

NATIONAL 5 PHYSICS

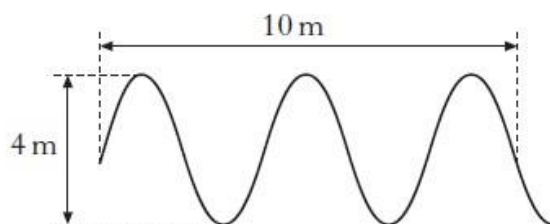
Waves and Radiation

Exam Questions

Wave Parameters and Behaviour

2011 Int2 12 MC

1. The following diagram gives information about a wave.



Which row shows the amplitude and wavelength of the wave?

1

	Amplitude (m)	Wavelength (m)
A	2	2
B	2	4
C	2	5
D	4	2
E	4	4

2012 C 2b

2. A band is performing at music festival.



The festival is being broadcast live on radio.

Drivers in two cars, A and B, are listening to the performance on the radio. The performance is being broadcast on two different wavebands, from the same transmitter.

The radio in car A is tuned to an AM signal of frequency 1152 kHz.

The radio in car B is tuned to an FM signal of frequency 102.5 MHz.

Both cars drive into a valley surrounded by hills.

The radio in car B loses the signal from the broadcast.

Explain why this signal is lost.

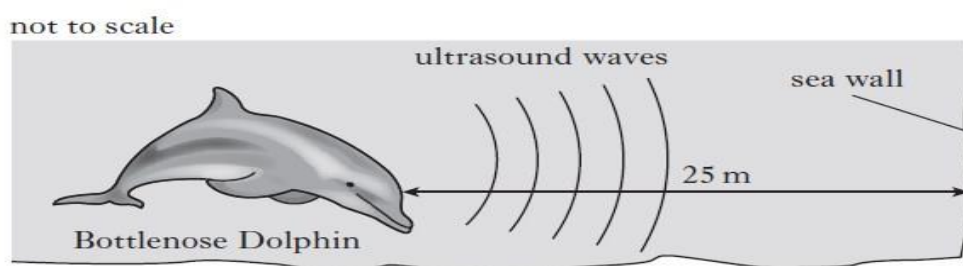
2

2012 C 5

3. Bottlenose dolphins produce sounds in the frequency range 200 Hz - 150 kHz.

Echolocation is the location of objects by using reflected sound.

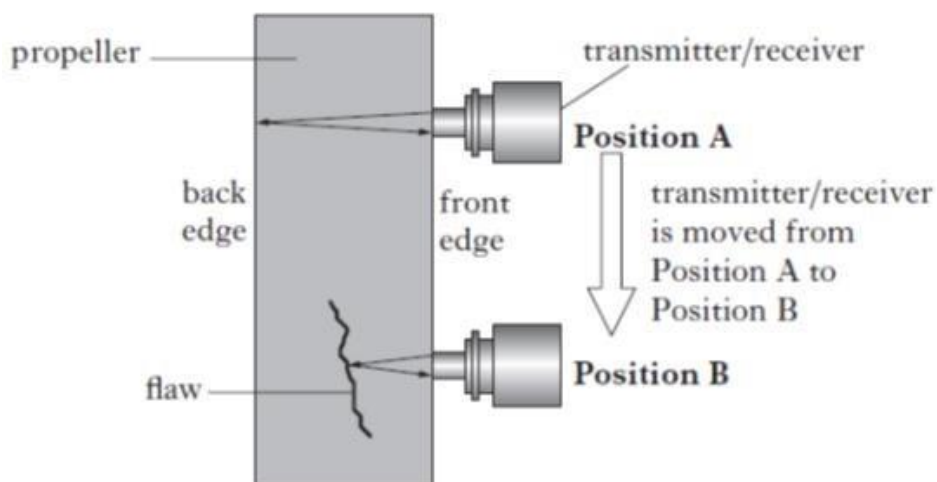
Bottlenose dolphins use ultrasounds for echolocation.



A sound of frequency 120 kHz is transmitted through the water by a bottlenose dolphin.

- (a) Using the data sheet, state the speed of sound waves in water. 1
- (b) When the dolphin is 25 m from the sea wall, it emits a pulse of ultrasound. Calculate the time taken for this pulse to return to the dolphin. 4
- (c) The dolphin changes the frequency of sound it produces to 100 kHz.
- (i) State the effect this will have on the time taken for the pulse to travel the 25 m. 1
- (ii) Explain your answer. 1

4. In the aircraft industry non-destructive metal testing is used to look for flaws in aluminium propellers.
- Ultrasound pulses are sent at from a transmitter into the propeller being tested. If there are no flaws in the propeller the ultrasound will be reflected from the back edge of the propeller as shown at position A. The reflected signal is detected by a receiver. If a flaw is present inside the propeller a reflection from the flaw will take place inside the propeller as shown at position B.



