

PHYSICS



EXAM QUESTION PACK

TOPIC 5: LIGHT AND THE ELECTROMAGNETIC SPECTRUM (PACK 1)

SCORE

/91

PERCENTAGE

%

STEMUP

These questions belong to Pearson Edexcel, not to us.

The examination questions, mark schemes and examiner comments in this pack were written and published by Pearson Edexcel. They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with Pearson Edexcel and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. Pearson Edexcel has not endorsed, approved or been involved in the production of it. Pearson Edexcel and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

Pearson Edexcel publishes its past papers, mark schemes and examiner reports. Always check the current specification at [qualifications.pearson.com](https://www.pearson.com/qualifications) before you revise, because content and wording can change between series.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Q1.

A student investigates what happens when light travels from air to glass.

Figure 2 shows some of the apparatus used in the investigation.

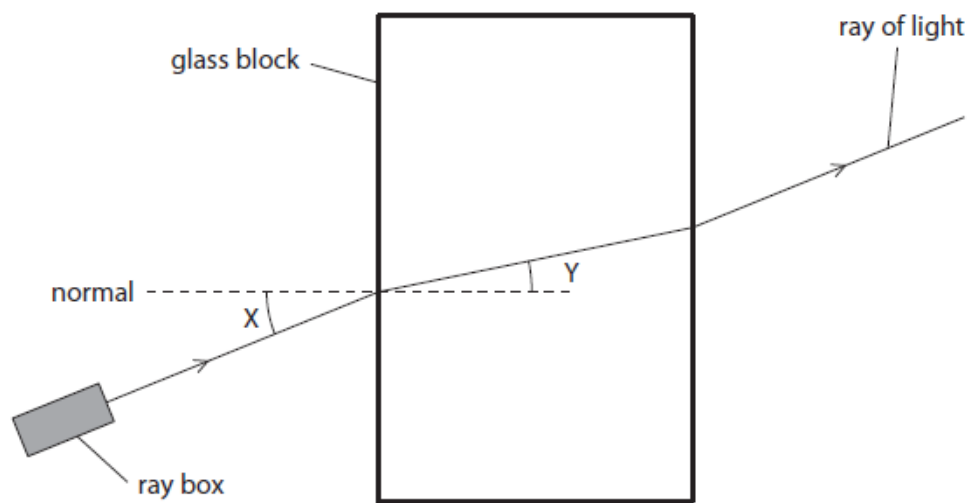


Figure 2

(i) In Figure 2, angle Y is the angle of

(1)

- ☐ **A** deflection
- ☐ **B** incidence
- ☐ **C** reflection
- ☐ **D** refraction

(ii) Figure 3 is a graph of the student's results.

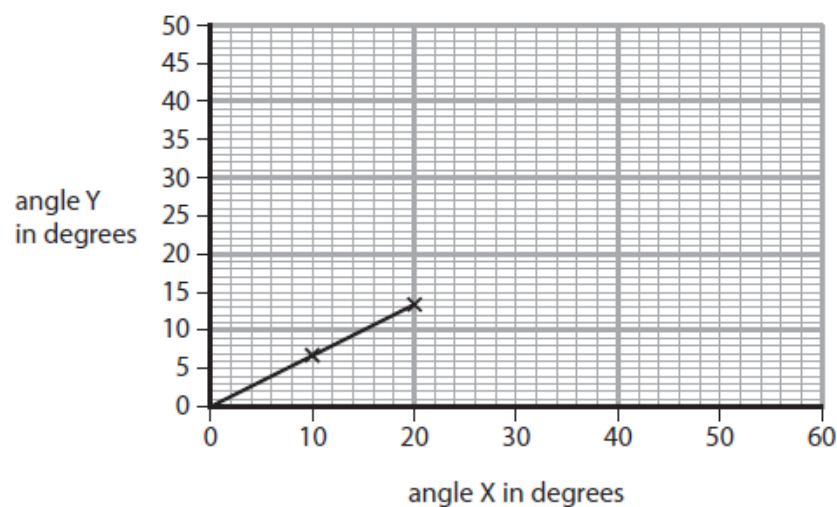


Figure 3

Use the graph to calculate a value for

$$\frac{\text{angle Y}}{\text{angle X}}$$

(2)

$$\frac{\text{angle Y}}{\text{angle X}} = \dots\dots\dots$$

(iii) The student concludes that angle Y is directly proportional to angle X.

Explain what the student must do to test this conclusion in more detail.

(3)

.....

.....

.....

.....

.....

.....

(Total for question = 6 marks)

Q2.

Shot-put is an Olympic event.
The shot is a heavy ball.
An athlete throws the shot as far as possible.

A sports scientist analyses an athlete's throw to help improve performance.

In one throw, the shot continues to rise by another 1.3 m after it leaves the athlete's hand.
The mass of the shot is 7.26 kg.

Calculate the amount of gravitational potential energy gained by the shot.

(2)

gravitational potential energy gained = ... J

(Total for question = 2 marks)

Q3.

Radio waves from Jupiter take 40 minutes to reach Earth.

Light waves from the Sun take 8 minutes to reach Earth.

Calculate how many times further it is from Earth to Jupiter than from Earth to the Sun.

State the property of electromagnetic radiation that is used in your answer.

(2)

..... times

property

.....

(Total for question = 2 marks)

Q4.

Figure 13 shows two ice skaters during a performance.



Figure 13

(i) The two ice skaters are travelling together in a straight line at 3.50 m/s.

Their total momentum is 371 kgm/s.

The man has a mass of 64.5 kg.

Calculate the mass of the woman.

(4)

mass = ... kg

(ii) Calculate the kinetic energy of the man.

(2)

kinetic energy = ... J

(Total for question = 6 marks)

Q5.

(i) The aircraft lands with a velocity of 71 m/s.

The mass of the aircraft is 3.6×10^5 kg.

Calculate the kinetic energy of the aircraft as it lands.

(2)

kinetic energy of aircraft = ... J

(ii) When the aircraft has come to a stop, all the kinetic energy has been transferred to the surroundings.

Give **one** way that the energy has been transferred to the surroundings.

(1)

.....
.....

(Total for question = 3 marks)

Q6.

In a science fiction story, lightning is used as an energy source for accelerating a car.

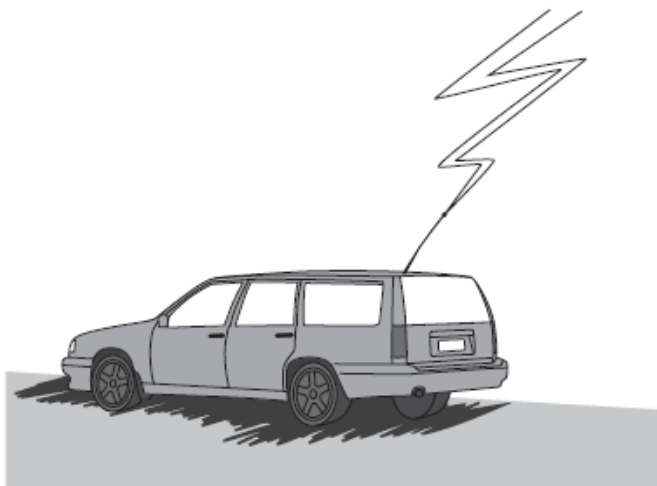


Figure 6

In the story, the car has a kinetic energy of 960 kJ at a speed of 40 m/s.

(i) Calculate the mass of the car.

(4)

mass = ... kg

(ii) Only 5% of the energy of the lightning bolt is transferred to the kinetic energy of the car.

Calculate the total energy of the lightning bolt in MJ.

(2)

energy = ... MJ

(Total for question = 6 marks)

Q7.

A kettle is used to heat water.

Figure 11 shows a graph of temperature against time for the water in the kettle.

