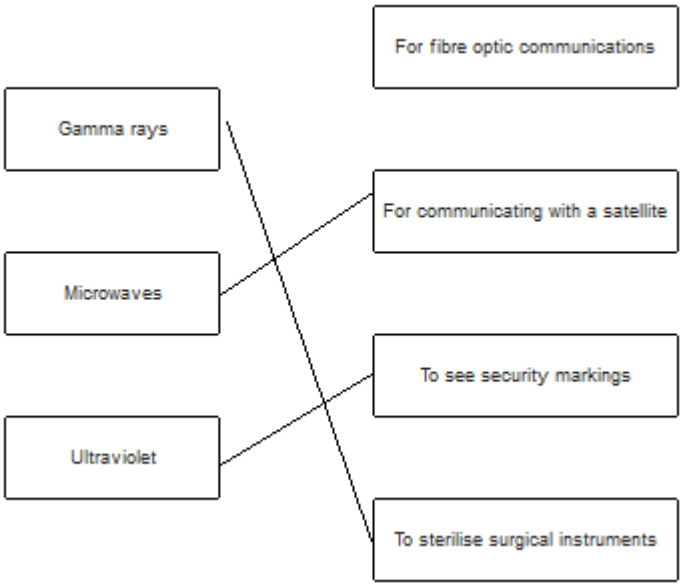
Mark schemes

1 (a) radio

1

(b)



*award **1** mark for each correct line*

if more than one line is drawn from any em wave then none of those lines gain credit

3

(c) ionising

1

[5]

2 (a) magnification = $\frac{\text{image height}}{\text{object height}}$

1

dividing by an object height of 1 cm gives the same (numerical) value

1

(b) accept anything practical that would work eg:

use a taller object

use a (travelling) microscope

attach a scale to the screen and use a magnifying glass

1

(c) both points plotted correctly

1

correct line of best fit drawn

a curve passing through all points (within ½ square), judge by eye

1

(d) values of 1.4 and 0.6 extracted from the graph

1

2.33 times bigger

accept any number between 2.3 and 2.5 inclusive

1

(e) by dividing the distance between the lens and the image by the distance between the lens and the object

1

at least one correct calculation and comparison eg 100÷25 = 4 which is the same as the measured magnification

1

[9]

3

Level 3 (5–6 marks):
A detailed and coherent plan covering all the major steps is provided. The steps in the method are logically ordered. The method would lead to the production of valid results.

A source of inaccuracy is provided.

Level 2 (3–4 marks):
The bulk of a method is described with mostly relevant detail. The method may not be in a completely logical sequence and may be missing some detail.

Level 1 (1–2 marks):
Simple statements are made. The response may lack a logical structure and would not lead to the production of valid results.

0 marks:
No relevant content.

Indicative content

place a glass block on a piece of paper

draw around the glass block and then remove from the paper

draw a line at 90° to one side of the block (the normal)

use a protractor to measure and then draw a line at an angle of 20° to the normal

replace the glass block

using a ray box and slit point the ray of light down the drawn line

mark the ray of light emerging from the block

remove the block and draw in the refracted ray

measure the angle of refraction with a protractor

repeat the procedure for a range of values of the angle of incidence

possible source of inaccuracy

the width of the light ray

which makes it difficult to judge where the centre of the ray is

[6]

4 (a) **Level 3 (5–6 marks):**
A detailed and coherent plan covering all the major steps is provided. The steps in the method are logically ordered. The method would lead to the production of valid results.

A source of inaccuracy is provided.

Level 2 (3–4 marks):
The bulk of a method is described with mostly relevant detail. The method may not be in a completely logical sequence and may be missing some detail.

Level 1 (1–2 marks):
Simple statements are made. The response may lack a logical structure and would not lead to the production of valid results.

0 marks:
No relevant content.

Indicative content

place a glass block on a piece of paper

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remove the block and draw in the refracted ray

measure the angle of refraction with a protractor

repeat the procedure for a range of values of the angle of incidence

possible source of inaccuracy

the width of the light ray

which makes it difficult to judge where the centre of the ray is

6

(b) velocity / speed of the light decreases

allow velocity / speed of the light changes

1

[7]

5 (a) any **one** from:

- (visible) light
- UV / ultra violet
- X-ray
- gamma / γ-ray

1

(b) less than

1

less than

1

the same as

1

[4]

6 (a) **use of infrared:**
remote controls
fibre optic (communications)

1

use of microwaves:
mobile/cell phones

accept mobiles

accept phone signals

satellite (communications/TV)
wi-fi
Bluetooth

1

(b) any **two** from

- same speed
  or
  travel at the speed of light (in a vacuum)
- transverse

  accept a full description of a transverse wave
- transfer energy (from one place to another)
- can be reflected
- can be refracted
- can be diffracted
- can be absorbed / transmitted
- can travel through a vacuum/space
- can be polarised

  travels in straight lines is insufficient

2

[4]

7 (a) electromagnetic

accept e.m.

1

(b) (i) 2.2 (arbitrary units)

allow an answer between 2.1 and 2.3

1

(ii) the thicker the tissue the lower the intensity

accept more intensity is needed to pass through thicker tissue

1

the relationship is not linear

accept the line is not straight

*allow for **1** mark*

it still goes through with thicker tissue

or

intensity does not reach zero

or

at 5 cm X rays still pass through

1

(iii) Both variables are continuous

1

(c) (they are) absorbed

accept (they are) stopped

1

(d) With a charge-coupled device (CCD).

1

(e) (i) X-rays are ionising

1

(ii) stand behind a (protective) screen

accept leave the room

accept wear a lead apron

1

[9]

8 (a) ultrasound is not ionising

allow ultrasound does not harm the (unborn) baby

1

but X-rays are ionising

1

so X-rays increase the health risk to the (unborn) baby

accept specific examples of health risks, eg cancer, stunted growth, impaired brain function etc

X-rays are dangerous is insufficient

1

(b) ultrasound/waves are partially reflected

(when they meet a boundary) (between two different media / substances / tissues)

must be clear that not all of the wave is reflected

1

the time taken is measured (and is used to determine distances)

1

(c) 1600 (m/s)

*800 (m/s) gains **2** marks*

*160 000 (m/s) gains **2** marks*

*0.0016 (m/s) gains **2** marks*

*allow **2** marks for*

$$\frac{0.04}{25 \times 10^{-6}}$$

or

$$\frac{0.08}{50 \times 10^{-6}}$$

*80 000 (m/s) gains **1** mark*

*0.0008 (m/s) gains **1** mark*

*allow **1** mark for*

$$\frac{0.04}{25}$$

or

$$\frac{0.08}{50}$$

*allow **1** mark for evidence of doubling the distance or halving the time*

3

(d) (i) they are absorbed by bone

allow stopped for absorbed

X-rays are reflected negates this mark

1

they are transmitted by soft tissue

allow pass through for transmitted

allow flesh / muscle / fat

accept less (optically) dense material for soft tissue

1

(the transmitted) X-rays are detected

1

(ii) short

accept small

1

[12]

