{-12}$ W m$^{-2}$) is taken at 1 kHz **(1)** 2

(b) basic shape **(1)**
range (30Hz – 20kHz approx) **(1)**
minimum between 1 kHz and 3 kHz **(1)**

scale, including units **(1)**
logarithmic **(1)**




5

(c) (i) $I_2 = 10^6 I_1$ **(1)** $= 10^6 \times 1.0 \times 10^{-12} = 1.0 \times 10^{-6}$ W m$^{-2}$ **(1)**

(ii) number of dB $= 10\log_{10}\left(\frac{I_2}{I_1}\right) = 10\log_{10}\left(\frac{112}{100}\right)$ **(1)** = 0.5(dB) **(1)** 4

**[11]**

**10.** (a) (i) astigmatism usually caused by an irregularity in the curvature of the cornea **(1)**

(ii) a person with astigmatism would see an image which was less well-focussed in one particular plane [direction] **(1)**

(ii) defect is corrected using a (correctly orientated) cylindrical lens **(1)** 3

(b) (i) $P = \frac{1}{f} = \frac{1}{u} + \frac{1}{v} = \frac{1}{\infty} - \frac{1}{0.8}$ **(1)** = –1.25 dioptre **(1)**

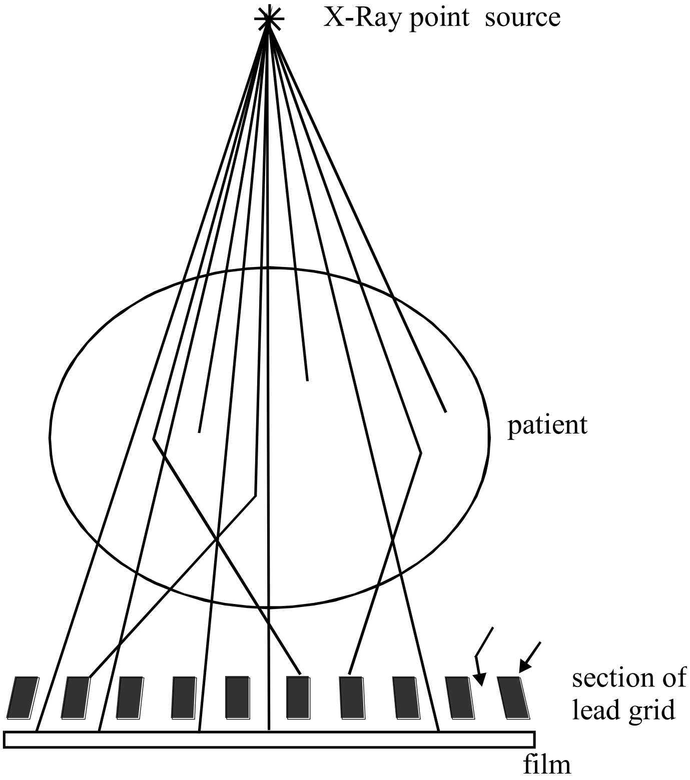
[no marks if *v* is not negative]

(ii) $\frac{1}{u} = \frac{1}{f} - \frac{1}{v} = -1.25 - \frac{1}{-0.15}$ **(1)** $= -1.25 + 6.67 = 5.42$

$u = 0.18$m**(1)** 4

**[7]**

**11.** (a) (i) lead absorbs X-rays very well **(1)**




(ii) straight through tracks **(1)**
scattered tracks absorbed by lead **(1)**
some X-rays absorbed by patient **(1)**
clarity lost if scattered rays reach film, darkening image in random places **(1)**
lead grid allows through to film only those rays which are not scattered **(1)**
image intensity distribution represents accurately the body structure through which the radiation has passed **(1)**
grid moved systematically to prevent it forming image on film — max 5

(b) point source gives a <u>sharp</u> (shadow) <u>image</u>
[or point source produces <u>no penumbra</u> (grey fading at shadow edges) **(1)** — 1

