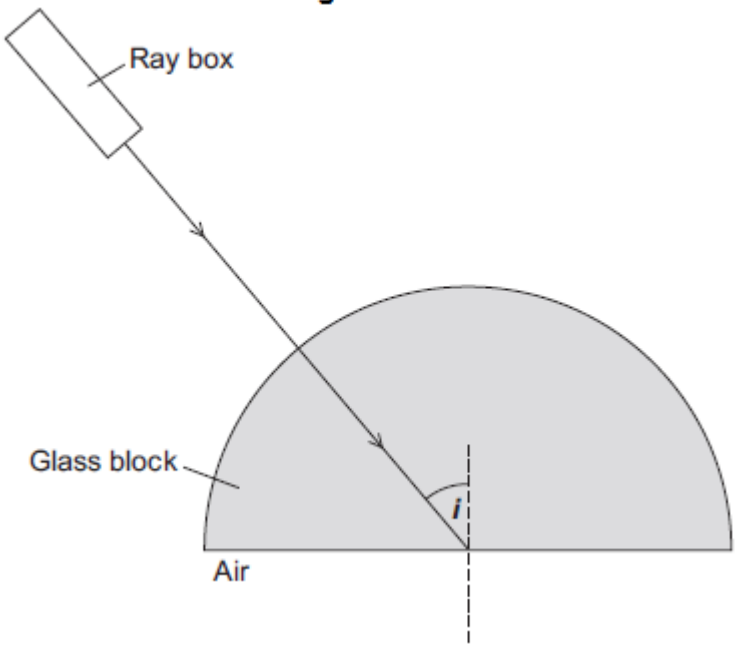
Q1.

Figure 1 shows a ray of light travelling through a semicircular glass block.
The angle of incidence is labelled ***i***.

Figure 1



(a) (i) The angle of incidence ***i*** equals the critical angle for the glass.

Complete **Figure 1** to show what happens to the ray of light at the glass-to-air boundary.

(1)

(ii) The critical angle for the glass is 41°.

Calculate the refractive index of the glass.

_____

_____

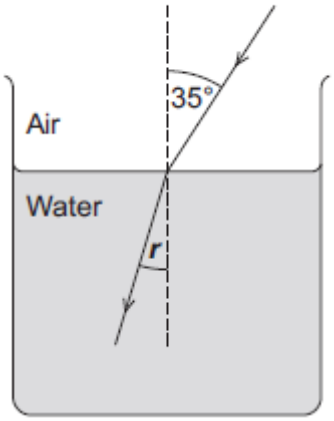
_____

Refractive index = _____

(2)

(b) **Figure 2** shows what happens to a ray of light as it meets the boundary between air and water.

Figure 2



Not to scale

The refractive index of the water is 1.3.

Calculate the angle of refraction ***r***.

_____

_____

_____

_____

_____

Angle of refraction = _____ degrees

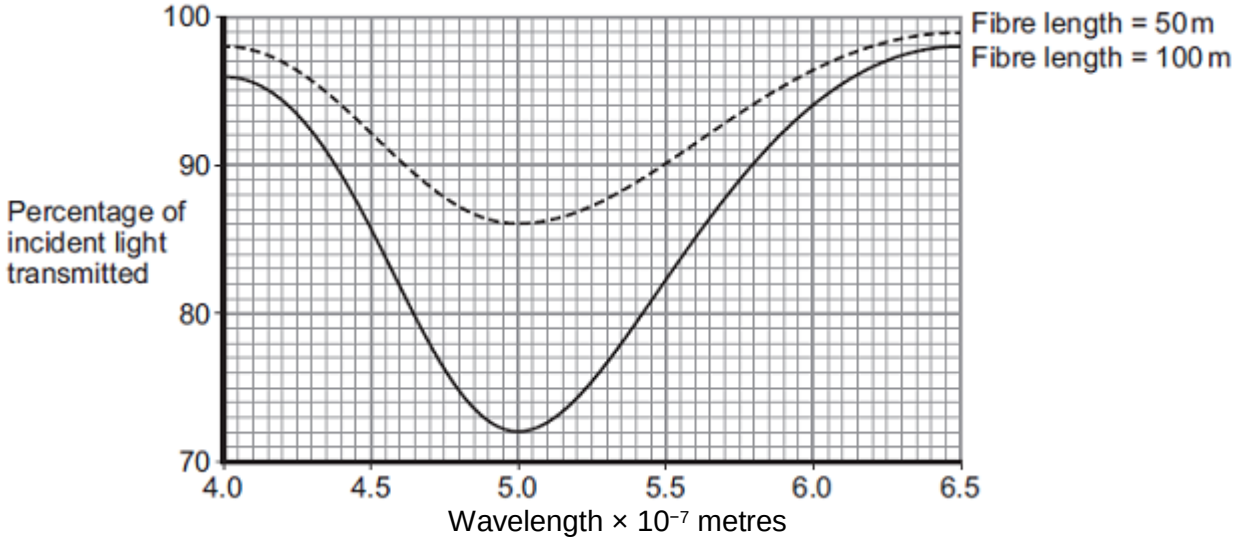
(3)

(Total 6 marks)

Q2.