9 (a) the image would decrease in size

1

the image would change (from virtual) to real

accept that the image (of bulb M) can be projected on to a screen

1

the image would change (from non-inverted) to inverted

1

(b) a ray through the centre of the lens

rays should be drawn with a ruler

ignore arrows

1

a ray parallel to the principal axis and passing through the principal focus to the right of lens

accept solid or dashed lines

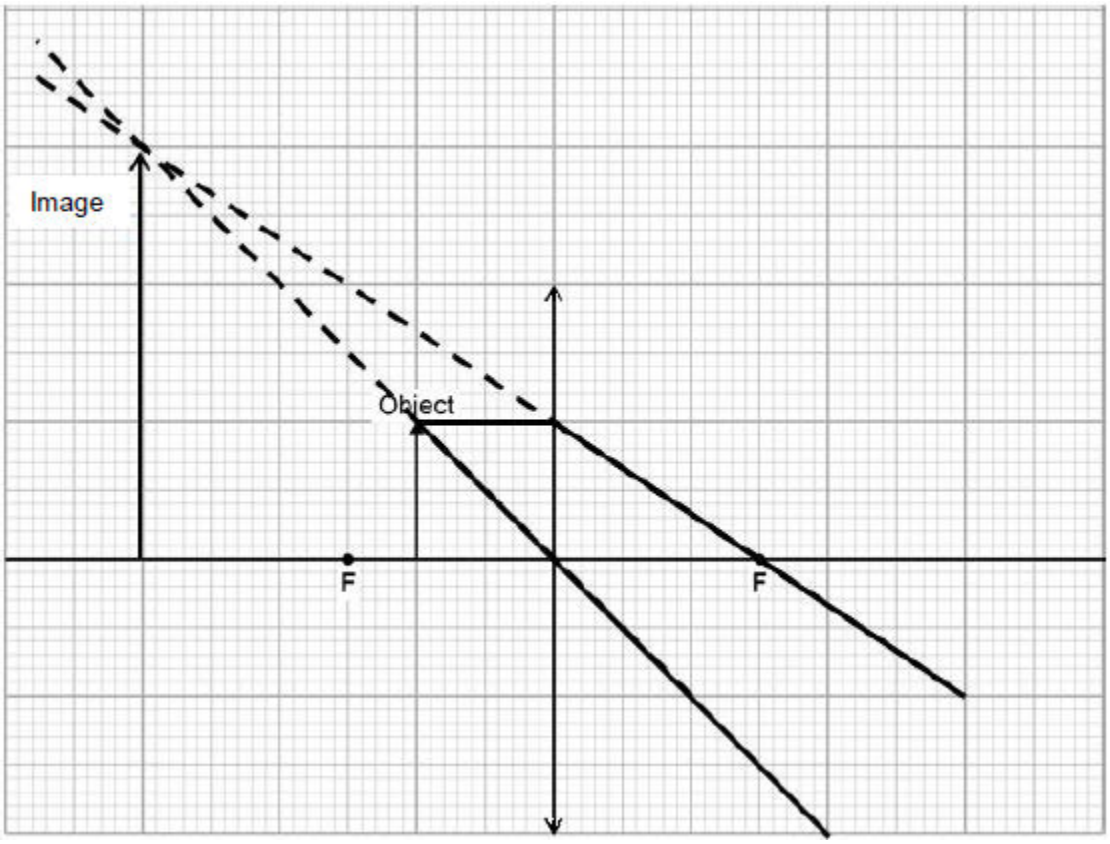
accept a ray drawn as if from the principal focus to the left of the lens, emerging parallel to the principal axis

1

image drawn where rays cross

image should be to left of the lens

1



(c) (i) (because the glass in) lens A has a greater refractive index

accept lens A is more powerful

accept lens A has a shorter focal length

1

(ii) when the magnification increases by 1, the image distance increases by 10 cm

*accept for **1** mark it is a linear pattern*

or

as the image distance increases, the magnification increases

*do **not** accept directly proportional*

2

(iii) diagram showing the surfaces of a convex lens C having greater curvature than lens B

the size of the lens drawn is not important

1

[10]

10 (a) B

must be in correct order

1

A

1

D

1

(b) (i) mass increases as refractive index increases

accept weight / density increases as refractive index increases

1

(ii) thinner

accept thin

1

heavier

accept heavy

1

(iii) maximum one advantage and one disadvantage of each design

water-filled

advantages:

- lenses are light
- wide range of focal length
- allows fine adjustment
- allows lenses to be altered independently.

1

disadvantages:
- unattractive
- lens might burst
- lens might leak
- uncomfortable.

1

sliding lenses
advantages:
- hard-wearing
- look like conventional glasses
- easy to adjust
- allows lenses to be altered independently.

1

disadvantages:
- heavy
- might slide out of position
- might get dirt between the lenses.

1

(c) any two from:
the image is
- blurred
- coloured
- inverted
- diminished.

accept not focussed

1
1

[12]

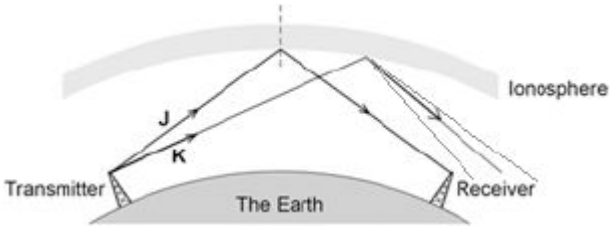
11 (a) (i) reflection of wave **K** at or within the ionosphere

allow dashed lines

1

angle i = angle r

'judge by eye'



tolerance for the reflected ray is between the first e and last r

ignore arrows

a reflected ray to the receiver doesn't score 2 nd mark

additional rays shown don't score 2 nd mark

1

(ii) normal

1

(b) (i) microwave

1

(ii) refraction

1

(c) All electromagnetic waves are transverse.

1

All electromagnetic waves have the same speed in a vacuum.

1

[7]

12 (a) (i) microwave

1

(ii) refraction

1

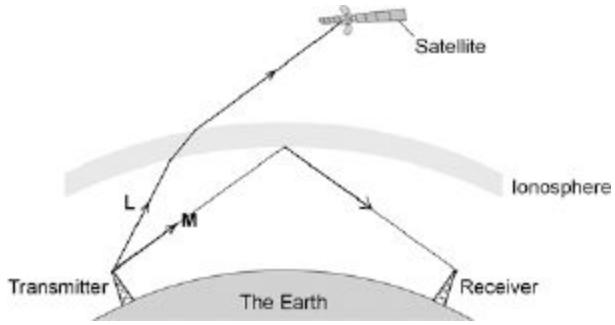
(b) (i) wave M continues as a straight line to the ionosphere and shown reflected

accept reflection at or within the ionosphere

1

correctly reflected wave shown as a straight line reaching the top of the receiver

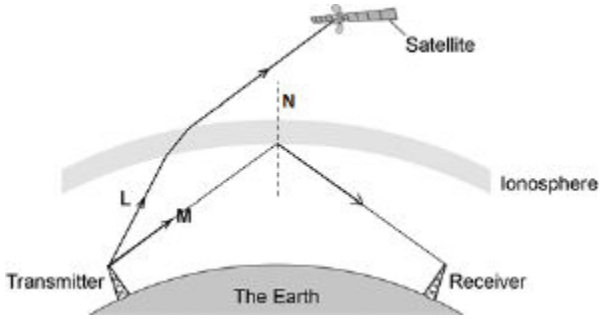
if more than 2 rays shown 1 mark maximum



ignore arrows

1

(ii) normal drawn at point where their **M** meets the ionosphere



1

(c) any **two** from:

- transverse
- same speed (through air)

  *accept speed of light **or** 3 × 10^8 m / s*
- can be reflected
- can be refracted
- can be diffracted
- can be absorbed
- transfer energy
- can travel through a vacuum