**[6]**

**12.** (a) (i) short sight [myopia] **(1)**

(ii) lens produces virtual image at uncorrected far point **(1)**

$P = \frac{1}{f} = \frac{1}{-0.5} = -2.0\text{D}$ [allow dioptre or $m^{-1}$] **(1)** **(1)**

maximum one mark if unit or negative sign omitted

(iii) rays cross in front of retina from parallel incident rays **(1)**

(iv) image on retina, object at uncorrected far point **(1)**

(v) long eyeball [or strong lens or eye insufficiently relaxed] **(1)** max 6

(b) (i) towards film **(1)**

(ii) $f = 36.4 - 1.2 = 35.2$ mm **(1)**

(iii) $\frac{1}{u} + \frac{1}{36.4} = \frac{1}{35.2}$ **(1)**
$u = 1068$ mm [1.1 m] **(1)**

(iv) image height (=object height $\times \frac{v}{u}$)
[or magnification correctly calculated] **(1)**
$= 0.60 \times \frac{36.4}{1068} = 0.020$ **(1)**
$0.020 < 0.024 \therefore$ yes [or conclusion consistent with calculation] **(1)** 7

(c) at focal point of objective **(1)**
long exposure allows more detail to be observed **(1)** 2

**[15]**

**13.** (a) treatment of defects of vision
welding of detached retina
removal of birthmarks any two **(2)**
treatment of tumours
used as cutting instrument 2

(b) method of application:
pulsed beams
delivered via optical fibres any two **(1) (1)**
specific wavelength of radiation needed

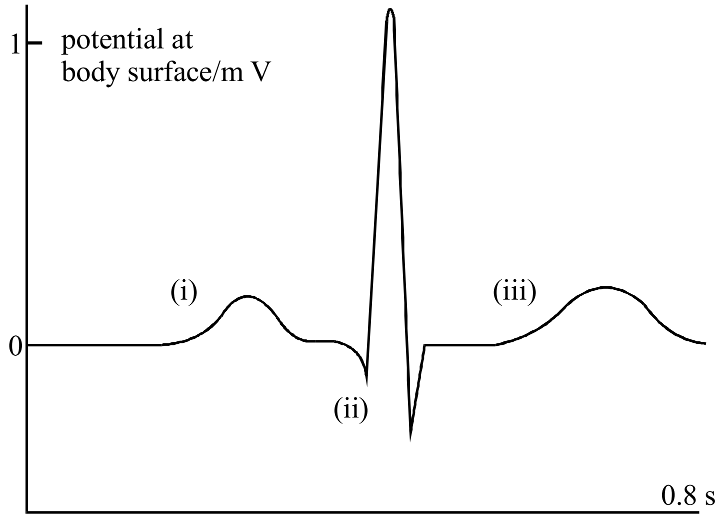
safety features:
lack of reflective surfaces
short focal length lens used at point of application
use of goggles any two **(1) (1)**
keep patient still 4
QWC

**[6]**

**14.** (a) electrodes made from a material which does not become polarised
electrodes coated with conducting gel any two **(2)**
hair and dead skin removed 2

(b) high gain
high input impedance any two **(2)**
low noise 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]**

**15.** (i) non-spherical cornea **(1)**

(ii) image in one plane is focused, but image in plane at right angles is out of focus **(1)**

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

(iv) power of the lens **(1)**
angle of correction **(1)** 5

**[5]**

**16.** (a) ear has logarithmic response **(1)**

accommodates wide range of intensities **(1)** 2

(b) dB scale has a flat response with frequency **(1)**
dBA scale is frequency compensated **(1)**
for dBA, threshold intensities are different for different frequencies **(1)** 3

(c) (use of intensity level $=10 \log\left(\frac{I}{I_0}\right)$ gives ) $94 = 10 \log\left(\frac{I}{1.0\times10^{-12}}\right)$ **(1)**