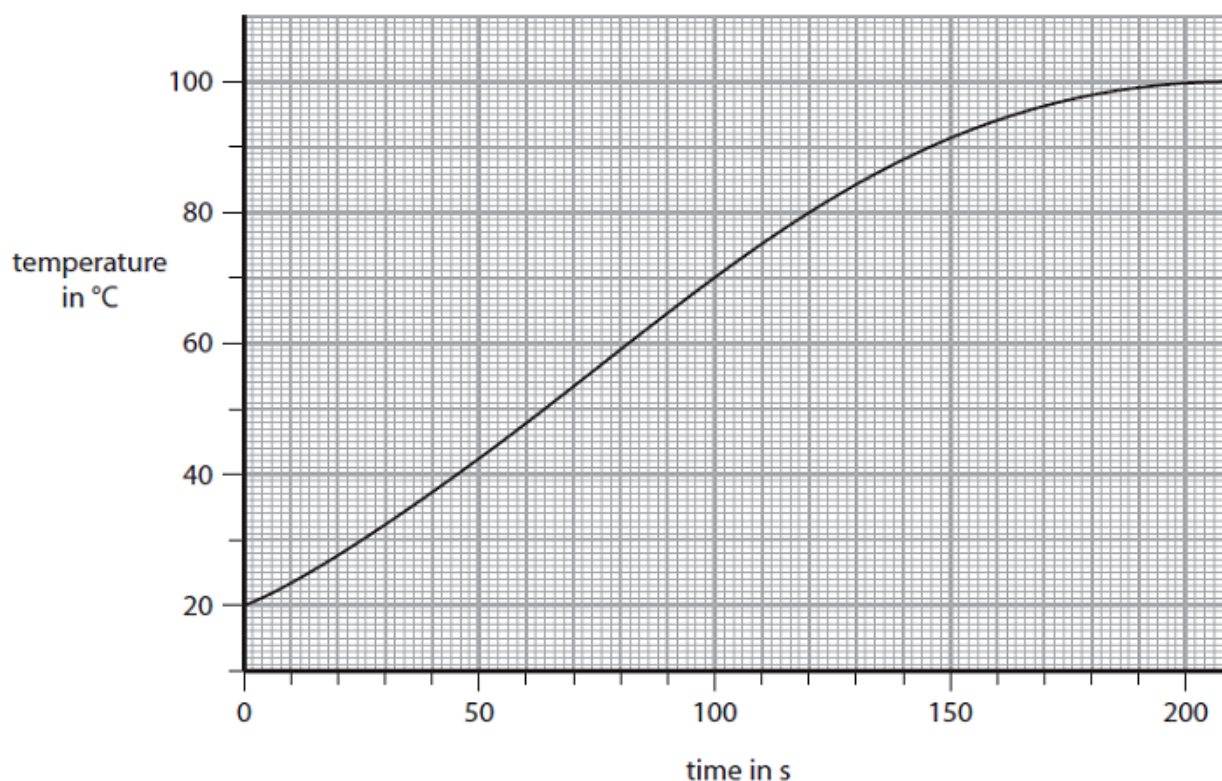


Figure 11

Calculate the rate of increase in temperature at a time of 150 s, by drawing a tangent to the curve in Figure 11 at a time of 150 s.

(3)

..... °C / s

(Total for question = 3 marks)

Q8.

A kettle is used to heat water.

The kettle has an efficiency of 91% in supplying energy to the water.
The thermal energy of the water increases by 3.3×10^5 J in 200 s.

Calculate the total amount of energy supplied to the kettle in the 200 s.

Use the equation

$$\text{efficiency} = \frac{(\text{useful energy transferred by the device})}{(\text{total energy supplied to the device})}$$

(2)

total amount of energy supplied = ... J

(Total for question = 2 marks)

Q9.

This question is about waves in the electromagnetic (e.m.) spectrum.

(i) A microwave oven uses waves of frequency 2.45 GHz.

Calculate the wavelength of the microwaves.

The velocity of light is 3.00×10^8 m/s.

(3)

wavelength = ... m

(ii) The microwave oven is 55% efficient and transfers 42 000 J of energy to some food when it is heated.

Calculate the total amount of energy that must be supplied to the oven.

(3)

energy supplied to oven = ... J

(Total for question = 6 marks)

Q10.

Some questions must be answered with a cross in a box (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

Which statement describes conservation of energy in a closed system?

(1)

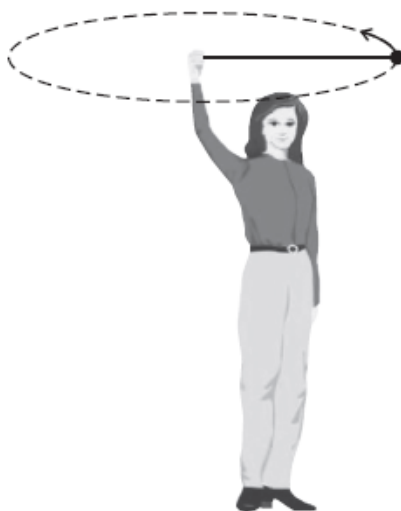
☒ **A** when there are energy transfers, the total energy reduces

- ☐ **B** when there are energy transfers, the total energy does not change
- ☐ **C** when there are no energy transfers, the total energy reduces
- ☐ **D** when there are no energy transfers, the total energy increases

(Total for question = 1 mark)

Q11.

(a) The diagram shows a girl swinging a rubber ball in a horizontal circle above her head.



(i) In which direction does the resultant force act on the ball?

Put a cross (X) in the box next to your answer.

(1)

- ☐ **A** away from the centre of the circle
- ☐ **B** in the direction of the arrow on the diagram
- ☐ **C** in the opposite direction to the arrow on the diagram
- ☐ **D** towards the centre of the circle

(ii) State the name of the resultant force acting on the ball.

(1)

.....

(iii) Suggest what would happen to the ball as the girl gets tired.

(2)

.....

.....

.....

.....

(iv) The girl lets go of the string and the ball hits a wall.

The collision is not elastic.

Explain what happens to both momentum and kinetic energy when the ball hits the wall.

(2)

.....

.....

.....

.....

*(b) Describe a cyclotron and how charged particles move inside it.

You may draw a labelled diagram to help with your answer.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question = 12 marks)

Radio waves and gamma radiation are at opposite ends of the electromagnetic spectrum.
Compare how these two electromagnetic radiations are produced.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 6 marks)

Q13.

* Nuclear fission and nuclear fusion are two non-renewable sources of energy.

Compare nuclear fission and nuclear fusion as possible sources of energy for generating electricity using a nuclear reactor.

Your comparison should refer to

- the differences between nuclear fission and nuclear fusion
- the relative advantages and difficulties involved in using these sources.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 6 marks)

Q14.

* X-rays and radio waves are part of the electromagnetic spectrum and have different uses.

These radiations are produced in different ways.

X-rays are emitted when electrons within an atom go through energy changes.

Radiowaves are produced by electrons in circuits.

Compare X-rays with radio waves.

Your answer should refer to

- the uses of both types of radiation
- the different ways that electrons are involved in producing X-rays and radio waves.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 6 marks)

Q15.

A student lifts a toy car from a bench and places the toy car at the top of a slope as shown in Figure 2.

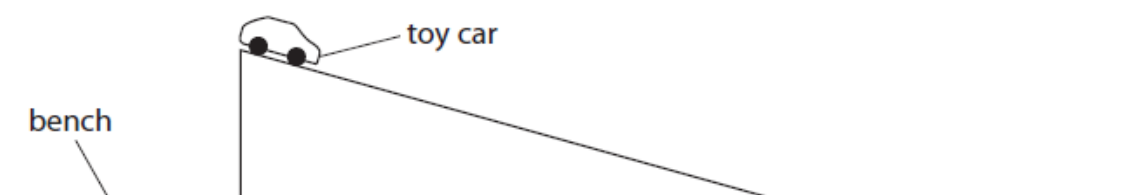


Figure 2

Describe an energy transfer that occurs when the student lifts the toy car from the bench and places the toy car at the top of the slope.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Q16.