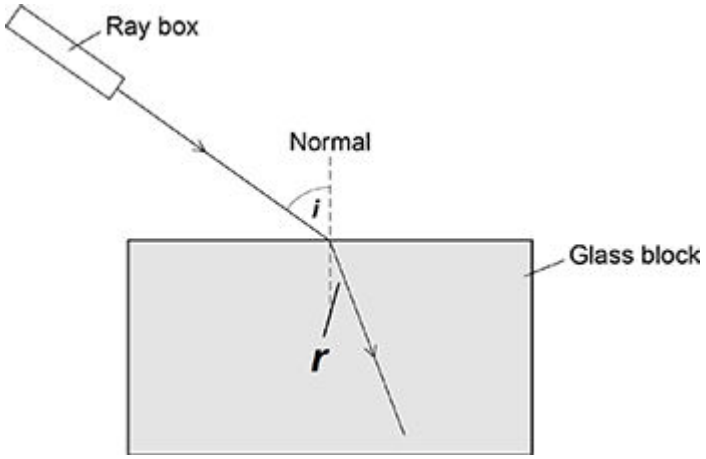
  *an answer travel at the same speed though a vacuum scores **2** marks*
- can be polarised
- show interference.

  travel in straight lines is insufficient

2

[7]

13 (a) (i)



1

(ii) 1 degree

1

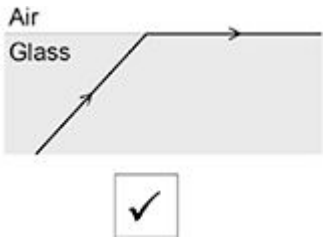
(iii) 1.6

*allow **1** mark for correct substitution, ie 0.80 / 0.5 provided no subsequent step shown*

working showing 1.59(9…..) scores zero

2

(b) 2nd diagram ticked



✓

1

(c) (i) any **one** correct description:

- upright
- virtual
- diminished.

treat multiple words as a list

1

(ii) 0.25

*allow **1** mark for correct substitution, ie 1 / 4 or 5 / 20 provided no subsequent step shown*

ignore any unit

2

(iii) Correcting short sight

1

[9]

14 (a) 20,000

accept 20 kilo

or

20 k

or *20 001*

1

an atom

1

(b) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer in the Marking Guidance and apply a 'best-fit' approach to the marking.

0 marks
no relevant content

Level 1 (1–2 marks)
At least one relevant statement is given for either type of wave

Level 2 (3–4 marks)
either
a use, risk and precaution is given for one type of wave
or
A medical use is given for both types of wave
plus
a risk or precaution for one type of wave

Level 3 (5–6 marks)
At least one medical use is given for both types of wave linked to the risks and any precautions necessary

Examples of the points made in the response

Medical use of X-rays

Any one from:

- Detecting bone fractures
- Detecting dental problems
- Killing cancer cells
- CT scanning.

Ignore details about how X-rays / ultrasound work

accept any specific use of X-rays, eg

- *detecting heart / lung disorders (with chest X-rays)*
- *mammograms / breast cancer detection*
- *detecting stones / bowel disease (with abdominal X-rays)*

Risks with X-rays

X-rays pose a risk / danger / hazard

accept are harmful

X-rays cause ionisation / damage to cells

or

mutate cells / cause mutations / increase chances of mutations

or

turn cells cancerous / produce abnormal growths / produce rapidly growing cells

or

kill cells

accept a description of what ionising is

instead of cell, any of these words can be used: DNA / genes / chromosomes / nucleus

accept (may) cause cancer

Operator precautions with X-rays

The X-ray operator should go behind a (metal / glass) screen / leave the room when making an X-ray / wear a lead lined apron

accept appropriate precautions for the patient e.g. limit the total exposure / dose (in one year)

wear a radiation badge is insufficient

Medical use of ultrasound

Any one from:

- Pre-natal scanning
- Imaging (a named body part).
- removal / destruction of kidney / gall stones
- removing plaque from teeth

cleaning teeth is insufficient

- accept examples of repair, eg alleviating bruising, repair scar damage, ligament / tendon damage, joint inflammation.

accept physiotherapy

*accept curing prostate cancer **or** killing prostate cancer cells*

Risks with ultrasound

Ultrasound poses no risk / danger / hazard (to the user / patient)

accept ultrasound is safer than using X-rays

Ultrasound is not ionising

or

Ultrasound does not damage (human) cells

Precautions with ultrasound

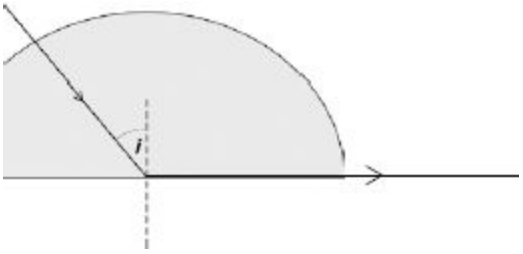
The operator needs to take no precautions when making an ultrasound scan

this can be assumed if it is stated that ultrasound is harmless or it is safer than using x-rays or it is non-ionising

6

[8]

15 (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]

16 (a) refraction

1

(b) towards the normal

1

(c) (i) convex

1

(ii) principal focus

accept focal point

1

(d) parallel on left

1

refracted towards the normal at first surface

1

refraction away from normal at second surface

1

passes through or heads towards principal focus

1

(e) refractive index

accept material from which it is made

1

(radius of) curvature (of the sides)

accept shape / radius

*do **not** accept power of lens*

ignore thickness / length

1

[10]

17 (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]

18 (a) wavelength correctly shown

1

(b) (i) increased

1

decreased

1

(ii) 17-18 inclusive

1

evidence of measurement divided by 3 or mean of 3 separate measurements

1

mm

accept cm if consistent with answer

1

(c) (i) red shift

1

(ii) moving away

1

(iii) the furthest galaxies show the biggest red shift

1

(meaning that) the furthest galaxies are moving fastest

1

(so the) Universe is expanding

1

(extrapolating backwards this suggests that) the Universe started from an initial point

1

(iv) cosmic microwave background radiation

allow CMBR

1

[13]

19 (a) (i) infrared / *IR*

1

(ii) *UV / X-rays / gamma rays*

1

appropriate use corresponding with given wave:

dependent on first marking point

- UV: security marking ***or*** *tanning*
- X-rays: medical imaging ***or*** *checking baggage*
- gamma rays: sterilising surgical instruments ***or*** killing harmful bacteria in food

accept any sensible alternative uses

1

(b) D

1

gap must be comparable to wavelength

accept converse

1

can create gap of that size in classroom

dependent on first marking point

1

(c) (i) Q

1

(ii) sound waves reflected

accept 'it' for sound waves

ignore bounce

1

at EF

1

angle of incidence equal to angle of reflection

1

(iii) stop sound going direct from clock to ear

1

(iv) 22 (m)

*allow **1** mark for correct substitution, ie*

*330 = 15 × λ scores **1** mark*

2

(v) outside audible range

1

[14]

20 (a) (i) short sight

accept myopia

1

(ii) diverging

1

(b) light

1

(c) Marks awarded for this answer will be determined by the quality of communication as well as the standard of the scientific response. Examiners should also apply a 'best-fit' approach to the marking.

0 marks
No relevant content

Level 1 (1–2 marks)
There is a basic description of one advantage ***or*** disadvantage of using **either** of the methods

Level 2 (3–4 marks)
There is a *description* of some advantages **and** / **or** disadvantages of using **both** methods
or
a full, detailed description of the advantages and disadvantages of using **either** of the methods.

