AQA GCSE PHYSICS (HIGHER) · 8463

PHYSICS



MARK SCHEME

4.6.2 ELECTROMAGNETIC WAVES (PACK 2)

SCORE	PERCENTAGE
/207	%

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Q1.

(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

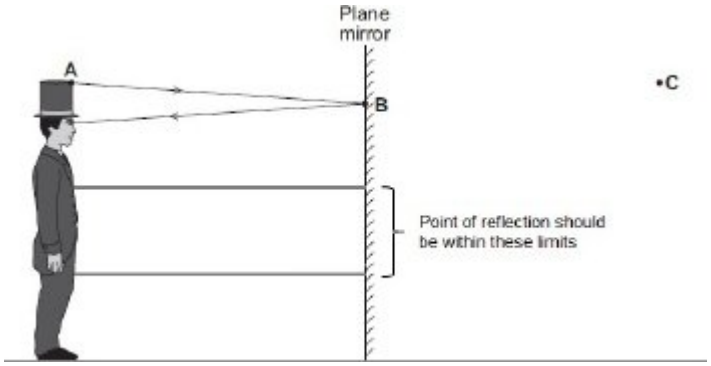
1

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]

Q2.

(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]

Q3.

(a) (i) perpendicular

accept correct description 1

1

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(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]

Q4.

(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

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*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]

Q5.

(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)

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- 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

6

(b) (because the X-rays) are ionising

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)*

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*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]

Q6.

(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)

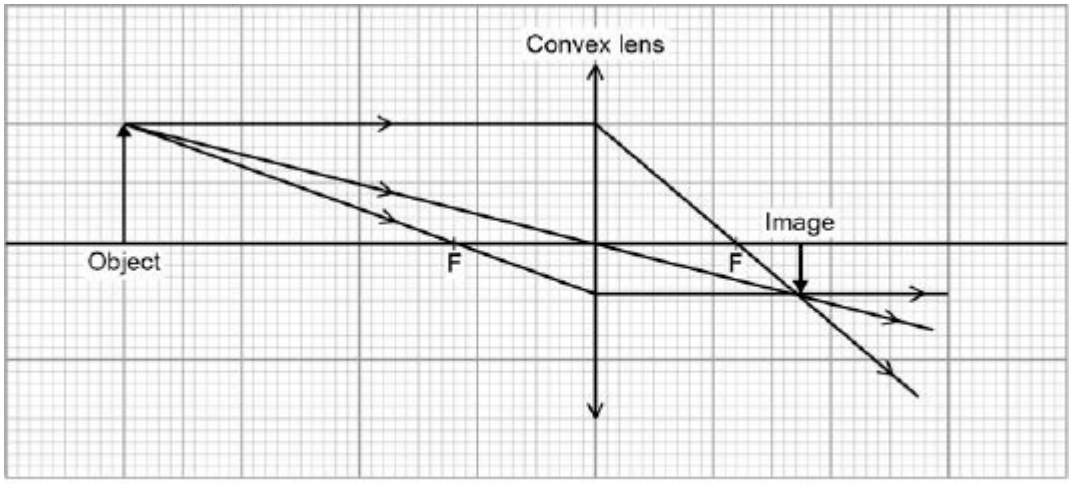
<u>inverted</u> image drawn (with arrow) in correct location

1

one arrowhead from object to image on any construction ray

conflicting arrowheads negate this mark

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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]

Q7.

(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*

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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

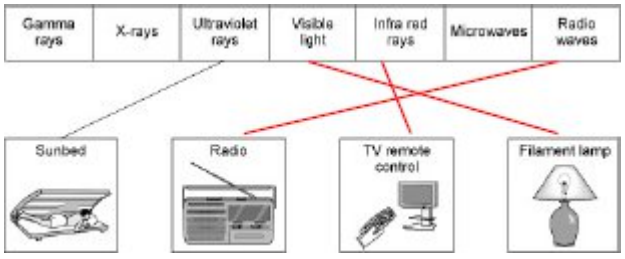
(iii) (Universe is) expanding

1

[9]

Q8.

(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

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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]

Q9.

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]

Q10.

(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]

Q11.

(a) C or 0.18 mm

1

(b) 0.6 (m)

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*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]

Q12.

(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

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(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 positive 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]

Q13.

(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

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(d) (i) 3

1

(ii) 3.6

or

their (d)(i) × 1.2 correctly calculated

v = f × λ

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

ie 3 or their (d)(i) × 1.2 provided that no subsequent step is shown

2

[10]

Q14.