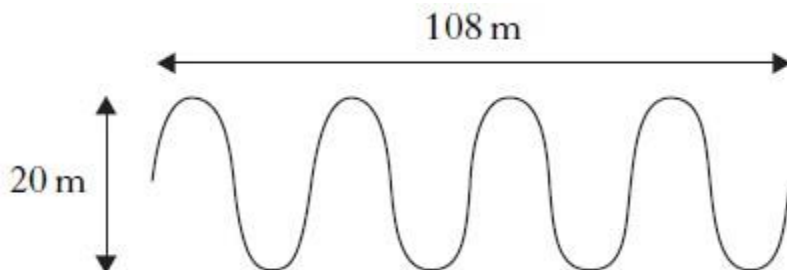
The frequency of the ultrasound pulses is 15 MHz.

Calculate the wavelength of the ultrasound pulses in the propeller.

3

2010 Int2 13MC

5. The diagram gives information about a wave.



The time taken for the waves to travel 108 m is 0.5 s.

A student makes the following statements about the waves.

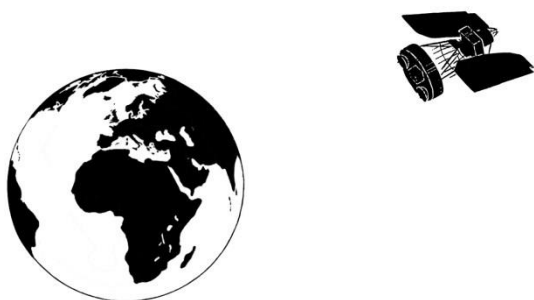
- I The wavelength of the waves is 27 m.
- II The amplitude of the waves is 20 m.
- III The frequency of the waves is 8 Hz.

Which of the statements is/are correct?

1

- A I only
- B II only
- C I and III only
- D II and III only
- E I, II and III

6. A satellite sends microwaves to a ground station on Earth.



(a) The microwaves have a wavelength of 60mm.

(i) Calculate the frequency of the waves.

3

(ii) Determine the period of the waves.

3

(b) The satellite sends radio waves along with the microwaves to the ground station.

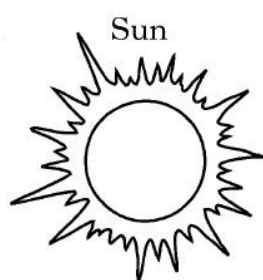
Will the radio waves be received by the ground station before, after or at the same time as the microwaves?

Explain your answer.

2

2005 Int2 29ab

7. The sun is 1.5×10^{11} m from Earth. The sun emits all radiations in the electromagnetic spectrum. All these radiations travel through space at 3×10^8 ms⁻¹.



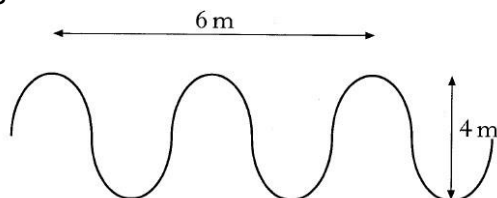
(a) What do all waves transfer?

1

(b) Calculate the time taken for sunlight to reach Earth.

3

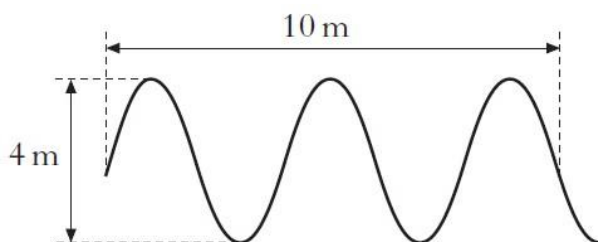
8. The diagram shows a transverse wave.



The amplitude of the wave is

- A 2m
- B 3m
- C 4m
- D 6m
- E 8m

9. The following diagram gives information about a wave.



Which row shows the amplitude and wavelength of the wave?

	Amplitude (m)	Wavelength (m)
A	2	2
B	2	4
C	2	5
D	4	2
E	4	4

10. A pupil is sent exam results by a text message on a mobile phone. The frequency of the signal received by the phone is 1900MHz.