Level 3 (5–6 marks)
There is a *clear description* of the advantages and disadvantages of using **both** methods.

examples of the points made in the response
extra information

laser surgery

advantages:

- *appearance*
- *permanent effect*
- no glasses which need changing

disadvantages:

- risks associated with surgery
- large cost
- not able to drive etc straightaway
- (still) might need glasses for reading

wearing glasses

advantages:

- able to function straightaway
- any problems easy to sort out

disadvantages:

- *easily broken*
- *easily lost*
- need changing
- overall cost might be greater if several changes in vision
- might eventually need two pairs of glasses

(d) move lens

1

closer to film

1

[11]

21 (a) decreases

correct order only

1

increases

1

(b) (i) intensity (of transmitted light) depends on thickness
or
to enable a valid comparison
or
it is a control variable

accept absorption depends on thickness
it would affect the results is insufficient
fair test is insufficient

1

(ii) transmits the least light
or
absorbs the most light

accept very little light is transmitted
*do **not** accept transmits none of the light*
*do **not** accept absorbs all of the light*
any reference to heat negates this mark

1

[4]

22 (a) transmits

correct order

1

absorbs

1

(b) light

allow ultra violet ***or*** *UV* ***or*** *infrared* ***or*** *IR* ***or*** *gamma*

1

(c) 20

allow ***1*** *mark for correct working, ie* $\frac{60}{3}$ *provided no subsequent step*

2

(d) Killing cancer cells

1

[6]

23 (a) long

1

(b) lens A

1

it is a concave / diverging lens

this mark is only gained if lens A is stated

any reference to lens material or mass of lens negates this mark

allow it will focus light onto the retina

1

(c) The refractive index of the lens material

1

(d) 4

ignore any signs

allow ***1*** *mark for correct substitution, ie* $\frac{1}{0.25}$ *provided no subsequent step*

2

(e) Cauterising open blood vessels

1

(f) 5

allow ***1*** *mark for correct substitution, ie* $\frac{70}{14}$ *provided no subsequent step*

2

[9]

24 (a) (sound waves) which have a frequency higher than the upper limit of hearing for humans
or
a (sound) wave (of frequency) above 20 000 Hz

sound waves that cannot be heard is insufficient

a wave of frequency 20 000 Hz is insufficient

1

(b) 640

*an answer of 1280 gains **2** marks*

*allow **2** marks for the correct substitution*

ie 1600 × 0.40 provided no subsequent step

*allow **2** marks for the substitution* $\frac{1600 \times 0.80}{2}$

provided no subsequent step

*allow **1** mark for the substitution 1600 × 0.80 provided no subsequent step*

*allow **1** mark for the identification that time (boat to bed) is 0.4*

3

(c) any **one** from:

- pre-natal scanning / imaging
- imaging of a named organ (that is not surrounded by bone), eg stomach, bladder, testicles

  accept heart

  *do **not** allow brain **or** lungs (either of these negates a correct answer)*
- Doppler scanning blood flow

1

(d) advantage

any **one** from:

- (images are) high quality or detailed or high resolution

  clearer / better image is sufficient
- (scan) produces a slice through the body
- image can be viewed from any direction

  allow images are (always) 3D / 360°
- an image can be made of <u>any</u> part (inside the body)

  allow whole body can be scanned
- easier to diagnose **or** see a problem (on the image)

1

disadvantage

any **one** from:

- (the X-rays used **or** scans) are <u>ionising</u>

  allow a description of what ionising is
- mutate cells **or** cause mutations **or** increase chances of mutations

  allow for cells:

  DNA / genes / chromosomes / nucleus / tissue

- turn cells cancerous **or** produce abnormal growths **or** produce rapidly growing cells
- kill cells

  damage cells is insufficient
- shielding is needed

  can be dangerous (to human health) unqualified, is insufficient

1

[7]

25 (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 wavelength (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]

26 (a) the oscillation / vibration (causing the wave)

a movement causes the wave is insufficient

1

for a transverse wave is perpendicular to the direction of energy transfer

accept direction of wave travel

1

and for a longitudinal wave is parallel to the direction of energy transfer

accept direction of wave travel

*if no marks awarded allow **1** mark for correctly linking perpendicular with transverse and parallel with longitudinal*

the marks may be scored by the drawing of two correctly labelled diagrams

1

(b) for radio waves:

accept converse for each mark

are transverse

1

travel at speed of light / higher speed

1

have greater frequencies

1

can travel through vacuum

*accept sound waves are not electromagnetic for **1** mark*

1

[7]

27 (a) (i) magnified

1

upright

1

(ii) v = −6(cm)

*max **2** marks if no minus sign*

*6(cm) gains **2** marks*

1/v = 1/12 − 1/4 = −1/6
*gains **2** marks*

1/12 = 1/4 + 1/v
*gains **1** mark*

−5.99(cm)
*using decimals gains **3** marks*

3

(b) it is <u>virtual</u>

1

[6]

28 (a) (i) (visible) light

accept visible

1

(ii) microwaves

1

(b) J

1

(c) (i) B

1

(ii) shorter than

1

(d) (i) To find out if using a mobile phone is harmful to health

1

(ii) any **two** from:

- (X has a) low(er) SAR value
  "it" refers to mobile phone
  accept has a low(er) rate
- (maximum) energy absorbed (by the head) is less
  accept energy emitted (by phone) is less
  accept radiation for energy
- (if mobiles are harmful) less likely to cause harm
  accept will not cause harm
  accept it is safer

2

[8]

29 (a) C

1

(b) reflection at the mirror of ray from shoe to person's eye

may be drawn freehand

1

angle of incidence = angle of reflection

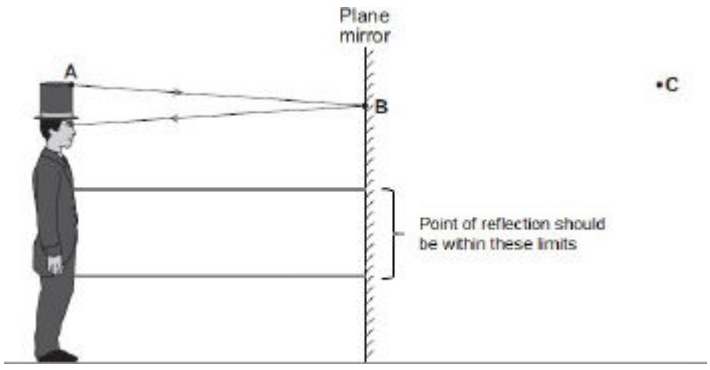
judged by eye
a ruler must have been used

1

arrow to show correct direction on either incident or reflected ray

only one arrow needed but if more drawn must be no contradiction
both incident and reflected ray must be shown

1



(c) virtual

1

[5]

30 (a) vibrate / oscillate

accept a correct description

move is insufficient

1

(b) 336

*allow **1** mark for correct substitution, ie 420 × 0.8(0) provided no subsequent step shown*

2

[3]

31 (a) (i) perpendicular

accept correct description 1

1

(ii) light off – no / slow rotation

1

light on – fast(er) rotation

accept starts rotating

ignore references to energy transfers

1

(b) one ray drawn from wrist watch and reflected by mirror

accept solid or dashed lines

1

two rays drawn from wrist watch and reflected by mirror with i = r for both rays

judge angles by eye

1

one ray traced back behind mirror

accept solid or dashed lines

1

image in correct position

judged by eye

accept image marked where two reflected rays traced back cross behind the mirror

1

(c) cannot be formed on a screen

accept image formed behind the mirror

or

rays of light seem to come from it but do not pass through it

1

[8]

32 (a) 10^{-15} metres to 10^{4} metres

1

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

- (TV / video / DVD) remote controls
  mobile phones is insufficient
- (short range) data transmission
  accept specific example, eg linking computer peripherals
- optical fibre (signals)
  *do **not** accept Bluetooth*

1

(ii) 0.17

*an answer 17 cm gains **3** marks*

*an answer given to more than 2 significant figures that rounds to 0.17 gains **2** marks*

*allow **1** mark for correct substitution, ie* $3 \times 10^8 = 1.8 \times 10^9 \times \lambda$

3

(c) (maybe) other factors involved

accept a named 'sensible' factor, eg higher stress / sedentary lifestyle / overweight / smoking more / diet / hot office / age

not testing enough people is insufficient

unreliable data is insufficient

1

[6]

33 (a) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking guidance, and apply a 'best-fit' approach to the marking.