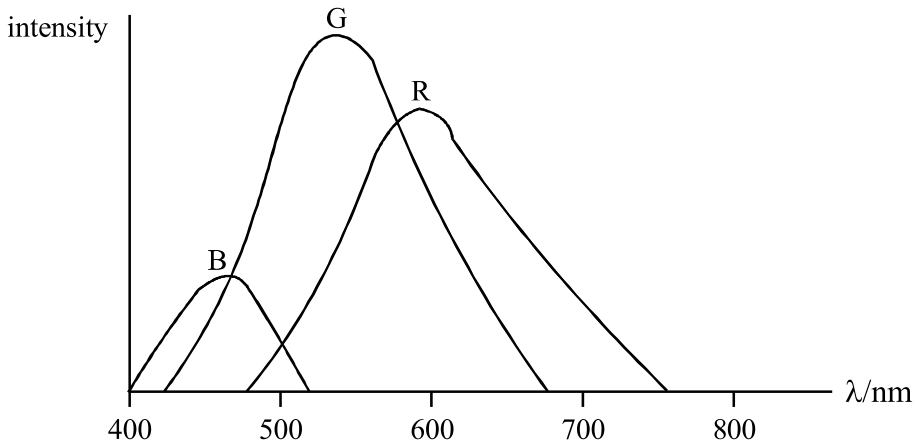
$I = 1.0 \times 10^{-12} \times 10^{9.4}$ **(1)** $= 2.5 \times 10^{-3}$ W m$^{-2}$ **(1)** 3

(d) intensity = $2 \times 2.5 \times 10^{-3}$ (W m$^{-2}$) **(1)**
(allow C.E. for *I* from part (c))

intensity level = $10 \times \log\left(\frac{5.0\times10^{-3}}{1.0\times10^{-12}}\right) = 97$ dB **(1)** 2

**[10]**

**17.** (a)




three overlapping colour curves labelled blue, green and red **(1)**
unit and scale on wavelength axis **(1)**
peaks at ≈ 430 (blue), 520 (green), 570 (red) **(1)**(± 30 for each)
ranges ≈ 400 - 520 (blue), 430 -670 (green), 480 - 730 (red) **(1)** (± 30) 4

(b) (i) two stimulated receptors must be separated by (at least) one unstimulated receptor **(1)**

(ii) (in bright light) cones activated **(1)**
cones smaller than rods **(1)**
angular separation thus smaller **(1)** max 3

(c) (i) lights flashing at ≥ 20 Hz appear steady
[or image appears steady although stimulus is flashing] **(1)**

(ii) any correct example e.g. cine films, television **(1)** 2

**[9]**

**18.** (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)** 2

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

(use of $I = I_o e^{-\mu x}$ gives) $I = 6.0 \times e^{-0.217 \times 2}$ **(1)**
(allow C.E. for value of $\mu$)
$= 3.9\ \text{W m}^{-2}$ **(1)** 3

**[11]**

**19.** (a) (i) $Z_{air} = 330 \times 1.3 = 430\ \text{kg m}^{-2}\ \text{s}^{-1}$ **(1)**

(ii) $Z_{tissue} = 1540 \times 1100 = 1.7 \times 10^6\ (\text{kg m}^{-2}\ \text{s}^{-1})$ **(1)**

(iii) (use of $\frac{I_r}{I_i} = \left[\frac{(Z_2 - Z_1)}{(Z_2 + Z_1)}\right]^2$ gives) $\frac{I_r}{I_i} = \left[\frac{1700000 - 430}{1700000 + 430}\right]^2 = 0.999$ **(1)**

(allow C.E. for values from (i) and (ii)) 3

(b) without gel, air between probe and tissue **(1)**
reflects nearly all the ultrasound or very little enters the body **(1)**
with gel air excluded and require $I_r = 0$ **(1)**
$\therefore Z_{gel} = 1.7 \times 10^6$ or equals that of skin/tissue **(1)** max 3

(c) (i) transmitter produces <u>short</u> pulses
at internal boundary some reflected, rest transmitted to next boundary
reflected pulse received by probe and signal sent to oscilloscope
oscilloscope sweep started when pulse is first transmitted
(any two) **(1) (1)**