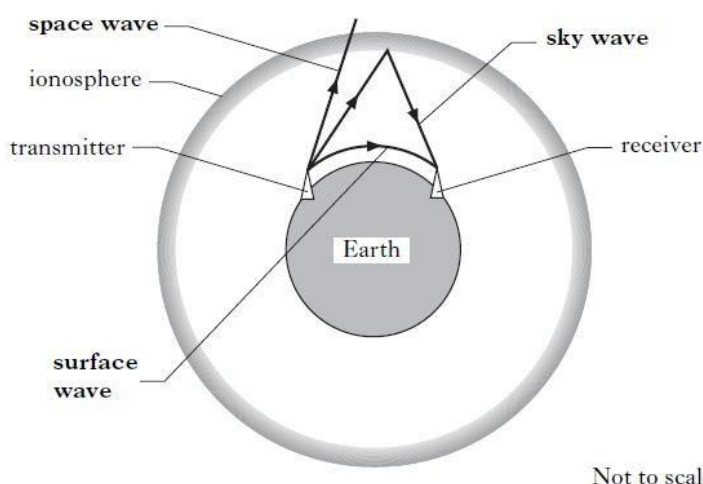


The mobile phone receives radio waves (signals).

- (a) What is the speed of radio waves? 1
 (b) Calculate the wavelength of the signal. 3
 (c) The pupil sends a video message from the mobile phone. The message is transmitted by microwaves. The message travels a total distance of 72 000 km. Calculate the time between the message being transmitted and received. 3

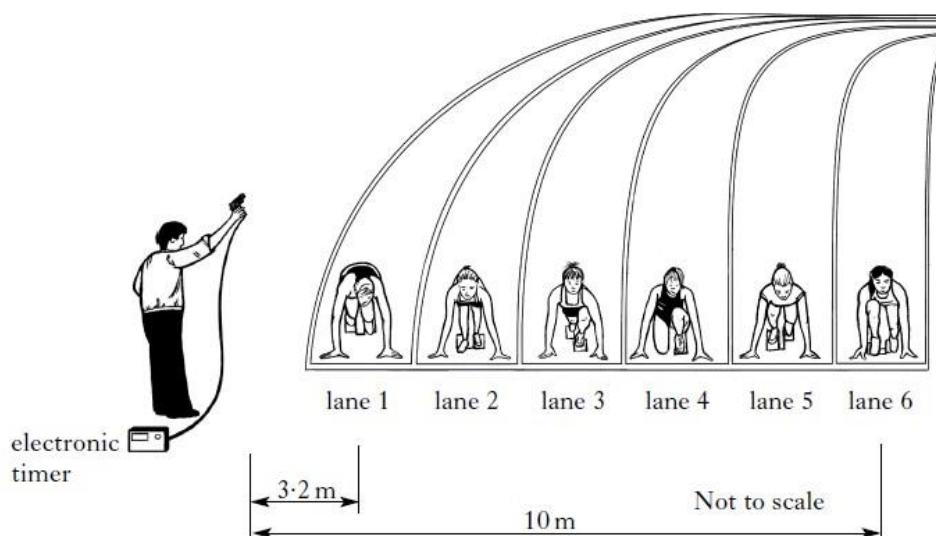
2007 C 2b

11. The diagram shows how radio signals of different wavelengths are sent between a transmitter and a receiver.



- (a) Which of the waves in the diagram shows diffraction? 1
 (b) What does this indicate about the wavelength of the diffracted wave compared to the other two waves? 1
 (c) The Earth's ionosphere is shown on the diagram. The ionosphere is a layer of charged particles in the upper atmosphere. High frequency waves are transmitted as sky waves.
 Explain how the transmitted waves reach the receiver. 1
 (d) Super high frequency (SHF) signals are shown as space waves on the diagram. Although they can only travel in straight lines, they can be used for communications on Earth between a transmitter and receiver.
 Describe how the SHF signals get to the receiver. 2

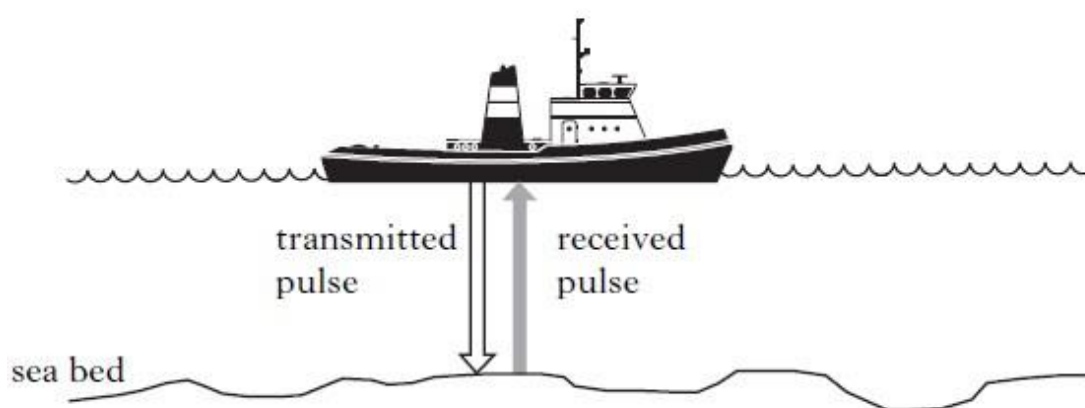
12. In a sprint race at a school sports day, the runners start when they hear the sound of the starting pistol. An electronic timer is also started when the pistol is fired into the air.