0 marks
No relevant / correct content.

Level 1 (1-2 marks)
There is a basic description of either wave
OR
What happens to either wave when they enter the body. However there is little other detail.

Level 2 (3-4 marks)
There is either:
A clear description of BOTH waves
OR
A clear description as to what happens to BOTH waves inside the body
OR
A clear description of ONE of the waves with clear detail as to what happens to either wave inside the body.

Level 3 (5-6 marks)
There is a detailed description of BOTH of the waves
AND
A detailed description as to what happens to EITHER wave inside the body.

Examples of the points made in the response:

Description of an X-ray

- X-rays are electromagnetic waves / part of the electromagnetic spectrum
  *do **not** allow a description of a property – eg X-rays travel*
- X-rays are (very) high frequency (waves)
  through a vacuum / at the speed of light
- X-rays are (very) high energy (waves)
- X-rays have a (very) short wavelength
- Wavelength (of X-rays) is of a similar size to (the diameter of) an atom
- X-rays are a transverse wave
  correct description acceptable – oscillations / vibrations are perpendicular (at 90°) to direction of energy transfer
- X-rays are ionising radiation

Description of ultrasound

- ultrasound has a frequency above 20 000 (hertz)

  or

  ultra sound is above 20 000 hertz
- ultrasound is above / beyond the human (upper) limit (of hearing)
  accept ultrasound cannot be heard by humans
- ultrasound is a longitudinal wave
  correct description acceptable – oscillations / vibrations (of particles) are parallel (in same direction) to direction of energy transfer

Statement(s) as to what happens to X-rays inside the human body:

- X-rays are absorbed by bone
- X-rays travel through / are transmitted by tissue / skin

Statement as to what happens to ultrasound inside body:

- ultrasound is (partially) reflected at / when it meets a boundary between two different media
- travel at different speeds through different media

(b) (because the X-rays) are <u>ionising</u>

accept a description of what ionising is

1

(they will) damage cells

instead of cell, any of these words can be used:

DNA / genes / chromosomes / nucleus

or

mutate cells / cause mutations / increase chances of mutations

or

turn cells cancerous / produce abnormal growths / produce rapidly growing cells

*do **not** accept they can be dangerous (to human health)*

*do **not** accept damage to soft tissue*

or

kill cells

1

(c) any **one** from:

- removal / destruction of kidney / gall stones
- repair of damaged tissue / muscle

  accept examples of repair, eg alleviating bruising, repair scar damage, ligament / tendon damage, joint inflammation

  accept physiotherapy

  *accept curing prostate cancer **or** killing prostate cancer cells*
- removing plaque from teeth

  cleaning teeth is insufficient

1

[9]

34 (a) any **two** correct construction lines:

if more than 2 construction lines treat as a list

2

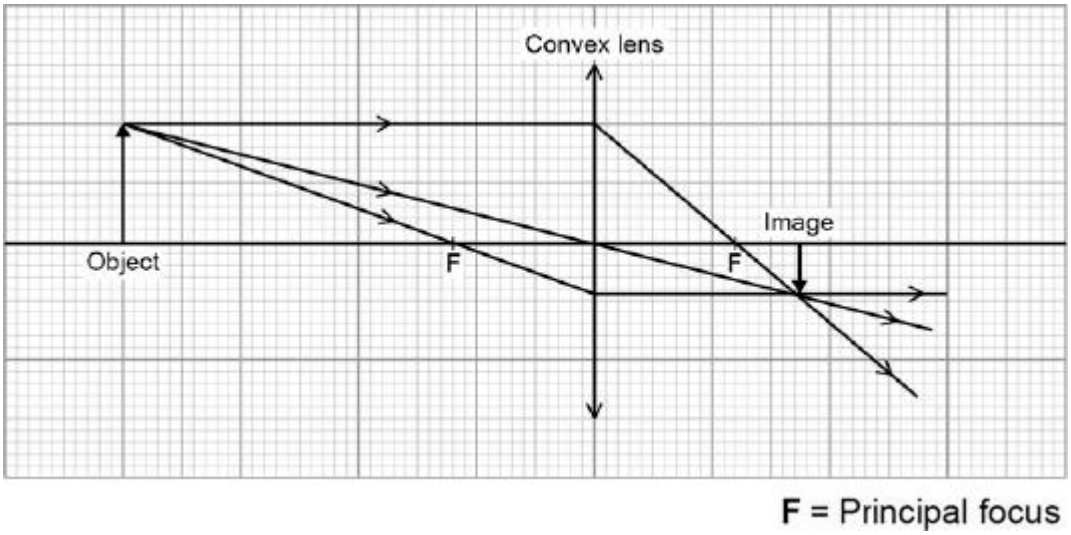
- line passing straight through centre of lens (& out other side)
- line travelling parallel to principal axis & then being refracted through principal focus (on RHS)
- line travelling through principal focus (on LHS) & then being refracted to be parallel to principal axis (on RHS)

<u>inverted</u> image drawn (with arrow) in correct location

1

one arrowhead from object to image on any construction ray

conflicting arrowheads negate this mark



1

(b) any **two** from:

- inverted

  accept upside down

- real

- diminished / smaller

  *allow ecf if ray diagram wrongly drawn but descriptions must relate to **their image***

  a converse negates mark, eg real and virtual scores zero

2

[6]

35 (a) (i) gamma

accept correct symbol

1

(ii) any **one** from:

- (ultraviolet has a) higher frequency

  ultraviolet cannot be seen is insufficient

- (ultraviolet has a) greater energy

- (ultraviolet has a) shorter wavelength

  ignore ultraviolet causes cancer etc

1

(b) 1.2×10^7 / 12 000 000

*allow **1** mark for correct substitution, ie $3 \times 10^8 = f \times 25$*

2

hertz / Hz / kHz / MHz

*do **not** accept hz **or** HZ*

*answers 12 000 kHz **or** 12 MHz gain **3** marks*

for full credit the numerical answer and unit must be consistent

1

(c) (i) away (from each other)

accept away (from the Earth)
accept receding

1

(ii) distance (from the Earth)

accept how far away (it is)

1

speed galaxy is moving

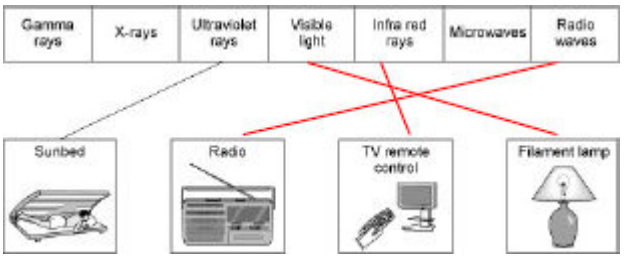
1

(iii) (Universe is) expanding

1

[9]

