1. (a) (i) X-rays   2

infra red (rays)

radio (waves)

all three in correct order

*allow **1** mark for **1** correct*

(ii) to kill cancer cells   1

(iii) energy   1

[4]

2. (i) 0.5   1

(ii) wave speed = frequency × wavelength   1

accept v   =   f × λ

accept s for v

accept m/s   =   Hz   ×   m

accept

providing subsequent method correct

(iii) 15.2 km   2

both numerical answer and unit are required for both marks

numerical answer and unit must be consistent

*allow **1** mark for 15.2 with incorrect or no unit*

*allow **2** marks for an answer of*
1.52   km if the answer to (b)(i) was given as 5

or

1 mark for correct transformation

or

1 mark for correct use of
speed   =   distance/time

unit on its own gains no credit

[4]

3. (a) (i) Ignore arrows on rays 3
perpendicular rays goes straight in and out
other ray refracts towards normal (not along)
emerges parallel incident ray (by sight) if refraction correct (ignore reflections)

for 1 mark each

(ii) emergent angle marked Y 1
if emerges parallel to right of normal

for 1 mark

(b) straight ray to water surface 3
refracts/bends
straight to eye/towards surface on right
image correctly shown
or states the same
mark prose only of diagram incomplete

any 3 for 1 mark each

[7]

4. (a) (i) ray reflected back 1

at approximately same angle
both needed

(ii) ray passes into air 1

refracted away from normal
both needed

(b) total internal reflection 1
repeated each time ray bits side of fibre 1

[4]

5. (a) radio - 1500 4
ultra violet 3×10^{-8}
visible - 5×10^{-7}
X-rays - 1×10^{-11}

(b)　1×10^{10}Hz 10^{10}HzOK　　　　　　　　　　　　　　　　　　　　　4

　　　　　　for 4 marks

　　else 1×10^{10}

　　　　　　for 3 marks

　　else $3 \times 10^8/0.03$

　　　　　　for 2 marks

　　else v = frequency × wavelength or $3 \times 10^8 = 0.03f$
　　any answer with unit Hz scores 1, 2 or 3

　　　　　　for 1 mark

(c)　(i)　microwaves　　　　　　　　　　　　　　　　　　　　　　1

　　(ii)　ultra-violet　　　　　　　　　　　　　　　　　　　　　1

　　(iii)　gamma-rays　　　　　　　　　　　　　　　　　　　　　1

　　　　　　　　　　　　　　　　　　　　　　　　　　　　[11]