The runner in lane 1 is 3.2 m from the starting pistol. The runner in lane 6 is 10 m from the starting pistol. The runner in lane 1 hears the starting pistol first. Calculate how much later the runner in lane 6 hears this sound after the runner in lane 1.

4

13. A ship is carrying out a survey of the sea bed using ultrasound waves. When stationary, the ship transmits and receives pulses of ultrasound waves. The transmitted ultrasound waves have a frequency of 30 kHz.

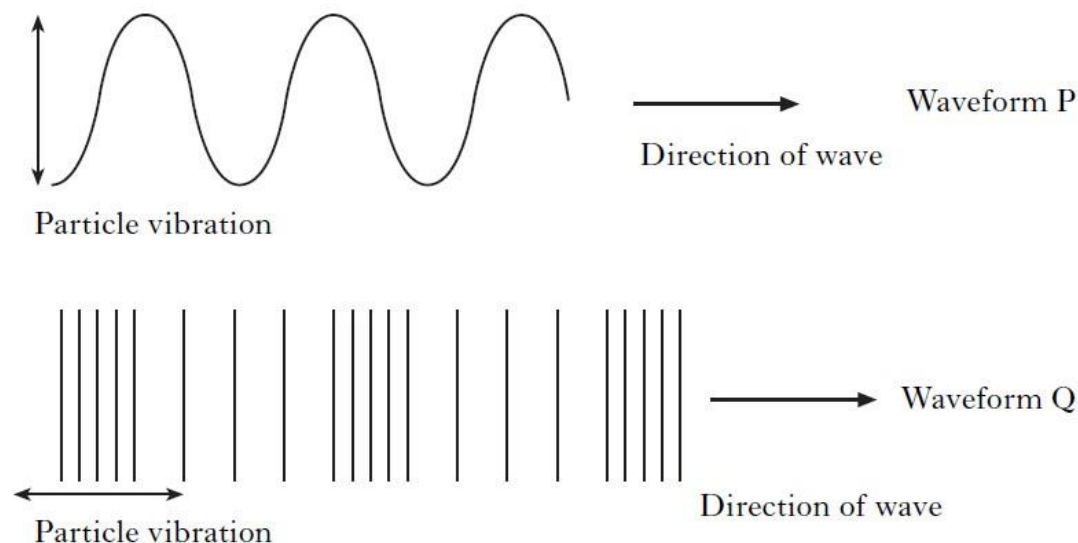


- (a) What is the speed of ultrasound waves in water?
- (b) One pulse of ultrasound is received back at the ship 0.36 s after being transmitted. Calculate the depth of the sea bed.

1

4

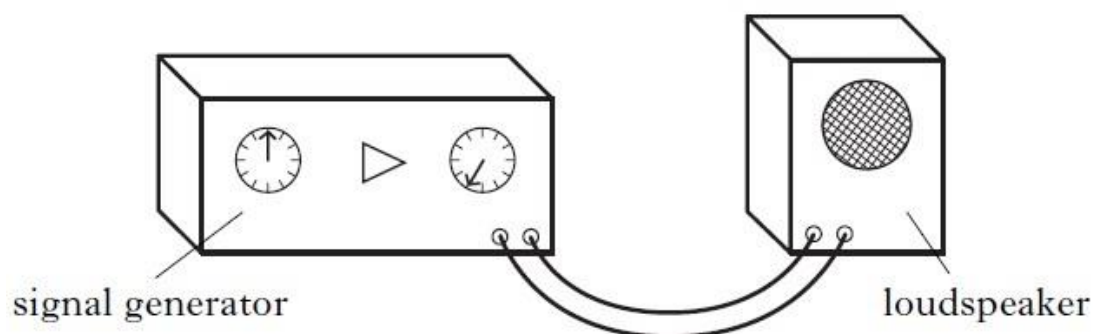
14. (a) Two types of waveform are shown.



(i) Which waveform represents a longitudinal wave? 1

(ii) Which waveform represents a sound wave? 1

(b) A signal generator is connected to a loudspeaker which produces a sound wave of frequency 2 kHz.