36 (a) all three lines correct



*allow **1** mark for each correct line*

if more than one line goes from a device then all lines from that device are wrong

3

(b) (i) <u>skin</u> cancer

*do **not** accept cancer*
*do **not** accept sunburn*

correct answer only

1

(ii) other factors may be involved

accept may have been in the Sun too long

accept (over)-use of sunbeds and (over)- exposure to the Sun (both) give the same symptoms
accept any other sensible factor that could lead to doubt

*do **not** accept irrelevant answers eg may be run over by a car*

*do **not** accept killed by exposure to the Sun*

1

(iii) can assess risk

answers should be in terms of assessing our own health risk

or

make your own decision

accept so you limit its use / don't use one

*do **not** accept so you don't get skin cancer*

*do **not** accept so you don't get sunburn*

1

[6]

37 less / no light pollution

accept no / fewer streetlights

1

less cloud cover / above clouds

1

less atmospheric pollution

accept air for atmosphere

accept idea of thinner atmosphere

*do **not** accept closer to stars*

1

[3]

38 (a) (both graphs show an initial) increase in count rate

accept both show an increase

1

(b) only the right kidney is working correctly

1

any **two** from:

*if incorrect box chosen maximum of **1** mark can be awarded*

reference to named kidney can be inferred from the tick box

- count-rate / level / line for right kidney decreases (rapidly)

  it decreases is insufficient

- count-rate / level / line for left kidney does not change

  it does not change is insufficient

- radiation is being passed out into urine – if referring to right kidney
- radiation is not being passed out – if referring to the left kidney
- left kidney does not initially absorb as much technetium-99

2

[4]

39 (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

ignore explanations

1

[6]

40 (a) (i) answer in the range 3.0 ↔ 3.1 inclusive

*accept for **1** mark*
3.6 ÷ 1.2 or 3.7 ÷ 1.2
***or** 36 ÷ 12 or 37 ÷ 12*
***or** 18 ÷ 6 or 18.5 ÷ 6*
***or** 10.2 ÷ 3.4 or 102 ÷ 34*
***or** answer in the range but with a unit eg 3 cm*

2

(ii) (principal) focus / focal (point(s)) / foci / focus

accept 'focusses'
accept focals
*do **not** accept focal length*

1

(iii) at the intersection of virtual / imaginary rays

or *'where virtual / imaginary rays cross'*

or *the rays of (real) light do not cross*

or *the image on the same side (of the lens) as the object*

or *the image is drawn as a dotted line*

or *the image is upright*

do ***not*** *accept 'cannot be put on a screen'*

do ***not*** *accept any response which refers to reflected rays*

1

(b) (i) another correct observation about relationship between values of **d**

example

15 is three times bigger than 5 but

1

(but) not the relationship between corresponding values for magnification

2.0 is not three times bigger than 1.2

1

(ii) when the distance / **d** increases the magnification increases

or *the converse*

accept 'there is a <u>positive</u> *correlation'*

do ***not*** *accept any response in terms of proportion / inverse proportion*

1

(iii) (student has) no evidence (outside this range)

accept data / results / facts for 'evidence'

1

[8]

41 (a) (i) X-ray(s)

1

(ii) gamma rays

1

(iii) infrared

1

(b) the same speed as

1

(c) (i) horizontal arrow drawn pointing to the right

judge by eye

accept drawn anywhere on diagram

1

(ii) **Y**

1

(iii) any **one** from:

- any type of electromagnetic wave
  accept electromagnetic wave(s)
- water (wave)
  *do **not** accept seismic waves*
- (earthquake / seismic) S waves
  *do **not** accept P waves*
  *do **not** accept earthquakes*

1

(d) (i) 3

1

(ii) 3.6

or

their (d)(i) × 1.2 correctly calculated
$v = f \times \lambda$
*allow **1** mark for correct substitution*
ie 3 or their (d)(i) × 1.2 provided that no subsequent step is shown

2

[10]

42 (a) (i) to check rise in temperature (of other thermometers) was due to the (different wavelengths of) light
accept as a control / comparison
to measure room temperature is insufficient

1

(ii) any **two** from three:

- different colours produce different heating effects / (rises in) temperatures
- red light produces the greatest heating effect / (rise in) temperature

or

- violet produces the least heating effect / (rise in) temperature
- all colours produce a greater heating effect than outside the spectrum
  an answer
  the longer the <u>wavelength</u> the greater the (rise in) temperature
  or
  the lower the <u>frequency</u> the greater the (rise in) temperature gains both marks

2

(b) move a thermometer into the infrared region / just beyond the red light

allow use an infrared camera / infrared sensor

1

the temperature increases beyond 24(°C)

accept temperature higher than for the red light

1

(c) $v = f \times \lambda$

9.4×10^{-6}

accept 9.375×10^{-6} or 9.38×10^{-6}

or

0.0000094

accept 0.000009375
or *0.00000938*
*allow **1** mark for correct substitution*
ie $3 \times 10^{8} = 3.2 \times 10^{13} \times \lambda$

2

(d) at night the surroundings are cooler

accept at night the air is colder
there is no heat from the Sun is insufficient

or

at night there is a greater temperature difference between people and surroundings

1

(so surroundings) emit less infrared (than in daytime)

accept camera detects a greater contrast

or

gives larger difference in infrared emitted (between people and surroundings)

1

[9]

43 (a) (i) converging

1

(ii) (x) 2

*allow **1** mark for correct substitution*
*ie 10/5 **or** 20/10 **or** 2/1*
ignore any units

2

(b) decreases

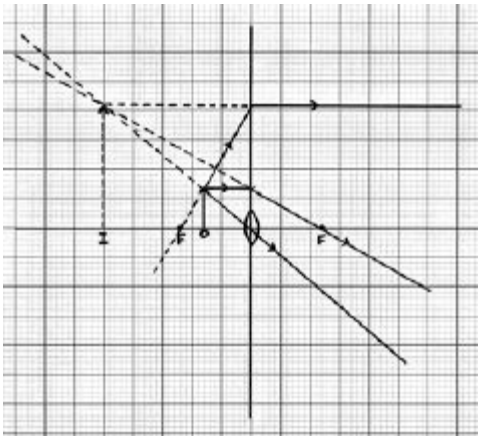
1

[4]

44 (a) (i) **two** correct rays drawn

***1** mark for each correct ray*

- ray parallel to axis from top of object **and** refracted through focus **and** traced back beyond object
- ray through centre of lens **and** traced back beyond object
- ray joining top of object to focus on left of lens taken to the lens refracted parallel to axis **and** traced back parallel to axis beyond object



2

an arrow showing the position **and** correct orientation of the image for their rays

*to gain this mark, the arrow must go from the intersection of the traced-back rays to the axis **and** the image must be on the same side of the lens as the object and above the axis*

1

(ii) (x) 3.0

accept 3.0 to 3.5 inclusive

or

$$\frac{\text{their image height}}{\text{object height}}$$

correctly calculated

*allow **1** mark for correct substitution into equation using their figures*

ignore any units

2

(b) any **two** from:

in a camera the image is:

- real not virtual
- inverted and not upright

  accept upside down for inverted
- diminished and not magnified

  accept smaller and bigger
  accept converse answers but it must be clear the direction of the comparison
  both parts of each marking point are required