Ultraviolet waves cover a range of frequencies.

Scientists divide this range into three types, UVA, UVB and UVC.

The table in Figure 11 shows the frequency range for each type.

type	frequency range in Hz
UVA	7.5×10^{14} to 9.4×10^{14}
UVB	9.4×10^{14} to 10×10^{14}
UVC	10×10^{14} to 30×10^{14}

Figure 11

Figure 12 is a diagram about the effect that the Earth's atmosphere has on three types of ultraviolet radiation.

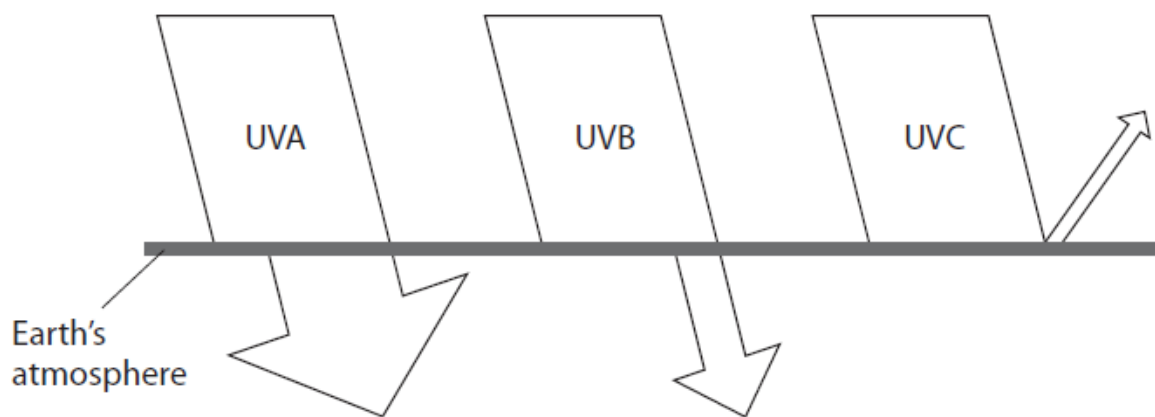


Figure 12

Describe how the effects change with **wavelength**, using information from Figure 11 and Figure 12.

The width of the arrows drawn indicates the amount of radiation that is involved.

Calculations are **not** required.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 4 marks)

Q17.

To investigate refraction in a rectangular glass block a student uses the apparatus shown in Figure 3.

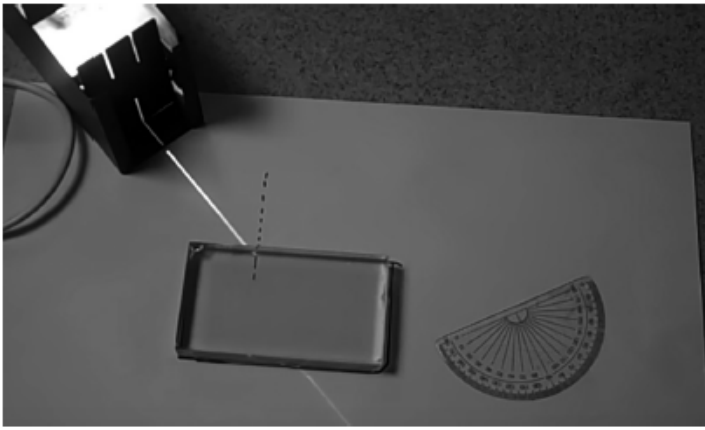


Figure 3

Describe how the student should measure the angle of refraction.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Q18.

Expanded polystyrene, used to insulate buildings, has different densities.

Figure 4 shows how the thermal conductivity of expanded polystyrene changes with the density of expanded polystyrene.

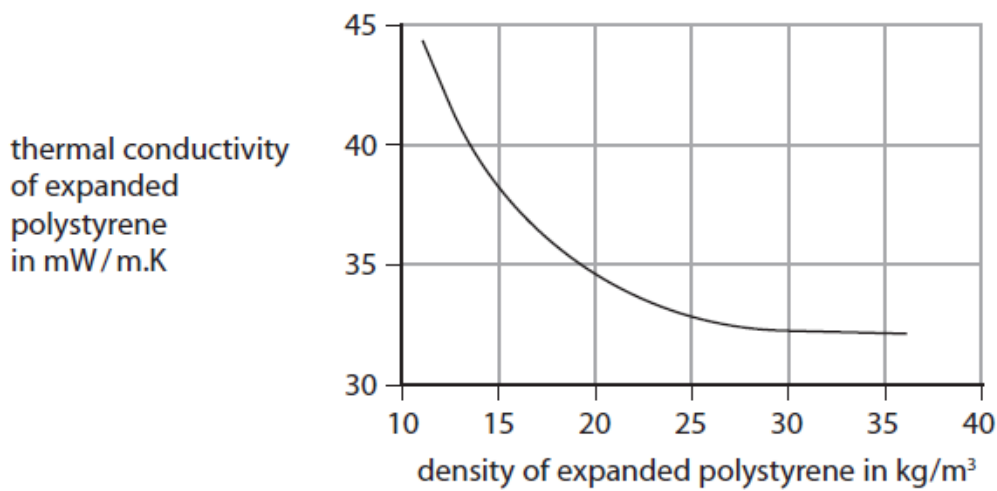


Figure 4

Using the graph in Figure 4, describe how the thermal conductivity of expanded polystyrene changes with the density of expanded polystyrene.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Q19.

A student uses the apparatus in Figure 3 to find out which of two materials, sand or sawdust, is the better insulator.



Figure 3

The student also has a kettle to boil water, a thermometer and a stop clock.

(i) Draw a labelled diagram to show how the student should set up the equipment to investigate which material is the better insulator.

(3)

(ii) Give **three** factors that the student must control in this investigation.

(3)

- 1
- 2
- 3

(Total for question = 6 marks)

Q20.

(a) Here are some forms of energy:

chemical	elastic potential	electrical
heat (thermal)	kinetic	light
nuclear	sound	

(i) Use words from the box to complete the table.

Each word may be used once, more than once, or not at all.

The first one has been done for you.

(3)

device	energy transferred from...	energy is mostly transferred into...
electric motor	electrical	kinetic
bow and arrow	elastic potential	
electric kettle	electrical	
microphone		electrical

(ii) In the electric motor only some of the electrical energy is transferred into kinetic energy.

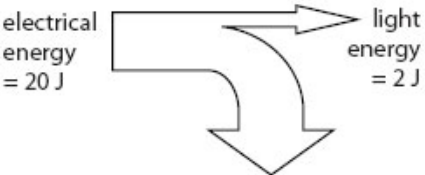
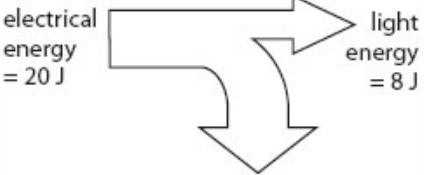
State what happens to the remaining electrical energy.

(1)

(b) Many appliances are sold with an energy efficiency rating.

A-rated appliances are the most energy efficient.

Here is some information about two types of electric lamp.

	halogen lamp	compact fluorescent lamp (CFL)
energy efficiency rating		
energy transfer diagrams (not drawn to scale)	energy transfer in one second 	energy transfer in one second 

(i) Calculate how much energy is wasted in one second by the compact fluorescent lamp (CFL).