(i) Calculate the wavelength of the sound wave in air. 3

(ii) The loudspeaker is placed a distance of 10.2m from a wall. Calculate the time taken for the sound to return to the loudspeaker. 3

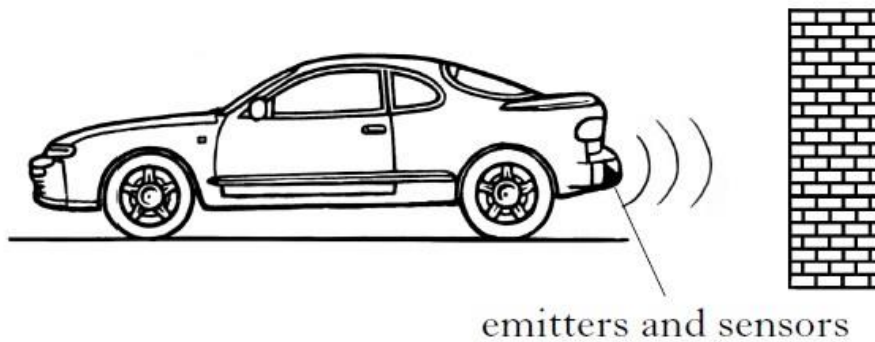
(c) The loudspeaker is now placed in a tank of carbon dioxide gas. The frequency remains at 2 kHz.

What effect does this have on the wavelength of the sound?

Explain your answer.

2

15. Parking sensors are fitted to the rear bumper of some cars. A buzzer emits audible beeps, which become more frequent as the car moves closer to an object.



Ultrasonic pulses are emitted from the rear of the car. Objects behind the car reflect the pulses, which are detected by sensors. Ultrasonic pulses travel at the speed of sound.

- (b) The time between these pulses being sent and received is $2 \times 10^{-3} \text{ s}$.

Calculate the distance between the object and the rear of the car.

4

- (c) At a certain distance, the buzzer beeps every 0.125 s.

Calculate the frequency of the beeps.

3

The Electromagnetic Spectrum

2012 C 4a

1. A toy helicopter is operated using an infrared signal from a remote control. The helicopter has a receiver that can detect infrared radiation.



State a suitable detector of infrared radiation.

1

2013 C 14

2. Images from outer space can be obtained using space telescopes.



Radioastron



Hubble



James Webb

Two space telescopes which orbit the Earth are the Hubble space telescope and the Radioastron space telescope.

- (a) The telescopes detect radiations which are members of the electromagnetic spectrum.

A diagram showing the electromagnetic spectrum is shown.

Gamma rays	P	Q	Visible light	Infra red	Microwave	Radio and TV
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Electromagnetic Spectrum

Name radiations P and Q.

1

- (b) The Hubble space telescope is nearing the end of its useful life and will be replaced with the James Webb space telescope. The James Webb space telescope is designed to detect infra-red radiation from outer space.

Name a detector of infra-red radiation.

1

3. Which of the following electromagnetic waves has a higher frequency than microwaves and a lower frequency than visible light?

A Gamma rays
 B Infrared
 C Radio
 D Ultraviolet
 E X-rays

1

4. The diagram shows members of the electromagnetic spectrum in order of increasing wavelength.

Gamma rays	P	Ultraviolet radiation	Q	Infrared radiation	R	TV & radio waves
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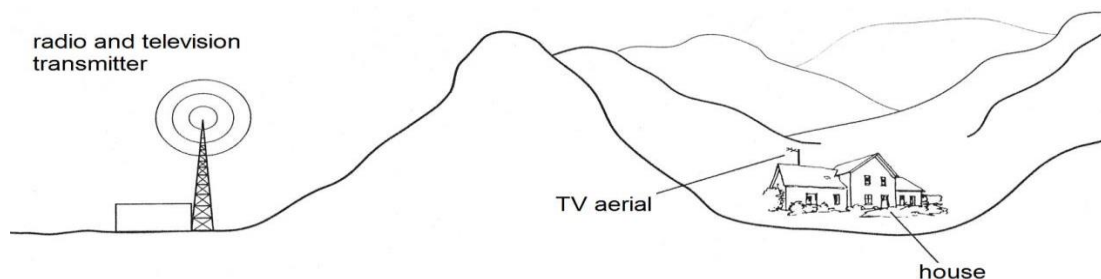
————— increasing wavelength —————→

Which row in the table identifies the radiations represented by the letters P, Q and R?

1

	P	Q	R
A	X-rays	visible light	microwaves
B	X-rays	microwaves	visible light
C	microwaves	visible light	X-rays
D	visible light	microwaves	X-rays
E	visible light	X-rays	microwaves

5. A hill lies between a radio and television transmitter and a house. The house is within the range of both the radio and television signals from the transmitter.



- (a) In the house, a radio has good reception but a TV has poor reception from this transmitter.

Suggest an explanation for this.