2

[7]

45 (a) any **two** from:

- travel (at same speed) through a vacuum / space

  *do **not** accept air for vacuum*
- transverse
- transfer energy
- can be reflected
- can be refracted
- can be diffracted
- can be absorbed
- travel in straight lines

2

(b) can pass through the ionosphere

accept atmosphere for ionosphere
*do **not** accept air for ionosphere*
accept travel in straight lines
accept not refracted / reflected / absorbed by the ionosphere

1

(c) $v = f \times \lambda$

1.2×10^6 / 1200 000

*allow **1** mark for correct substitution*
ie $3.0 \times 10^8 = f \times 2.5 \times 10^2$

2

hertz / Hz

*do **not** accept hz **or** HZ*

*accept kHz **or** MHz*

*answers 1.2 MHz **or** 1200 kHz gain all **3** marks*

for full credit the unit and numerical value must be consistent

1

[6]

46 (a) two rays drawn from the bulb and reflected by the glass

*angle **I** = angle **R** judged by eye*

*allow **1** mark for one incident and reflected ray even if angle **I** doesn't equal angle **R***

2

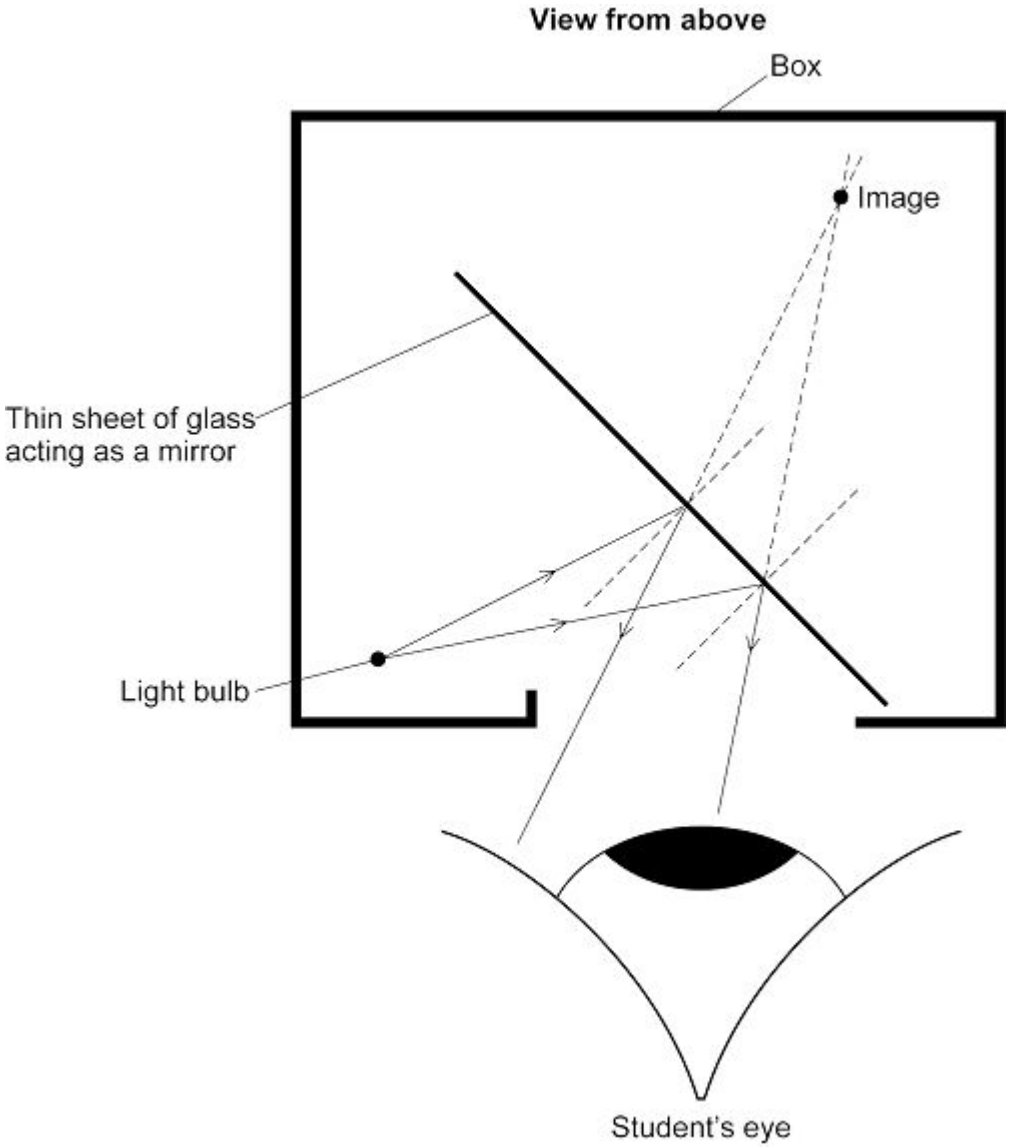
at least one arrow drawn in correct direction

any conflicting arrows negate this mark

ignore any arrows drawn on construction lines behind the glass

1

position of image correct



judged by eye

1

(b) image is formed by virtual / imaginary rays crossing

accept construction lines only show where the light seems to come from

accept the image is behind the glass / mirror

accept image is seen through the glass / mirror

accept (real) rays of light do not pass through the image

accept (real) rays do not cross

accept the image is a reflection (of the object)

accept the image is formed by reflection

*do **not** accept a virtual image can't be formed on a screen*

*do **not** accept the object / image is reflected*

1

[5]

47 (a) higher frequency

general properties / uses are neutral

or

shorter wavelength

*do **not** accept different frequency / wavelength / energy*

or

greater energy

1

(b) the same (speed)

accept they travel at the speed of light

1

(c) pass through / transmitted by the plastic / casing

1

<u>reflected</u> by the metal / plates

*do **not** accept bounce / deflected etc for reflected*

*if neither marking point scores an answer reflected (back to boat / from the device) scores **1** mark*

1

(d) (i) waves are not <u>reflected</u> from the walls

accept microwaves / radar for waves

*do **not** accept bounce / deflected etc for reflected*

or

only waves (reflected) from the device are detected

accept to stop reflected waves affecting results

1

(ii) different types (of device) can be compared

fair test is insufficient

accept idea that only one variable is then changed

1

(iii) so (measurements / results / scientists) are not biased towards one type / manufacturer of device/s

accept to avoid bias

accept so they are not biased

1

(e) (i) any **two** from:

*if temperature is mentioned rather than angle a maximum of **1** mark can be scored*

- (for any angle) **A** values < **B** values
  ***or** converse eg **B** values are higher / better / stronger*
- **A** values increase with (increasing) angle
  accept weakest at 0° strongest at 15°
  values go up is insufficient
- **B** values decrease with (increasing) angle
  accept strongest at 0° weakest at 15°
  values go down is insufficient
- **A** values do not vary as much (as **B** values)

2

(ii) **D**

mark is for the reason
*reason cannot score if **D** is not chosen*

values are always over 2(.0)

1

[10]

48 1.4

*allow **1** mark for correct substitution*
ie 14 ÷ 10
or
28 ÷ 20

[2]

49 (a) converging (lens)

accept 'con vex (lens)'
accept biconvex

1

(b) (principal) foci

accept 'focus' / 'focuses' / 'focis'
focal point(s)