(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}

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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]

Q15.

(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]

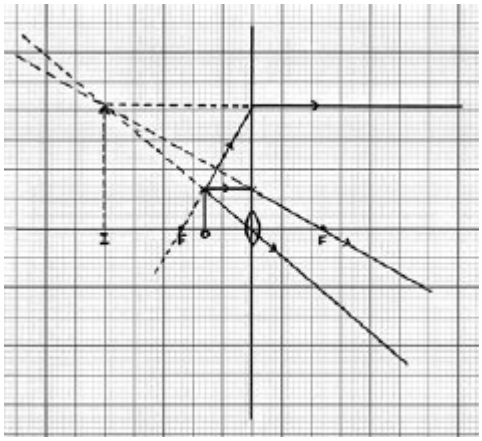
Q16.

(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

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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]

Q17.

(a) any **two** from:

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- 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) $v = f \lambda$

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]

Q18.

(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

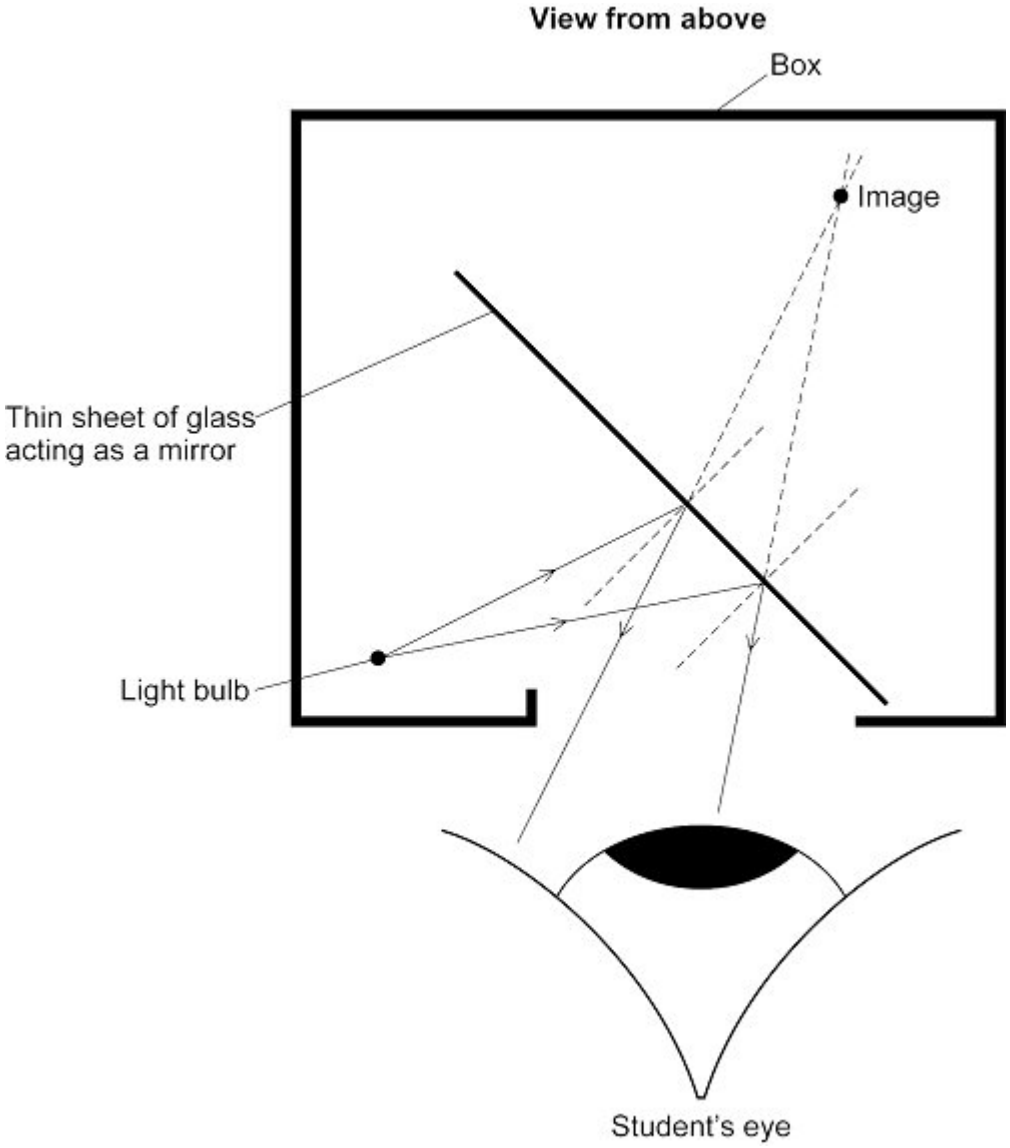
at least one arrow drawn in correct direction

any conflicting arrows negate this mark
ignore any arrows drawn on construction lines behind the glass

1

position of image correct

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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]

Q19.