Different wavelengths of light can be used to transmit information along optical fibres.

The graph below shows how the percentage of incident light transmitted through a fibre varies with the wavelength of light and the length of the fibre.



Compare the percentages of incident light transmitted through the two different fibres over the range of wavelengths shown.

_____

_____

_____

_____

_____

_____

_____

_____

_____

(Total 3 marks)

Q3.

Different parts of the electromagnetic spectrum have different uses.

(a) The diagram shows the electromagnetic spectrum.

Radio waves	Microwaves	Infrared	Visible light	Ultraviolet	X-rays	Gamma rays

(i) Use the correct answers from the box to complete the sentence.

amplitude	**frequency**	**speed**	**wavelength**

The arrow in the diagram is in the direction of increasing _____

and decreasing _____ .

(2)

(ii) Draw a ring around the correct answer to complete the sentence.

The range of wavelengths for waves in the electromagnetic spectrum is approximately

10^{-15} to 10^{4}
10^{-4} to 10^{4}
10^{4} to 10^{15}

metres.

(1)

(b) The wavelength of a radio wave is 1500 m.

The speed of radio waves is 3.0×10^8 m / s.

Calculate the frequency of the radio wave.

Give the unit.

_____

_____

_____

Frequency = _____

(3)

(c) (i) State **one** hazard of exposure to infrared radiation.

_____

(1)

(ii) State **one** hazard of exposure to ultraviolet radiation.

_____

(1)

(d) X-rays are used in hospitals for computed tomography (CT) scans.

(i) State **one** other medical use for X-rays.

_____

_____

(1)

(ii) State a property of X-rays that makes them suitable for your answer in part **(d)(i)**.

_____

_____

(1)

(iii) The scientific unit of measurement used to measure the dose received from radiations, such as X-rays or background radiation, is the millisievert (mSv).

The table shows the X-ray dose resulting from CT scans of various parts of the body.

The table also shows the time it would take to get the same dose from background radiation.

Part of the body	X-ray dose in mSv	Time it would take to get the same dose from background radiation
Abdomen	9.0	3 years

Sinuses	0.5	2 months
Spine	4.0	16 months

A student suggests that the X-ray dose and the time it would take to get the same dose from background radiation are directly proportional.

Use calculations to test this suggestion and state your conclusion.

(3)

(Total 13 marks)

Q4.

(a) The wavelengths of four different types of electromagnetic wave, including visible light waves, are given in the table.

Type of wave	Wavelength
Visible light	0.0005 mm
A	1.1 km
B	100 mm
C	0.18 mm

Which of the waves, **A**, **B**, or **C**, is an infra red wave?

(1)

(b) A TV station broadcasts at 500 000 kHz. The waves travel through the air at 300 000 000 m/s.

Calculate the wavelength of the waves broadcast by this station.

Show clearly how you work out your answer.

_____

_____

Wavelength = _____ m

(2)

(c) What happens when a metal aerial absorbs radio waves?

_____

_____

_____

_____

(2)

(d) Stars emit all types of electromagnetic waves. Telescopes that monitor X-rays are mounted on satellites in space.

Why would an X-ray telescope based on Earth **not** be able to detect X-rays emitted from distant stars?