(1)

energy wasted = ...J

(ii) Use the energy transfer diagrams to explain why the CFL lamp has a better efficiency rating than the halogen lamp.

(2)

(c) The photograph shows an electric heater used to warm garages.



When the heater is switched on, it quickly warms up and then stays at a constant temperature.

Explain why the heater stays at a constant temperature.

(2)

.....

.....

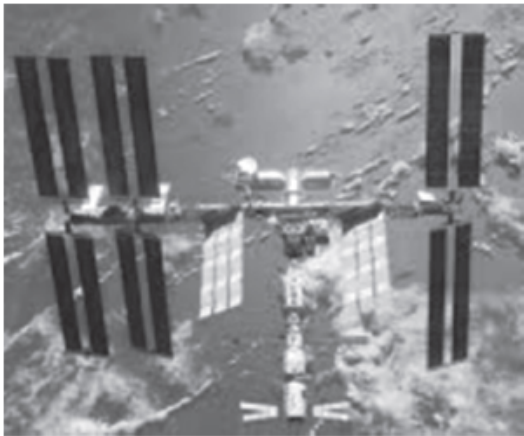
.....

.....

(Total for Question is 9 marks)

Q21.

The International Space Station (ISS) has several solar panels called wings.



(a) The wings convert energy from the Sun into a form useful in the ISS.

(1)

- ☐ **A** transverse and electromagnetic
- ☐ **B** electromagnetic but not transverse
- ☐ **C** transverse but not electromagnetic
- ☐ **D** neither transverse nor electromagnetic

(b) In one second, the useful energy available from one wing is 34.3 kJ.
The energy incident on the wing from the Sun is five times this amount.

What is the percentage efficiency of the wing?

(3)

efficiency = ... %

(c) A wing is in direct sunlight.
The ISS is not receiving energy from the wing.
The temperature of the wing remains constant.

Explain why the temperature of the wing remains constant in these conditions.

(2)

.....

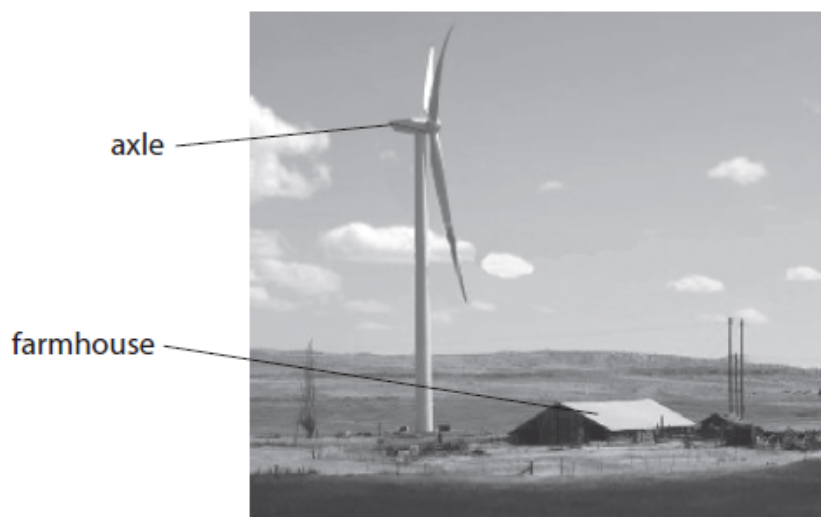
.....

.....

.....

Q22.

(a) A wind generator is used as the source of energy for a remote farmhouse.



(i) Complete the sentence by putting a cross (☒) in the box next to your answer.

If the farmhouse is about 7 m high, the height of the axle of the generator is

(1)

☐ **A** 20 m

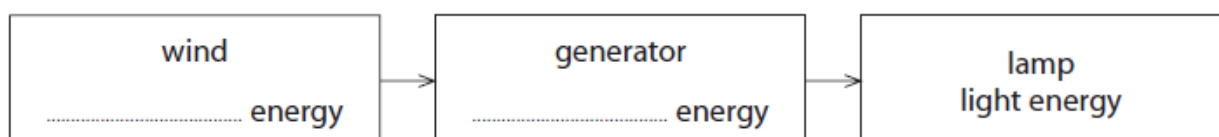
☐ **B** 50 m

☐ **C** 100 m

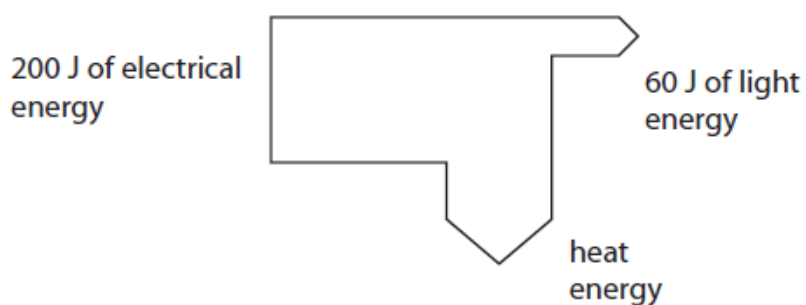
☐ **D** 150 m

(ii) Complete the flow chart to show the energy transfers that take place from the wind to light a lamp.

(2)



(b) A student produced a diagram to show energy changes in a lamp.



(i) Calculate the amount of heat energy produced by the lamp.

(1)

heat energy = ...J

(ii) Calculate the efficiency of the lamp.

(2)

efficiency = ...

(iii) When the lamp is first switched on, it heats up.
It then reaches a constant temperature.

Explain why the temperature of the lamp remains constant.

(2)

.....

.....

.....

.....

(c) A wind power system costs £6000 to install.
It saves £250 each year.

Calculate the payback time.

(2)

payback time = ...

(Total for Question = 10 marks)

Q23.

A student is investigating the refraction of light.

Figure 4 shows part of the apparatus and the angles to be measured.

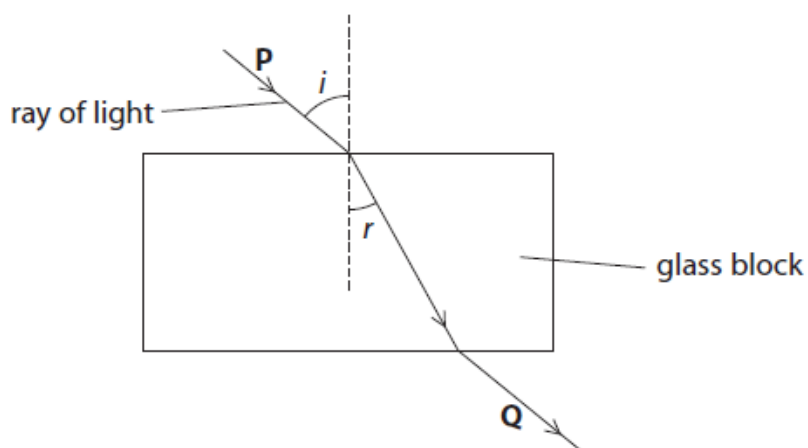


Figure 4

The student measures angle r for several different values of angle i .

Figure 5 shows the student's results.