(a) higher frequency

general properties / uses are neutral

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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

reflected 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 reflected 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)

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2

(ii) **D**

mark is for the reason

*reason cannot score if **D** is not chosen*

values are always over 2(.0)

1

[10]

Q20.

1.4

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

ie 14 ÷ 10

or

28 ÷ 20

[2]

Q21.

(a) converging (lens)

accept 'convex (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

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*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]

Q22.

(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]

Q23.

(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]

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Q24.

(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]

Q25.

(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]

Q26.

(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

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(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]

Q27.

(a) (i) infra red (rays)

accept IR

or

radio (waves)

*do **not** accept heat waves*

*do **not** accept TV waves*

1

(ii) <u>radio</u> (waves)

this answer only

1

(b) frequency

1

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(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]

Q28.

(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*

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$\frac{300000000}{0.125}$ *or* $\frac{300000000}{0.125}$

ie

*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]

Q29.

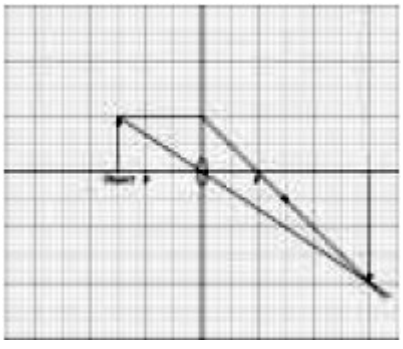
(a) any **two** for **1** mark each

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

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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]

Q30.

(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]

Q31.

(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

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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]

Q32.

(a) (i) radio(waves)

1

(ii) energy

correct answer only

1

(b) (i) 0.0125 (m)

*allow **1** mark for correct transformation <u>and</u> substitution*

2

(ii) make it hot(ter)

*do **not** accept cook it*
accept (air) particles inside ball will move faster
accept water in the ball gets hotter

1

[5]

Q33.

(a) C (only)

1

(b) A (only)

1

[2]

Q34.

(a) reflection at the mirror of ray from tip of real puppy's ear to real puppy's eye (1)

may be drawn freehand

accurate (1)

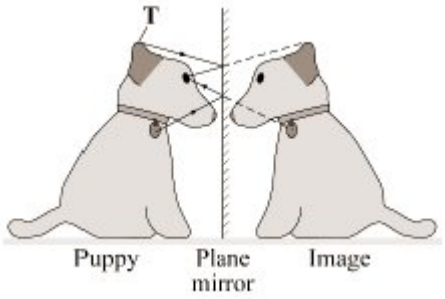
ruler must have been used and the reflected ray is an extension of the straight line from point virtual ear however the virtual part of the line need not be shown

arrow to show correct direction (1)

only one arrow needs to be shown but there must be no contradiction

example of (3) mark response

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3

(b) flat

accept 'it's not curved/bent'
accept 'it's straight'

1

[4]

Q35.

(a) (i) compare (the health of) mobile phone users with non-mobile phone users

must be an implied comparison between users and non-users
any idea of doing an experiment negates the mark

1

(ii) increase the sample size

accept use more people
accept have a large sample size
repeat the research / test is neutral

1

(iii) ethical

1

(b) (i) so the phones can be compared (fairly)

a fair test is insufficient
accept different tests (may) give different results
*do **not** accept to make the results reliable, unless qualified eg all variables are controlled*
*do **not** accept bias unless qualified*

1

(ii) yes all are below the legal limit / 2 (W/kg)

or no and any **one** from:

- even absorbing a small amount of energy may be harmful
  accept microwaves for energy
  accept emits energy absorbed by head / other parts of body
- no proof that small amounts of energy are not harmful
  accept because the SAR value is not 0 (W/kg)

1

(c) any **one** from:

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- to get an independent opinion
- company scientists may be biased
  accept company scientists may manipulate results

1

[6]

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