_____

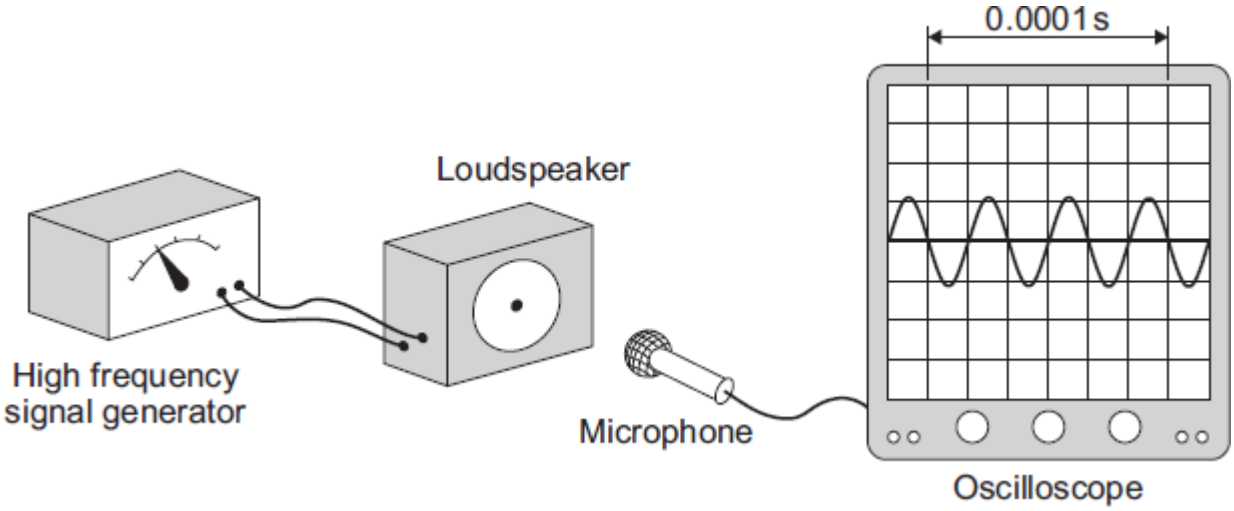
_____

(1)

(Total 6 marks)

Q5.

(a) The diagram shows a microphone being used to detect the output from a loudspeaker.
The oscilloscope trace shows the wave pattern produced by the loudspeaker.



(i) How many waves are produced by the loudspeaker in 0.0001 seconds?

_____

(1)

(ii) How many waves are produced by the loudspeaker every second? Assume the input to the loudspeaker does not change.

_____

_____

(1)

(iii) A person with normal hearing cannot hear the sound produced by the loudspeaker.

Explain why.

_____

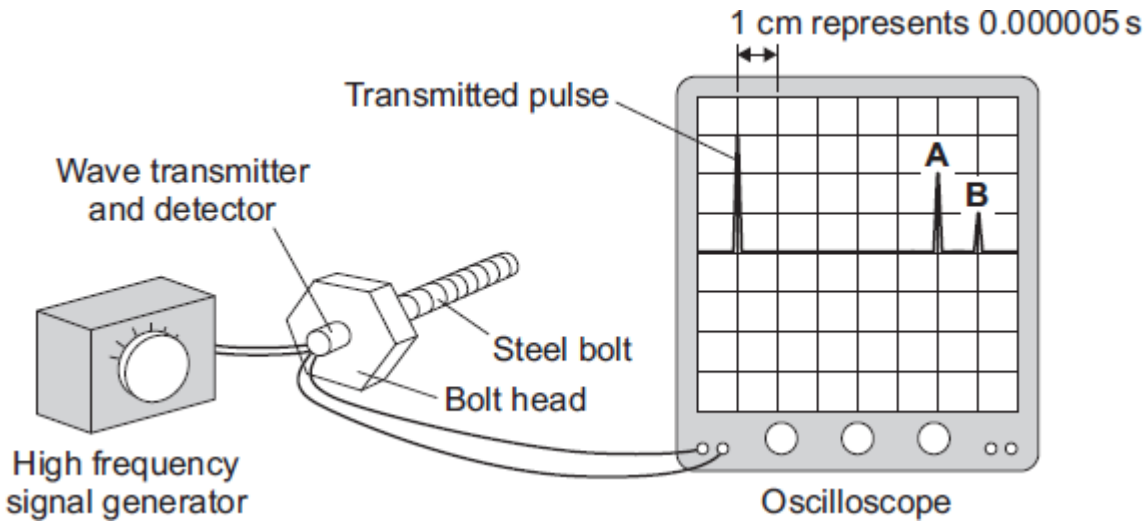
_____

_____

_____

(2)

(b) The diagram shows how a very high frequency sound wave can be used to check for internal cracks in a large steel bolt. The oscilloscope trace shows that the bolt does have an internal crack.



(i) Explain what happens to produce pulse **A** and pulse **B**.

_____

_____

_____

_____

(2)

(ii) Use the information in the diagram and the equation in the box to calculate the distance from the head of the bolt to the internal crack.

distance = speed × time

Speed of sound through steel = 6000 m/s

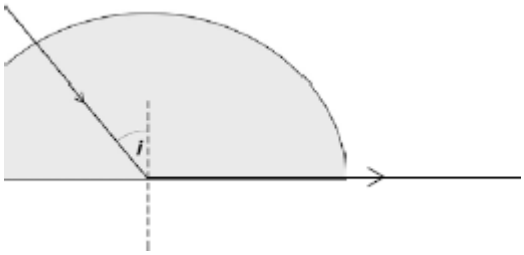
Show clearly how you work out your answer.