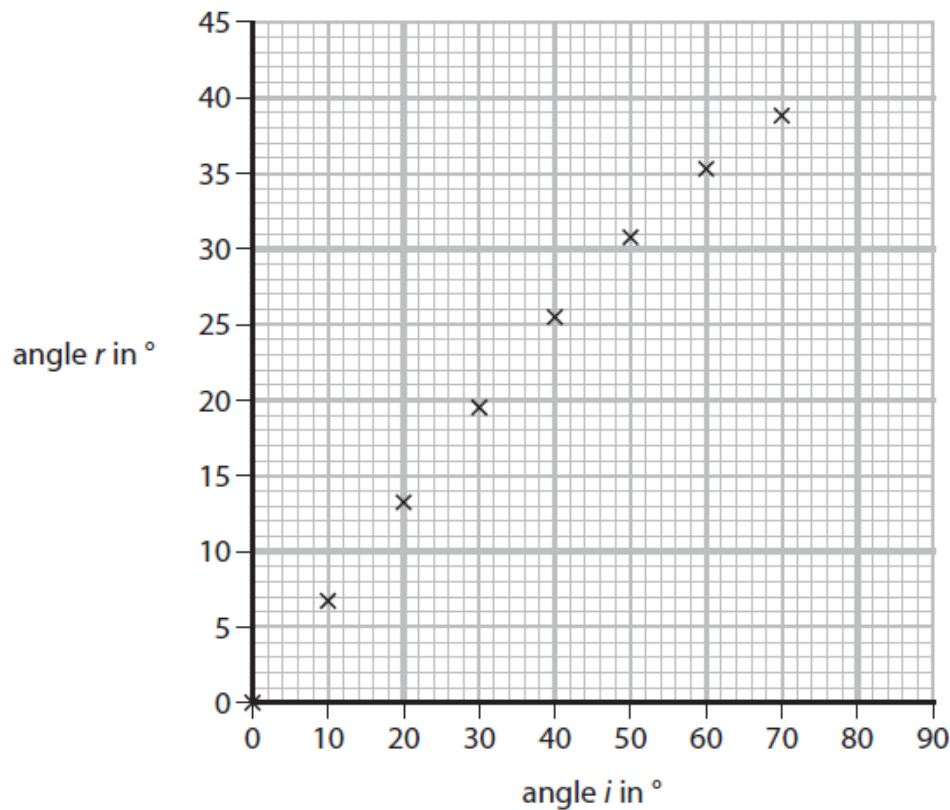


Figure 5

(i) On the graph in Figure 5, draw the best fit curve.

(1)

(ii) Use the graph in Figure 5 to estimate the value of angle r when angle i is 80° .

(1)

angle r = ... $^{\circ}$

(iii) Describe how angle r changes with angle i for the results shown on the graph in Figure 5.

(2)

.....

.....

.....

.....

(Total for question = 4 marks)

Q24.

Explain what happens to a wavelength of light when it passes from air into glass.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Q25.

In Figure 6, only refraction of light is shown.

Other things happen to the light as it travels from **P** to **Q**.

The intensity (brightness) of the light at **Q** is less than the intensity of the light at **P**.

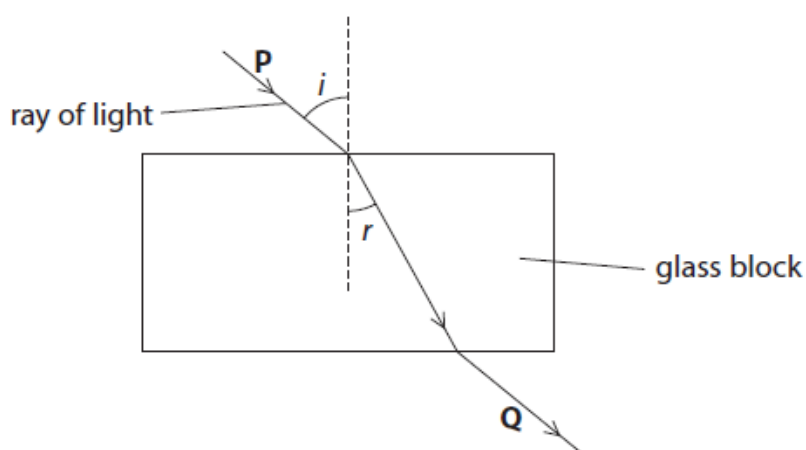


Figure 6

Explain the decrease in intensity as the light travels from **P** to **Q**.

You may add to Figure 6 to help your answer.

(3)

.....

.....

.....

.....

.....

.....

(Total for question = 3 marks)

Q26.

Explain what can happen to the body if a person has a prolonged exposure to gamma rays.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Q27.

Figure 4 is a simplified diagram to show radio waves from a transmitter moving upwards, then meeting a boundary between lower and upper layers of the atmosphere.

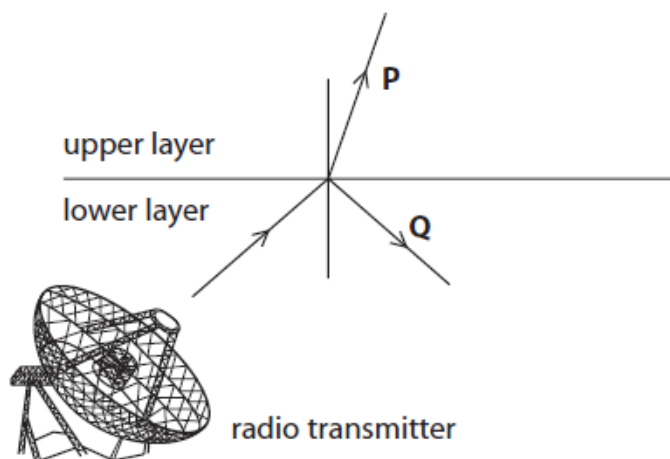


Figure 4

Explain what happens to the radio waves after they meet the boundary between the lower and upper layers as shown in Figure 4.

Your explanation should refer to changes in direction and speed of the waves.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 4 marks)

Q28.

Some television remote controls use infrared radiation and other remote controls use radio waves.

Explain why an infrared remote control may not switch on the television from behind an

armchair but a radio wave remote control always will.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Q29.

Gamma radiation can be used in food processing to irradiate food.

Explain why some food is irradiated with gamma radiation.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Q30.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ~~☒~~ and then mark your new answer with a cross ☒.

This question is about waves in the electromagnetic (e.m.) spectrum.

The potential danger associated with the waves of the e.m. spectrum increases as

- ☐ **A** frequency decreases
- ☐ **B** frequency increases
- ☐ **C** velocity decreases
- ☐ **D** velocity increases

(Total for question = 1 mark)

Mark Scheme

Q1.

Question Number	Answer	Mark
(i)	D refraction is the only correct answer <i>A 'deflection' is an incorrect distracting description</i> <i>B 'incidence' is incorrect, that would be angle X</i> <i>C 'reflection' is incorrect, no reflection being shown in the diagram</i>	(1) AO 1 1

Question Number	Answer	Additional guidance	Mark
(ii)	any pair of coordinates selected from the line (1) in range → 0.6(0) to 0.7(0) (1)	e.g. 20 and (13 or 14) or 10 and (6 or 7) ignore any units given award full marks for a correct answer without working	(2) AO 2 1

Question Number	Answer	Additional guidance	Mark
(iii)	an explanation linking: repeat (1) different angles / more values of X (1) for larger angles / values of X (1)	allow 'more measurements' / 'repeat experiment' / collect more data > 20°	(3) AO 3 3a

Q2.

Question number	Answer	Additional guidance	Mark
	Substitution (1) $PE = 7.26 \times 10 \times 1.3$ Evaluation (1) 94.4 (J)		(2)

Q3.

Question Number	Answer	Additional guidance	Mark
	(Jupiter is) 5 times (further away) (1) radio waves and light waves travel at the same speed (in space) (1)	All electromagnetic (EM) waves travel at the same speed accept attempt to use consistent speed (of light) to calculate two distances	(2)

Q4.

Question number	Answer	Additional guidance	Mark
(i)	substitution (1) $371 = (64.5 + m) \times 3.5$ rearrangement (1) $m + 64.5 = 371 / 3.5$ evaluation of total mass (1) $m + 64.5 = 106 \text{ (kg)}$ evaluation of woman's mass (1) $m = 106 - 64.5$ $= 41.5 \text{ (kg)}$	full marks will be awarded for correct numerical answer without working	(4)

Question number	Answer	Additional guidance	Mark
(ii)	substitution (1) $KE = \frac{1}{2} \times 64.5 \times 3.5^2$ evaluation (1) 395 (J)	allow answers which round to 395 e.g. 395.0625 full marks will be awarded for correct numerical answer without working	(2)

Q5.