2

- (b) State the speed of microwave signals in air.

1

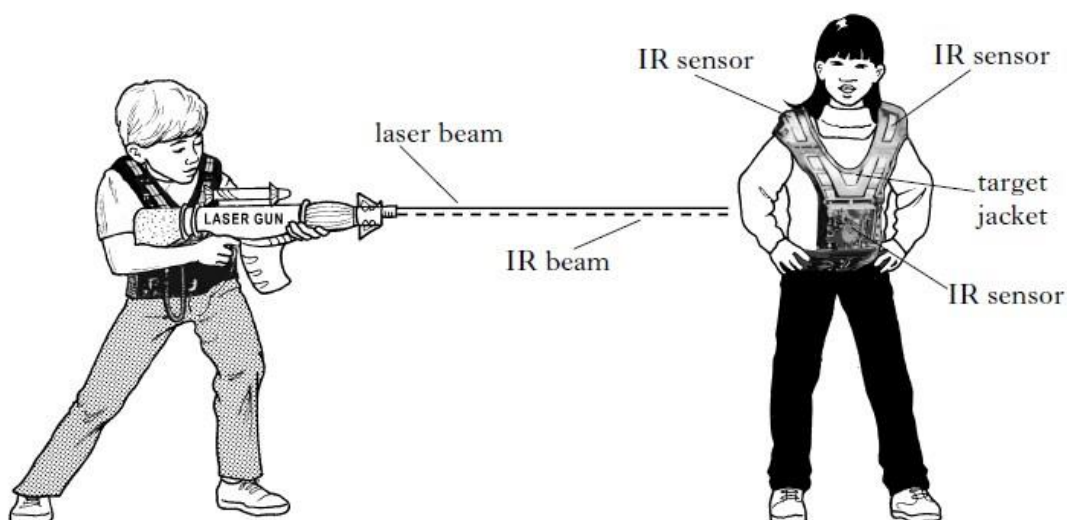
6. A student makes the following statements about members of the electromagnetic spectrum.
- I Gamma rays have a longer wavelength than X-rays.
 - II Ultraviolet rays have a longer wavelength than infrared rays.
 - III TV and radio waves have a longer wavelength than microwaves.

Which of the statements is/are correct?

- A I only
- B II only
- C III only
- D I and II only
- E II and III only

1

7. A group of students visit a Laser Game Centre. The laser gun emits both a visible beam and an IR beam. Each target jacket contains three IR sensors.



- (a) What does the term IR stand for?
- (b) Which of the two beams arrives at the target first?
You must explain your answer.

1

2

8. A student is asked to write down some types of electromagnetic waves in order of increasing wavelength. The student's answer is **not** correct.

X-rays	Ultraviolet	Infrared	Visible light	Microwaves
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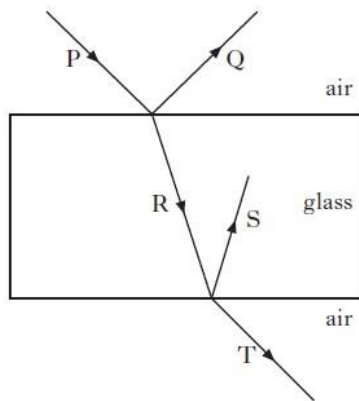
Which two of these should be exchanged to make the student's answer correct? 1

- A X-rays and infrared
- B Visible light and infrared
- C Infrared and ultraviolet
- D Infrared and microwaves
- E X-rays and microwaves

Light

2011 Int2 15 MC

1. The diagram shows a ray of light P incident on a rectangular glass block.



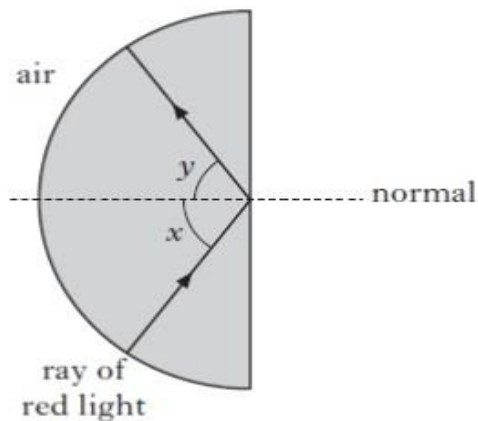
Which of the following are refracted rays?

1

- A Q and R
- B R and S
- C S and T
- D Q and S
- E R and T

2011 Int2 16 MC

2. The diagram shows the path of a ray of red light in a glass block.



A student makes the following statements.

- I Angle x is equal to angle y.
- II Total internal reflection is taking place.
- III Angle x is the critical angle for this glass.