(3)

(Total 9 marks)

Q1.

(a) (i) line drawn at 90 degrees to the normal:



ignore (partial) reflection of the ray

1

(ii) 1.5

award both marks for an answer that rounds to 1.5

*award **1** mark for correct substitution ie 1 / sin 41*
***or** 1 / 0.656(059)*

2

(b) 26

*award **3** marks for an answer that rounds to 26*

*award **2** marks for*

$$1.3 = \frac{0.57(3576)}{\sin r}$$

or

$r = \sin^{-1}(0.57(3576) / 1.3)$

*award **1** mark for correct substitution.ie* $1.3 = \frac{\sin 35}{\sin r}$

or

sin 35° shown correctly, ie 0.57(3576), or used correctly in the calculation

an answer of 0.44 scores 2 marks

an answer of 26.9 scores 0

3

[6]

Q2.

(for both fibres) increasing the wavelength of light decreases and then increases the percentage / amount of light transmitted

*accept for **1** mark:*
(for both fibres) increasing the wavelength (of light) to 5 (x 10^{-7} metres), decreases the (percentage) transmission

1

(for both fibres) the minimum transmission happens at 5 (x 10^{-7} metres)
or
maximum transmission occurs at 6.5 (x 10^{-7} metres)

*accept for a further **1** mark:*
(for both fibres) increasing the wavelength of the light from 5

(x 10^{-7} metres) increases the amount of light transmitted
increasing <u>wavelength</u> (of light), decreases the percentage transmitted is insufficient on its own

1

the shorter fibre transmits a greater percentage of light (at the same wavelength)

*accept for **1** mark:*
Any statement that correctly processes data to compare the fibres

1

[3]

Q3.

(a) (i) frequency

1

wavelength

1

(ii) 10^{-15} to 10^{4}

1

(b) 2.0×10^{5}

correct substitution of
*3.0×10^{8} / 1500 gains **1** mark*

2

Hz

1

(c) (i) (skin) burns

1

(ii) skin cancer / blindness

1

(d) (i) any **one** from:

- (detecting) bone fractures
- (detecting) dental problems
- treating cancer

1

(ii) any **one** from:

- affect photographic film
- absorbed by bone
- transmitted by soft tissue
- kill (cancer) cells

*answer must link to answer given in **(d)(i)***

1

(iii) 9 / 36 = 0.25
0.5 / 2 = 0.25
4 / 16 = 0.25

accept:
36 / 9 = 4

2 / 0.5 = 4
16 / 4 = 4

2

conclusion based on calculation

*two calculations correct with a valid conclusion scores **2** marks*

*one correct calculation of k scores **1** mark*

1

[13]

Q4.

(a) C or 0.18 mm

1

(b) 0.6 (m)

*allow **1** mark for correct substitution and/or transformation **or** **1** mark for changing frequency to Hz*
*answer 600 gains **1** mark*

2

(c) creates an alternating current

accept 'ac' for alternating current
accept alternating voltage

1

with the same frequency as the radio wave

accept signal for radio wave

*accept it gets hotter for **1** mark provided no other marks scored*

1

(d) X-rays cannot penetrate the atmosphere

accept atmosphere stops X-rays

*do **not** accept atmosphere in the way*

or

X-rays are absorbed (by the atmosphere) before reaching Earth

<u>ignore</u> explanations

1

[6]

Q5.

(a) (i) 3

1

(ii) 30 000 **or** 10 000 × their (a)(i) correctly calculated

1

(iii) any **two** from:

- frequency is above 20 000 (Hz)

  accept the frequency is 30 000

- frequency is above the upper limit of audible range
- upper limit of audible range equals 20 000 (Hz)
  ignore reference to lower limit
- it is ultrasound/ultrasonic

2

(b) (i) wave (partially) reflected

1

at crack to produce **A** and end of bolt to produce **B**
accept at both ends of the crack

1

(ii) 0.075 (m) allow **2** marks for time = 0.0000125
*allow **1** mark for time = 0.000025*
*answers 0.15 **or** 0.015 **or** 0.09 gain **2** marks*
*answers 0.18 **or** 0.03 gain **1** mark*
the unit is not required but if given must be consistent with numerical answer for the available marks

3

[9]