	Answer	Additional guidance	Mark
(i)	selection and substitution (1) $(KE) = \frac{1}{2} \times 3.6 \times 10^5 \times 71^2$ evaluation (1) $9.1 \times 10^8 \text{ (J)}$	accept $9.07 \times 10^8 \text{ (J)}$ accept 907 380 000 (J) award full marks for correct answer without working do not award a power of ten error	(2) AO2

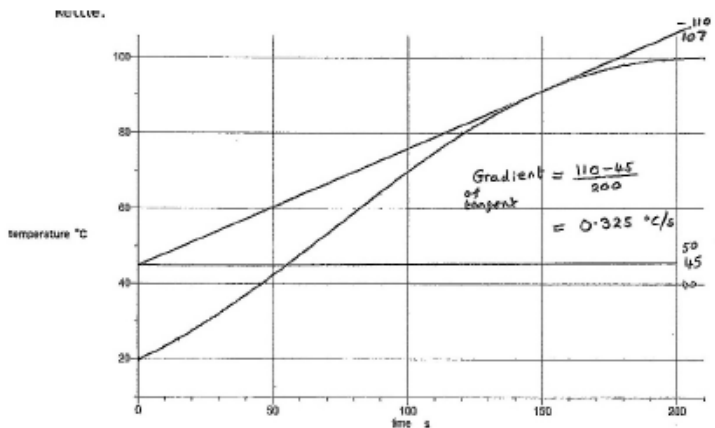
	Answer	Additional guidance	Mark
(ii)	any one from: mechanically (to the thermal store) (1) (heating) due to air resistance / friction (1) thermally (1)	allow dissipated thermal (store) / heat (energy)	(1) AO2

Q6.

Question number	Answer	Additional guidance	Marks
(i)	recall K.E. = $\frac{1}{2} m v^2$ (1) rearrangement (1) $(m =) 2 \times K.E. \div v^2$ substitution (1) $(m =) 2 \times 960\,000 \div 40^2$ Evaluation (1) $= 1200 \text{ (kg)}$	award full marks for the correct answer without working rearrangement and substitution in either order Ignore POT until evaluation	(4)

Question number	Answer	Additional guidance	Marks
(ii)	Use of efficiency equation (1) $\frac{960}{5}$ evaluation (1) =19 (MJ)	award full marks for correct numerical answer without working accept 19.2 (MJ)	(2)

Q7.

Question number	Answer	Additional guidance	Mark
	 drawing tangent attempt (1) correct data points from graph (1) 60,60 and 150,92 evaluation (1) 0.33 ± 0.07 ($^{\circ}\text{C} / \text{s}$)	accept other data from the graph award full marks for the correct answer without working	(3)

Q8.

Question number	Answer	Additional guidance	Mark
	rearrangement and substitution (1) energy supplied = $\frac{\text{useful energy}}{\text{efficiency}}$ $= \frac{3.3 \times 10^5}{0.91}$ evaluation (1) $3.6 \times 10^5 \text{ (J)}$	 (3.626×10^5) number that rounds to $3.6 \times 10^5 \text{ (J)}$ 3600 or 3626 scores 1 mark award full marks for the correct answer without working no marks for 91% of $3.3 \times 10^5 = 3.0 \times 10^5$ (J)	(2)

Q9.

Question Number	Answer	Additional guidance	Mark
(i)	selection and substitution (1) $3(.00) \times 10^8 = 2.45 (\times 10^9) \times \lambda$ rearrangement (1) $(\lambda =) \frac{3(.00) \times 10^8}{2.45 (\times 10^9)}$ evaluation (1) 0.12 (m)	allow substitution and rearrangement in either order $2.45 (\times 10^9) = \frac{3(.00) \times 10^8}{\lambda}$ $\lambda = \frac{v}{f}$ accept 0.122(m) power of ten error gains 2 marks award full marks for the correct answer without working	(3) A02

Question Number	Answer	Additional guidance	Mark
(ii)	selection and substitution (1) $(0.)55 = \frac{42\,000}{\text{total energy supplied (to device)}}$ rearrangement (1) $(\text{total energy supplied to device}) = \frac{42\,000}{(0.)55}$ evaluation (1) 76 000(J)	allow substitution and rearrangement in either order $(0.)55 = \frac{42\,000}{x}$ accept any value that rounds to 76 000(J) 760/764/763(J) gains 2 marks any other power of ten error gains 1 mark award full marks for the correct answer without working	(3) AO2

Q10.

Question Number	Answer	Mark
	B. when there are energy transfers, the total energy does not change <i>A is not correct because the total energy does not reduce</i> <i>C is not correct because the total energy does not reduce</i> <i>D is not correct because the total energy does not increase</i>	(1) AO1

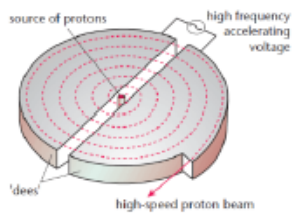
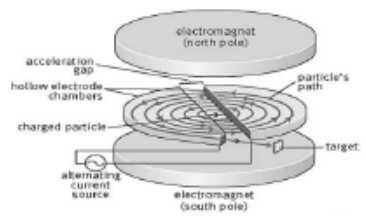
Q11.

Question Number	Answer	Acceptable answers	Mark
(a)(i)	D towards the centre of the circle		(1)

Question Number	Answer	Acceptable answers	Mark
(a)(ii)	centripetal (force)	reject centrifugal force accept misspellings where meaning is clear e.g. centripedal	(1)

Question Number	Answer	Acceptable answers	Mark
(a)(iii)	Any two of the following :- ball slows down (1) ball / it drops (down) / circles at a lower height (1) go in smaller circles (1)	less kinetic energy / momentum any lowering / less potential energy stops going in circles the ball/it would not make complete circles (not just 'stops')	(2)

Question Number	Answer	Acceptable answers	Mark
(a)(iv)	An explanation linking: - the idea that momentum (of the closed system) would stay the same (1) - the idea that kinetic energy would not be conserved (1)	momentum of the ball decreases / changes (direction) / passed to wall must specify which momentum; do not credit 'momentum decreases' by itself kinetic energy → heat/sound/wall ignore 'KE decreases / is lost' without qualification allow 'KE is lost because it's not elastic' (i.e. qualified)	(2)

Question Number	Indicative Content	Mark
QWC	* (b) A description including some of the following points :- Cyclotron • two D-shaped halves • gap between the Dees • (alternating) voltage across the gap • magnetic field (at right angles to the moving particles) • vacuum enables free movement of particles Particle movement • accelerate • start at the centre • move in a circular path • spiral outwards • exit in a straight line Examples of labelled diagrams which would give Level 3 by themselves (not all labels / details needed)   Level 2 if no labels but Dees AND particle path shown. Level 1 if no labels but either Dees OR spiral of particle shown Ignore uses of cyclotron	(6)

Level	0	No rewardable content
1	1 - 2	• a <u>limited</u> description of either particle movement OR cyclotron e.g. The particles move in a circle OR Cyclotrons have two Dees OR Cyclotrons are particle accelerators OR there's a vacuum • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy
2	3 - 4	• a <u>simple</u> description of particle movement AND cyclotron OR a more detailed description of one e.g. A cyclotron has two D-shaped halves and the particles inside accelerate OR A cyclotron has a magnetic field and a voltage across the gap OR Charged particles increase in speed as they spiral outwards OR vacuum allows free movement of particles • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy
3	5 - 6	• a description of particle movement AND cyclotron with a <u>detailed</u> description of one of them e.g. the charged particles get faster as they accelerate across the gap in the Dees OR the magnetic field (of the cyclotron) causes the particles to move in a circle • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

(Total for Question = 12 marks)

Q12.