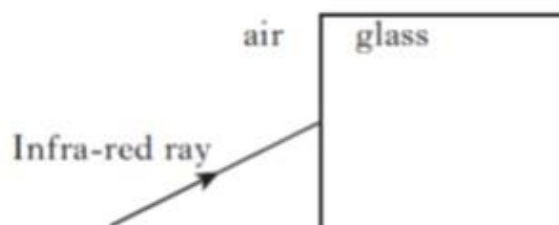
Which of the following statements is/are correct?

1

- A I only
- B II only
- C I and II only
- D II and III only
- E I, II and III

3. Optical fibres are used to carry internet data using infra-red radiation.

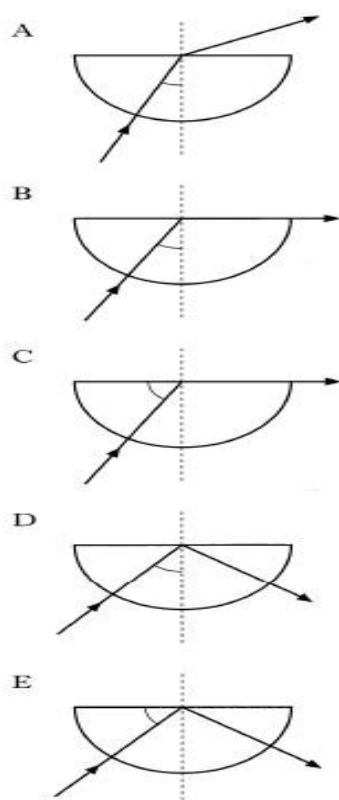
- (a) State if the wavelength of infra-red radiation is greater than, the same as, or less than the wavelength of visible light. 1
- (b) The diagram shows a view of an infra-red ray entering the end of a fibre.



- (i) Copy and complete the diagram to show the path of the infra-red ray as it enters the glass from air. 1
- (ii) Identify on your diagram the normal, the angle of incidence and the angle of refraction. 1

2005 Int2 16MC

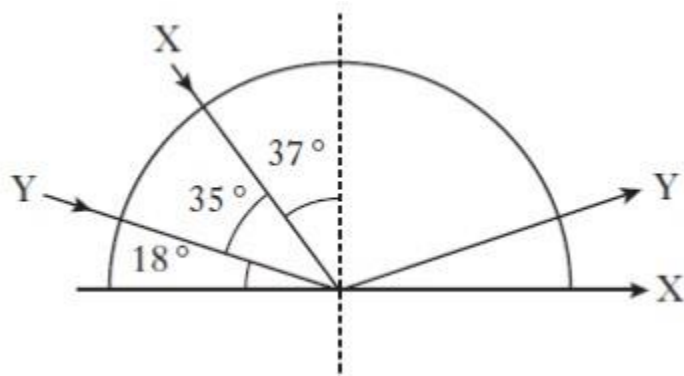
4 The diagrams show a light ray passing through a semi-circular glass block.



In which diagram is this angle the critical angle?

1

- 5 The diagram shows two rays of red light X and Y passing through a block of glass.