(ii) time taken between pulses from front and back of organ
(from oscilloscope) **(1)**
distance = $\text{speed} \times \frac{\text{time}}{2}$ **(1)** 4

**[10]**

**20.** (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]**

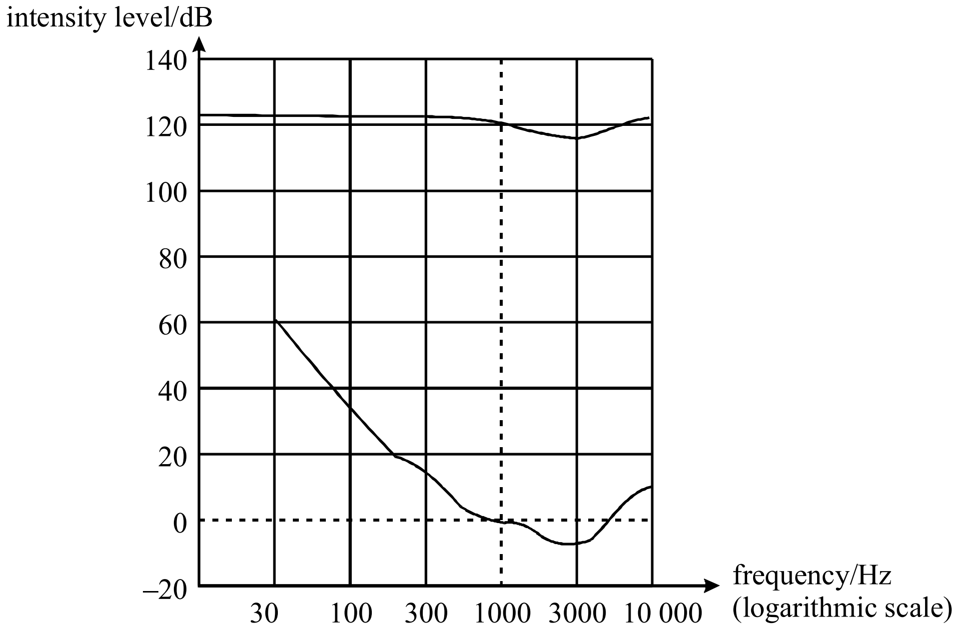
**21.** (a) (i) probe is used as a generator and receiver **(1)**

(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]**

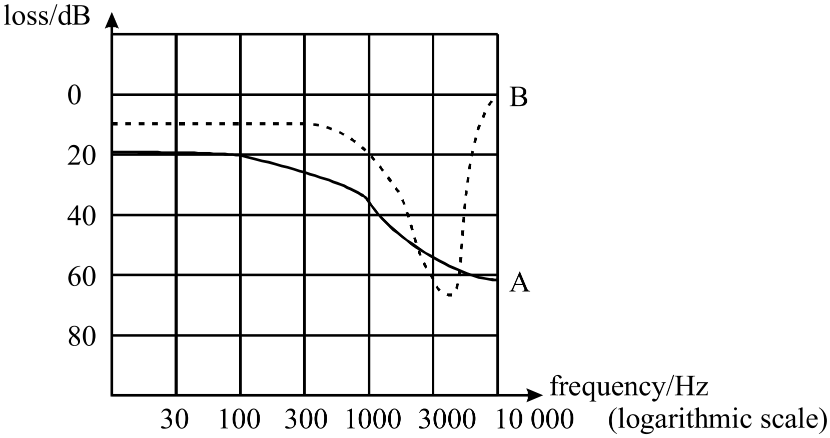
**22.** (a) (i)




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]**

**23.** (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 energy 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]**

**24.** (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]**

**25.** (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]**

**26.** (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]**

**27.** (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]**

**28.** (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]**

**29.** (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$\left(\frac{1.3\times10^{-4}}{1.0\times10^{-12}}\right)$ **(1)**