Question Number	Answer	Mark
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.	(6) exp
	AO1 strand 1 (6 marks) • radio waves are (often) produced intentionally (by humans) • gamma rays are (often) produced spontaneously / randomly • radio waves are produced by (free) electrons • radio waves are produced by oscillating (free) electrons / alternating current (ac) • radio waves are produced in electrical circuits / aerials • gamma rays may result from radioactive decay • gamma rays produced in the nucleus • gamma rays produced by energy changes / rearrangement in the nucleus • gamma rays produced to stabilise the nucleus • gamma rays produced in annihilations (PET scanning etc) • gamma rays may be produced as a result of (nuclear) fission or fusion	

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	- Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) - Presents an explanation with some structure and coherence. (AO1)
Level 2	3–4	- Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) - Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5–6	- Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) - Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Summary for guidance

Level	Mark	Additional Guidance	General additional guidance – the decision within levels
	0	No rewardable material.	e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
Level 1	1–2	<u>Additional guidance</u> isolated fact(s) about one radiation	<u>Possible candidate responses</u> gamma rays are (often) produced spontaneously / randomly
Level 2	3–4	<u>Additional guidance</u> Some understanding shown i.e. a limited comparison made including some facts about the production of each radiation OR more detailed facts given about the production of one of them	<u>Possible candidate responses</u> radio waves produced in wires and gamma produced in nucleus radio waves produced by AC in wires

Level 3	5–6	<u>Additional guidance</u> Understanding is detailed and fully developed. detailed comparison made with linked facts about the production of each (one radiation may have significantly more detail than the other but both should feature for level 3)	<u>Possible candidate responses</u> radio waves produced by electrons oscillating in wires; gamma produced by annihilation of electrons interacting with positrons
---------	-----	--	---

Q13.

Question number	Indicative content	Mark
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive, and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. A01 1 (6 marks) fission • (heavy) nucleus split • by a neutron • releases 2 daughter nuclei + more neutrons + energy • starts chain reaction advantages • already in use disadvantages • waste is radioactive • hard to dispose of • risk of accident	(6) A01

	fusion • (light) nuclei joined • at high energy/temperature/pressure/particle density • releases (eg) helium + energy advantages • no harmful waste products disadvantages • not achieved yet (on a practicable scale) • difficulty in achieving high energy/temperature/pressure/particle density	
--	---	--

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1-2	- Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) - Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	- Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) - Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	- Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) - Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> isolated facts	<u>Possible candidate responses</u> fission involves a nucleus being split by a neutron
Level 2	3–4	<u>Additional guidance</u> simple comparison of fission and fusion	<u>Possible candidate responses</u> fission involves a nucleus being split by a neutron whereas fusion requires combining two light nuclei.
Level 3	5–6	<u>Additional guidance</u> detailed comparison of fission and fusion and one advantage or one difficulty compared to the other	<u>Possible candidate responses</u> Fission involves nuclei split by a neutron. Fusion involves combining two light nuclei. The waste from fission is radioactive. Practicable fusion has not been achieved.

Question number	Indicative content	Mark
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive, and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1 Comparison X-rays: high frequency / short wavelength / ionising / high energy Radio waves: low frequency / long wavelength / not ionising / low energy X ray are used • in medical diagnosis, to find broken bones, damage to lungs • radiotherapy • treatment of cancer • airport security • revealing counterfeit art	(6) AO1

	X-rays are emitted when electrons change energy levels because • electrons in lower energy levels can absorb energy • the electrons move to higher energy levels • when the electrons return to a lower energy level • the electrons lose energy as radiation. • the electrons need to lose a large amount of energy • (so that) they emit x-ray radiation of high energy/frequency • Radio waves are used • broadcasting television • broadcasting radio • communications • satellite transmissions • mobile phones • radar	
--	---	--

	Radio-waves are emitted when • electrons oscillate in electrical circuits oscillations are • current (flow of electrons) that continually change direction • current flows up and down in a (transmitting) aerial • alternating current (AC) • this generates radio waves in the air around the aerial • the frequency of the radio waves corresponds to the oscillation frequency N.B. No credit is given for: Electrons within an atom go through energy changes OR Radio waves are produced in electrons in circuits These phrases are in the stem of the question	
--	---	--

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific, enquiry, techniques and procedures lacks detail. (AO1) Presents a description which is not logically ordered and with significant gaps. (AO1)
Level 2	3–4	Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas, enquiry, techniques and procedures is not fully detailed and/or developed. (AO1) Presents a description of the procedure that has a structure which is mostly clear, coherent and logical with minor steps missing. (AO1)
Level 3	5–6	Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas, enquiry, techniques and procedures is detailed and fully developed. (AO1) Presents a description that has a well-developed structure which is clear, coherent and logical. (AO1)

Level	Mark	Additional Guidance	General additional guidance – the decisions within levels e.g. – At each level as well as content, the scientific coherency of what is stated will help place the answer at the top or bottom of that level
	0	No rewardable material	
Level 1	1-2	<u>Additional guidance</u> Elements of physics present i.e. isolated knowledge of principles, two unconnected statements	<u>Possible candidate response</u> any use of X rays any use of radio waves any comparison electrons are around the nucleus a current is electrons (moving) electrons oscillate
Level 2	3-4	<u>Additional guidance</u> Some knowledge of principles with limited detail on use and a comparison or process	<u>Possible candidate response</u> any use of x-rays and of radio waves with limited detail and one of: a comparison or electrons lose energy to emit X-rays or electrons oscillate in circuits

Level 3	5-6	<u>Additional guidance</u> Detailed knowledge of principles on use with logical connections made about one process	<u>Possible candidate response</u> Use of X-rays and of radio waves with detail and one of: electrons lose energy to change to lower energy level and emit energy as X-rays or electrons oscillate in circuit and currents move up and down in aerials to generate radio waves
---------	-----	---	---

Question number	Answer	Additional guidance	Mark
	A description to include: mention relevant energy store such as GPE or chemical (1) 'correct' transfer in context (1)	allow KE or mechanical or thermal or heat chemical to (G)PE or chemical to KE (in lifting) allow misread GPE to KE/thermal on <u>slope</u> Allow KE to GPE in lifting	(2)

Q16.

Question Number	Answer	Additional guidance	Mark									
	a description including: UVA mostly transmitted OR some absorbed (1) UVB some transmitted OR mostly absorbed (1) UVC not transmitted OR mostly absorbed OR some reflected (1) correct relationship of absorption/ transmission to wavelength / λ (1)	UVA mostly travels through accept less transmitted than UVA more absorbed than UVA or UVB wavelength decreasing (with) absorption increasing OR longer wavelengths transmit more <table><tr><td>λ</td><td>abs</td><td>trans</td></tr><tr><td>inc</td><td>dec</td><td>inc</td></tr><tr><td>dec</td><td>inc</td><td>dec</td></tr></table>	λ	abs	trans	inc	dec	inc	dec	inc	dec	(4)
λ	abs	trans										
inc	dec	inc										
dec	inc	dec										

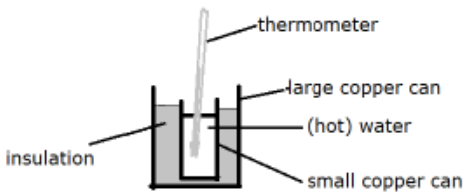
Q17.

Question number	Answer	Additional guidance	Mark
	A description including two from: trace / mark where the ray went into and out of(through) the glass block / line on either side of glass block(1) (remove block) join entry and exit points (of ray of light) (1) use the protractor to measure the angle between the refracted/drawn ray and the normal (1)	accept 90° line etc.	(2)

Q18.