1

(c) (i) formed where (real) rays (of light) intersect / meet / cross

accept rays (of light) pass through the image
accept 'image is on the opposite side (of the lens to the object)'
accept (construction) lines cross over
a response relating to a screen or similar is neutral
lines are solid and not dotted is neutral

1

(ii) inverted

accept any unambiguous correct indication

1

(d) (i) smooth curve which matches the points

*judge by eye but do **not** accept point to point by ruler or otherwise*

1

(ii) continuous

1

(iii) as distance increases, magnification decreases

accept negative correlation

*a statement 'inversely proportional' is incorrect and limits maximum mark for this part question to **1***

1

further detail eg magnification falls steeply between 40 and 50 cm
or
magnification begins to level out after / at 70 cm

1

[8]

50 (a) (i) (concave) mirror / reflector

*do **not** allow convex mirror / reflector*

1

(ii) refraction

1

(b) (i) converging

1

(ii) 4

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

ie 20 / 5 or 4 / 1

ignore any units

2

[5]

51 (a) 85

1

(b) (i) <u>thickness</u> (of glass)

accept how thick the glass is

*do **not** accept light intensity*

1

(ii) transmits less infra red

accept radiation / or heat for infra red

accept transmits less energy (at all wavelengths)

*accept (glass **B**) absorbs more infra red*

accept infra red is the same as heat

ignore reference to visible light

1

infra red has a heating effect

or

infra red warms the room

ignore references to conservatory

keeping cool

1

[4]

52 (a) (i) microwaves

1

(ii) can pass through the ionosphere

accept travels in a straight line

accept atmosphere for ionosphere

*do **not** accept air for ionosphere*

1

(b) higher the frequency, further the wave travels
(into the atmosphere before reflection)

1

(c) 15 000

*allow **1** mark for correct transformation and substitution*

ie $\frac{300\,000\,000}{20}$

*an answer of 15 000 000 only gains **1** mark*

allow both marks for an answer of 15 MHz (unit must be changed)

an answer of 15 gains no credit

2

[5]

53 (a) (i) bat(s)

1

(ii) elephant(s)

1

(iii) any example in the inclusive range 5 ↔ 29 Hz / hertz

appropriate number and unit both required

1

(b) (i) **B**

1

(ii) **F**

1

[5]

54 (a) (i) answer in the range 3.0 ↔ 3.1 inclusive

accept for 1

3.6 ÷ 1.2 or 3.7 ÷ 1.2

or 36 ÷ 12 or 37 ÷ 12

or 18 ÷ 6 or 18.5 ÷ 6

or 10.2 ÷ 3.4 or 102 ÷ 34

or answer in the range but with a unit eg 3 cm

2

(ii) (principal) focus / focal (point(s)) / foci / focus

accept 'focusses'

accept focals

*do **not** accept focal length*

1

(iii) at the intersection of virtual / imaginary rays

***or** 'where virtual / imaginary rays cross'*

***or** the rays of (real) light do not cross*

***or** the image on the same side (of the lens) as the object*

***or** the image is drawn as a dotted line*

***or** the image is upright*

*do **not** accept 'cannot be put on a screen'*

*do **not** accept any response which refers to reflected rays*

1

(b) (i) another correct observation about relationship between values of **d** (1)

(but) not the same relationship between corresponding values for magnification (1)

example

15 is three times bigger than 5 but

2.0 is not three times bigger than 1.2

2

(ii) when the distance / **d** increases the magnification increases

***or** the converse*

accept 'there is a (strong) <u>positive</u> correlation'

*do **not** accept any response in terms of proportion / inverse proportion*

1

(iii) (student has) no evidence (outside this range)

accept data / results / facts for 'evidence'

1

[8]

55 (a) (i) infra red (rays)

accept IR

or

radio (waves)

*do **not** accept heat waves*

*do **not** accept TV waves*

1

(ii) radio (waves)

this answer only

1

(b) frequency

1

(c) (i) *answer should be in terms of establishing if harmful or not harmful ie trying to clear up any uncertainty*

*do **not** accept answers that assume it is harmful*
eg Wi-Fi systems will make you ill

need to know if it is harmful / makes you ill

accept idea that safety issue may worry people

accept idea that (more) research may reassure people

accept idea of finding out (the truth)

1

(ii) an opinion

1

[5]

56 (a) (i) any **two** from:

- travel at the same speed (through a vacuum)
  accept travel at the speed of light
  accept air for vacuum
- can travel through a vacuum / space
  *do **not** accept air for vacuum*
- transfer energy
- can be reflected
- can be refracted
- can be diffracted
- can be absorbed
- can be transmitted
- transverse
  accept any other property common to electromagnetic waves
  accept travel at the same speed through a vacuum for both marks
  *do **not** accept both radiated from the Sun*

2

(ii) infra red
__both__ required for the mark

radio(waves)
accept IR for infra red

1

(b) 2 400 000 000
*correct transformation and substitution gains **1** mark*
ie $\frac{300000000}{0.125}$ ***or*** $\frac{300000000}{12.5}$
*an answer of 24 000 000 gains **1** mark*
***either** 2 400 000 kHz*
***or** 2 400 MHz scores **3** marks but the symbol only scores the 3rd mark if it is correct in every detail*

2

hertz
accept Hz
*do **not** accept hz*

1

(c) (i) presented (scientific) evidence / data

do an experiment / investigation is insufficient

1

(ii) to find out if there is a hazard (or not)

accept to find out if it is safe

accept not enough evidence to make a decision

not enough evidence is insufficient

1

[8]

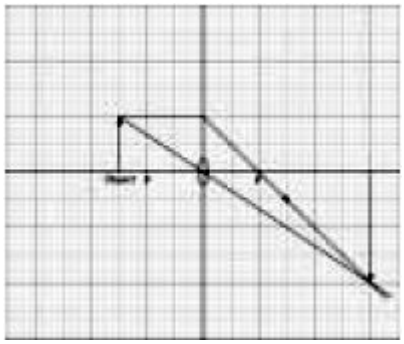
57 (a) any **two** for **1** mark each

deduct (1) from the first two marks if a ruler has not been used but the intention is clear

ray from the object's arrowhead

- through centre of lens
- parallel to the axis then, when it reaches the lens, through F on the right
- through F on the left then, when it reaches the lens parallel to the axis

*example of a **4** mark response*



*if more than two construction lines have been drawn all must be correct to gain **2** marks*

construction lines drawn as dashed lines do not score credit

2

image shown as vertical line from axis to where their rays intersect

image need not be marked with an arrowhead but, if it is, it must be correct

1

ray direction shown

only one correct direction

arrow needed but there must not be any contradiction

1

(b) any **two** from:

- inverted

  accept 'upside down'

- magnified

  accept 'bigger'

- real

  accept 'not virtual / not imaginary'
  *one correct feature gains **1** mark*
  ignore any reference to position
  an incorrect feature negates a correct response

2

[6]

58 (i) X-rays

infra red (rays)

radio (waves)

all three in correct order
*allow **1** mark for **1** correct*

2

(ii) to kill cancer cells

1

(iii) energy

1

[4]

59 (a) (i) shorter than

1

(ii) increase slightly

1

(b) (i) go up in the same ratio
or (directly) proportional **or** as speed (of the tennis ball) increases so does the (difference in) frequency

accept as one goes up, so does the other
accept positive correlation

1

(ii) 20 (m/s)

*allow **1** mark for showing correct method on graph*
(ie horizontal or vertical line anywhere on graph)
if indicated by a cross, must be ± half square of correct value)

2

(iii) frequency and speed are both continuous variables

1

[6]