= 81 dB **(1)** 2

**[5]**

**30.** (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]**

**31.** (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) $\mu$ (= $\rho\mu$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 $\mu$)
$x$ = 0.03(0) m **(1)** 3

**[6]**

**32.** 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)** max 4

**[4]**

**33.** (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)**

$I = 3.2 \times 10^{-4}$ ($\text{W m}^{-2}$) **(1)** ($3.16 \times 10^{-4}$ ($\text{W m}^{-2}$))
$P$ (= $IA$) = $3.16 \times 10^{-4} \times 65 \times 10^{-6} = 2.1 \times 10^{-8}$ W **(1)** ($2.06 \times 10^{-8}$ W)
(allow C.E. for value of $I$) 3

**[8]**

**34.** (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]**

**35.** (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

**[6]**

**36.** (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 = $10 \log \left(\frac{1.3\times10^{-3}}{1.0\times10^{-12}}\right)$ **(1)**
= 91(.1) dB **(1)** 4

**[9]**

**37.** (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]**

**38.** 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]**

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

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

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

(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

**[6]**

**40.** (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) $P = \frac{1}{-2.0} = -0.5$ D **(1)**

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

$u = 0.25$ m **(1)** (0.247 m)
(allow C.E. for value of $P$ from (ii)) 4

**[7]**

**41.** (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]**

**42.** (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]**

**43.** (a)

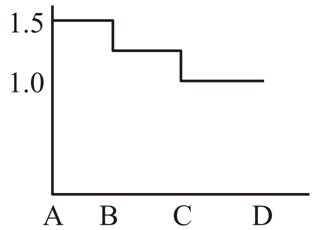
| **property** | **explanation** |
|---|---|
| monochromatic | waves of single frequency/wavelength |
| collimated | produces an approximately parallel beam |
| coherent | waves produced are in constant phase with each other |

**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)



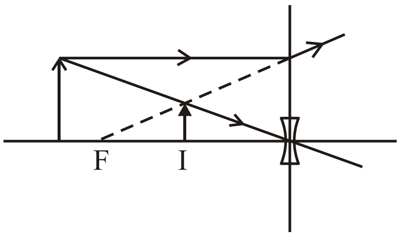

n (constant) = 1.5 from A to B, slight decrease and constant from B to C **(1)**
at C, *n* decreases to 1, remains at 1 from C to D **(1)**

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

$i = 15(.1)^{\circ}$ **(1)** 4

**[9]**

**44.** (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]**

**45.** 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)** max 8
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]**

**46.** (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]**

**47.** (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]**

**48.** (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

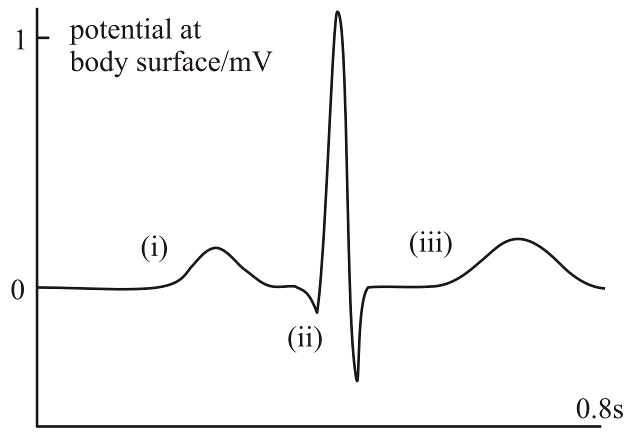
(b) high gain

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]**

**49.** (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$\left(\frac{3.98\times10^{-4} - 7.0\times10^{-5}}{1.0\times10^{-12}}\right)$ **(1)**

= 85(.2) dB **(1)** 4

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

**[7]**

**50.** (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 $mm^{-1}$ (0.217$mm^{-1}$) **(1)**

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

= 3.9 W $m^{-2}$ **(1)** 3

**[11]**