	Answer	Additional guidance	Mark
	a description giving as the density (of expanded polystyrene) increases the (thermal) conductivity decreases (1) non-linear / gradient decreases / at a decreasing rate / levels off / plateaus / becomes (almost) constant (1)	ORA allow inversely proportional / exponential for non-linear in this context ignore negative correlation unqualified quoted values are insufficient	(2) AO2

Q19.

Question Number	Answer	Additional guidance	Mark
(i)	a diagram showing: apparatus labelled to include three from • thermometer • water • insulator / sand / sawdust / material • (copper) can (1) thermometer in the water (1) arrangement for water and insulator in and between copper cans (e.g. as in diagram below) (1) 	independent of arrangement ignore kettle and stop clock accept reverse positions for water and insulator	(3) AO2

Question Number	Answer	Additional guidance	Mark
(ii)	any three factors from: {mass / volume} of water (1) {volume / thickness / mass} of insulators / materials (1) {starting / initial} temperature of water (1) time interval / temperature change (1)	accept amount / specified values / "how much" accept amount / specified values / "how much" accept temperature of hot / boiling water / specified values accept specified values of interval or change unqualified "same time" is insufficient	(3) AO3

	Answer	Acceptable answers	Mark
(ai)	(Bow and arrow:) kinetic (1) (Electric kettle:) heat (thermal) (1) (Microphone:) sound (1)	Heat/thermal	(3)
(a)(ii)	Any one from (transferred into) {thermal/heat/sound}(energy) (1) (Energy) is dissipated (1)	Do not accept light energy or it disappears goes into surroundings/air (energy) is wasted/lost	(1)
(b)(i)	12 (J) Ignore any unit given by candidate.	20 - 8 (J)	(1)
(b)(ii)	An explanation linking any two of • (For the) same amount of {electrical/supplied} (energy/power) (1) • (CFL/it) has a greater output (of light energy) (1) • (CFL/it) wastes less (electrical energy) (1)	Same input (energy) gives out/produces more {light/useful} (energy) Do not accept more energy is used in the (CFL/it) Ignore brightness. (CFL/it) produces less thermal/heat (energy) Accept explanations using data from the energy transfer diagrams as comparisons eg (CFL/it) is four times as efficient gains both marks	(2)
(c)	An explanation linking • dissipating heat (1) • at same (rate)/as quickly as energy is being supplied (1)	{gives out/radiates/conducts/ convects /loses /produces} {heat/thermal/ energy} gives out as much energy/power as it takes in(each second) Gains both marks If no other marks scored: There is a constant current/ steady flow of energy into the heater gains one mark Ignore refs to thermostat	(2)

Total for Question = 9 marks

Q21.

Question Number	Answer	Acceptable answers	Mark
(a)	A transverse and electromagnetic		(1)

Question Number	Answer	Acceptable answers	Mark
(b)	Evaluation 171.5 (1) Substitution $(34.3/171.5) \times 100$ (1) Evaluation 20 (%) (1)	award full marks for correct answer with no working 34.3×5 $[34.3 / (34.3 \times 5)] \times 100$ $[34.3 / (34.3 \times 5)]$ $[34.3 / 171.5]$ Allow 0.2 or 1/5 for 3 marks	(3)

Question Number	Answer	Acceptable answers	Mark
(c)	rate of {energy/heat} (from the Sun){absorbed/taken in} (1) equals rate of {energy/heat} {radiated/emitted/given out}(1)	Allow 'energy in = energy out' for 1 mark 'power in = power out' for 2 marks	(2)

Q22.

Question Number	Answer	Acceptable answers	Mark
(a)(i)	B (50 m)		(1)

Question Number	Answer	Acceptable answers	Mark
(a)(ii)	kinetic (1) electrical (1) in this order.	movement electric, electricity poor spellings of electrical electronic Reject 2 forms of energy in one answer	(2)

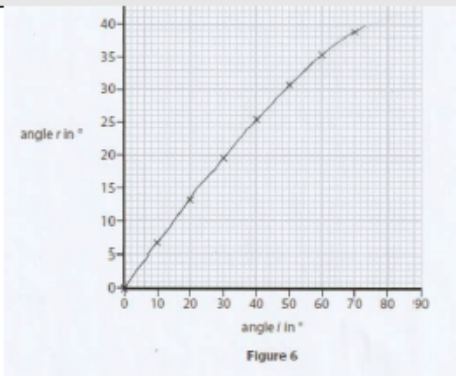
Question Number	Answer	Acceptable answers	Mark
(b)(i)	140 (J)	200 – 60 140 in words	(1)

Question Number	Answer	Acceptable answers	Mark
(b)(ii)	- substitution (1) $\frac{60}{200} \times 100 \%$ - evaluation (1) 30 %	$\frac{60}{200}$ 0.3 ignore units Award full marks for correct answer with no working	(2)

Question Number	Answer	Acceptable answers	Mark
(b)(iii)	explanation linking: - energy supplied and radiated (1) (at) equal (rate) (1)	allow used for radiated heat gained = heat lost 2 marks input energy = output energy 2 marks input power = output power 2 marks input = output 1 mark	(2)

Question Number	Answer	Acceptable answers	Mark
(c)	- substitution (1) $\frac{6000}{250}$ - evaluation (1) 24 (years)	Award full marks for correct answer with no working ignore units	(2)

Q23.

Question number	Answer	Additional guidance	Mark
(i)	curve through origin, through all points – by eye (1)	 Figure 6	(1) AO1

Question number	Answer	Additional guidance	Mark
(ii)	($r =$) $42(^{\circ}) \pm 2(^{\circ})$ (1)	ECF their graph	(1) AO3

Question number	Answer	Additional guidance	Mark
(iii)	Description to include two from: r increases as i increases (1) (but) not in proportion (1) increase in r becomes less (for same increase in i) (1)	r increases as i increases (but) not in even steps/not straight line/non-linear/gradient changes r always less than i	(2) AO3

Q24.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to: identification – knowledge (1 mark) and reasoning /justification – knowledge (1 mark): - the wavelength decreases because wavelength is the ratio of wave velocity to frequency (1) - and the wave velocity reduces at the boundary but the frequency remains the same (1)	allow the same number of waves per second arrive at the boundary as leave it for no change in frequency at the boundary	(2)

Q25.

Question number	Answer	Additional guidance	Mark
	Explanation linking three from: (some) light is <u>reflected</u> (1) (at) the top edge (1) (some) light is <u>absorbed</u> (1) by the glass (1)	in the air in the (glass) block credit responses in terms of attenuation/ dispersion/reflection at the second face/spreading out	(3) AO2

Q26.

Question number	Answer	Additional guidance	Mark
	explanation linking two from: (damage to) cell(s) (1) (because gamma rays are) ionising / high frequency/very energetic (1) (causing / curing/diagnosing) cancer / mutation / chromosomal damage / dna damage/burns (1)	(rapid/unwanted) division of cells	(2)

Q27.

Question number	Answer	Additional guidance	Mark
	explanation linking: wave P refracts (towards the normal) (1) because P slows down (1) AND wave Q is reflected (at an equal angle from the boundary) (1) without change of speed of Q (1)	accept 'upper layer' for 'P' accept 'wavelength decreases' accept 'bends' for 'refracts' in this instance accept 'lower layer' for 'Q' accept 'wavelength unchanged' accept 'wave Q bounces off' (at an equal angle) allow one mark for refraction and reflection if no other mark awarded	(4)

Q28.

Q30.

Question Number	Answer	Mark
	B frequency increases <i>A is not correct because the danger does not increase with decreasing frequency</i> <i>C is not correct because all waves in the e-m spectrum have the same velocity</i> <i>D is not correct because all waves in the e-m spectrum have the same velocity</i>	(1) AO1