Mark scheme for Extension Worksheet – Option I, Worksheet 1

1 **a** The intensity of sound at eardrum is $I = \frac{48 \times 10^{-6}}{54 \times 10^{-6}} = 0.889 \text{ W m}^{-2}$; hence

$$SIL = 10 \log \frac{0.889}{1.0 \times 10^{-12}} = 119.5 \approx 120 \text{ dB}$$ [2]

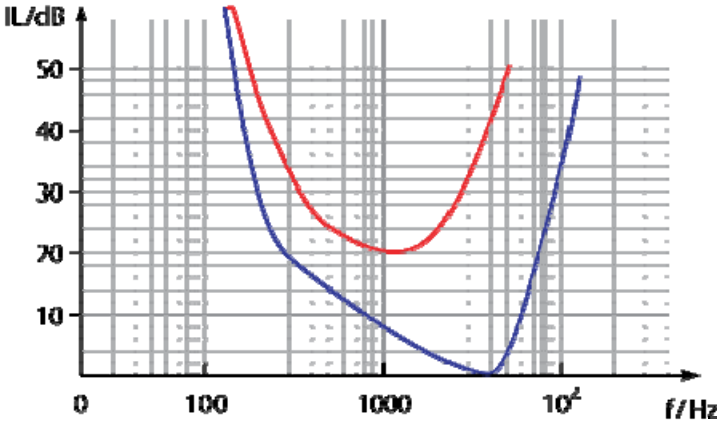
b The sound intensity level is at the threshold of pain/very high; damage will occur. [2]

2 $L = 10 \log \frac{I_{\text{healthy}}}{1.0 \times 10^{-12}}$ and $L + 15 = 10 \log \frac{I_{\text{patient}}}{1.0 \times 10^{-12}}$ hence

$10 \log \frac{I_{\text{healthy}}}{1.0 \times 10^{-12}} + 15 = 10 \log \frac{I_{\text{patient}}}{1.0 \times 10^{-12}}$; simplifying $10 \log \frac{I_{\text{patient}}}{I_{\text{healthy}}} = 15$; and so

$\frac{I_{\text{patient}}}{I_{\text{healthy}}} = 10^{1.5} = 31.6 \approx 32$ [3]

3 See curve in red.



[2]

4 **a** The cochlea. [1]

b Ordinary speech contains more high frequencies than lower frequencies; hence loss at high frequencies affects speech recognition. [2]

5 **a** $T = 1 - R = 1 - \left(\frac{Z_1 - Z_2}{Z_1 + Z_2} \right)^2 = 1 - \left(\frac{430 - 1.6 \times 10^6}{430 + 1.6 \times 10^6} \right)^2$; $T = 1.1 \times 10^{-3}$ [2]

b The calculation in **a** shows that very little ultrasound gets transmitted into tissue; placing gel on the skin makes the mismatch of impedances much less since gel and tissue have very similar impedances hence lots of ultrasound gets transmitted. [2]

6 Attenuation of ultrasound is frequency dependent and increases with increasing frequency; so there is a limit to frequency so that attenuation does not become dominant. [2]

7 **a** radio [1]

b The presence of the external magnetic field means that the energy of a proton in hydrogen atoms can be high or low depending on whether the spin of the proton is aligned or not with the magnetic field; the photons are emitted in the transition of a proton from the spin down to the spin up state. [2]

8 The patient is put in the presence of a large magnetic field; protons in the body have different energies depending on whether the spin of the proton is parallel or anti-parallel to the direction of the magnetic field; radio frequency EM waves are directed at the patient which force protons to make transitions from the spin up to the spin down state; the protons immediately make transitions down to the spin up state emitting radio frequency photons; an additional non-uniform magnetic field the patient is exposed can be used to determine the position in the body where these photons have been emitted. [5]

9 X-rays are directed through a horizontal slice of the patient's body; the amount of X-ray absorption at each pixel on the slice is measured so an image of the slice can be made; the procedure is repeated for other slices in the body and a computer reconstructs a 3-dimensional image; that can be viewed from any angle as the computer rotates the image. [4]

10 **a** Radiation is called ionising because (for sufficiently high energies) the radiation can knock electrons off atoms in the matter the radiation is travelling through. [1]

b Ionising radiation can completely kill a cell; or it can damage it to such a degree that it does not function properly; or it cannot reproduce correctly. [3]

c The effects of radiation are immediately obvious only for very large doses; small doses result, mainly, in long-term effects. [2]

11 **a** Photoelectric effect/Compton scattering. [1]

b The intensity at the tissue – bone boundary will be $I = I_0 e^{-0.14\times 6.0} = 0.432 I_0$; the transmitted intensity is then $0.432 I_0 \times e^{-0.74\times 3.5} = 0.0324 I_0$ [2]

c There is considerable difference in the intensity of X-rays before and after the bone; so that sufficient contrast exists for a image to be made. [2]

d X-rays take longer to expose photographic film than visible light; so X-rays that have gone through the patient are incident on a screen that emits visible light when exposed to X-rays; the visible light emitted is proportional to the intensity of X-rays and is used to expose the film. [3]