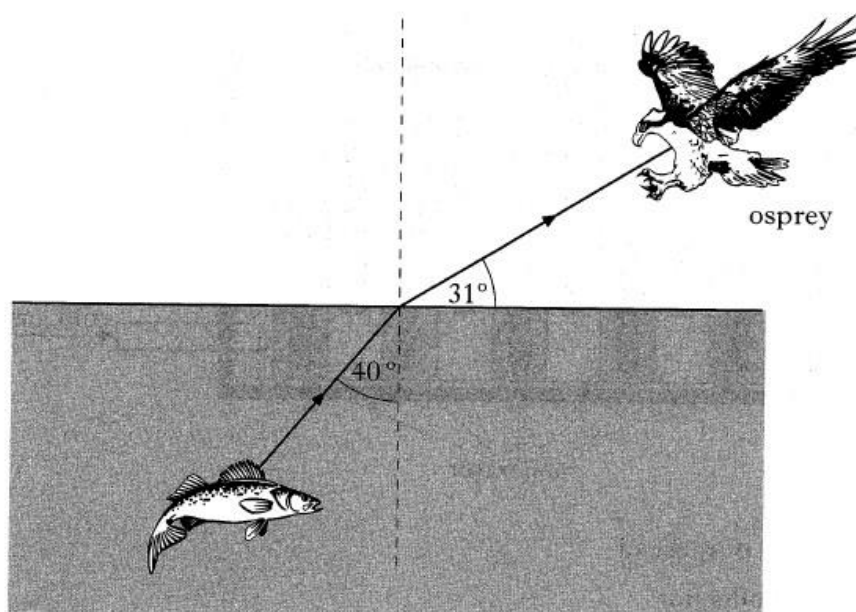


The critical angle of the glass for this light is

- B 18° B 35°
 C 37°
 D 53°
 E 72°

1

6. An osprey sees a fish in a loch.
 The diagram shows the path of a light ray from the fish to the osprey.



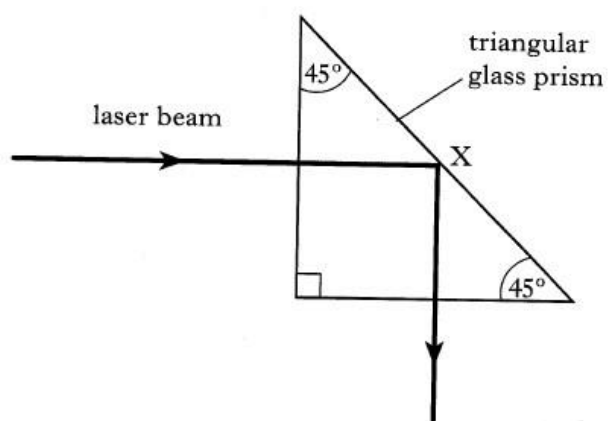
(a) State the size of the angle of incidence.

1

(b) State the size of the angle of refraction.

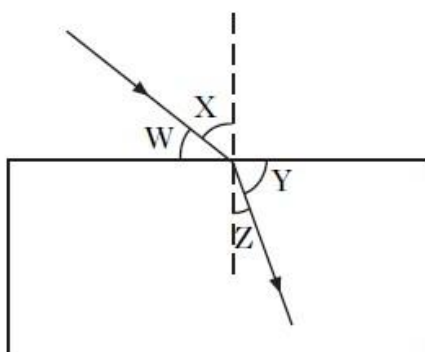
1

7. A student aims a laser beam at a triangular glass prism as shown. The beam changes direction at point X.



- (a) Name the optical effect which occurs at point X. 1
- (b) Suggest a suitable value of the critical angle for the type of glass used for this prism. You **must** explain your answer. 2

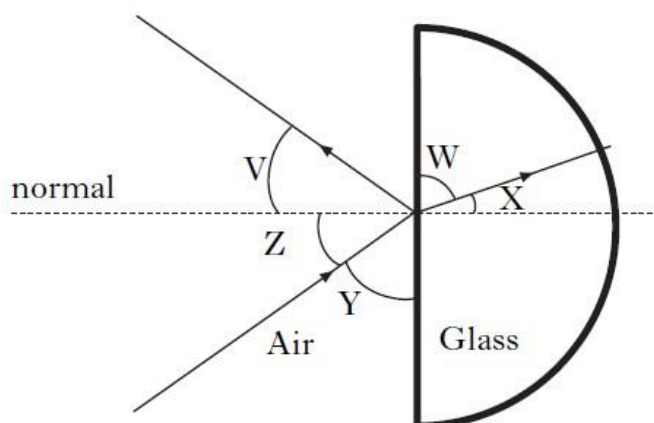
8. A ray of light passes from air into a glass block as shown.



Which row in the table shows the angle of incidence and the angle of refraction? 1

	Angle of incidence	Angle of refraction
A	W	Z
B	W	Y
C	X	Z
D	X	Y
E	Z	X

9. The diagram shows what happens to a ray of light when it strikes a glass block.



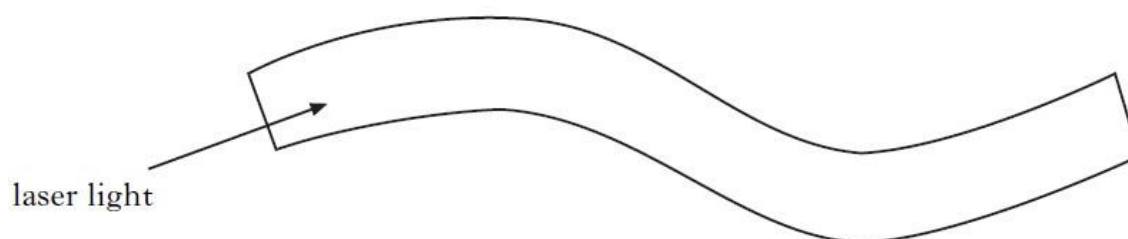
Which row in the table identifies the angle of incidence and the angle of refraction? 1

	Angle of incidence	Angle of refraction
A	V	W
B	Y	W
C	Y	X
D	Z	W
E	Z	X

10. Lasers can be used in optical fibres for medical purposes.

(a) Copy and complete the path of the laser light along the optical fibre.

2



(b) Name the effect when the laser light hits the inside surface of the fibre.

1

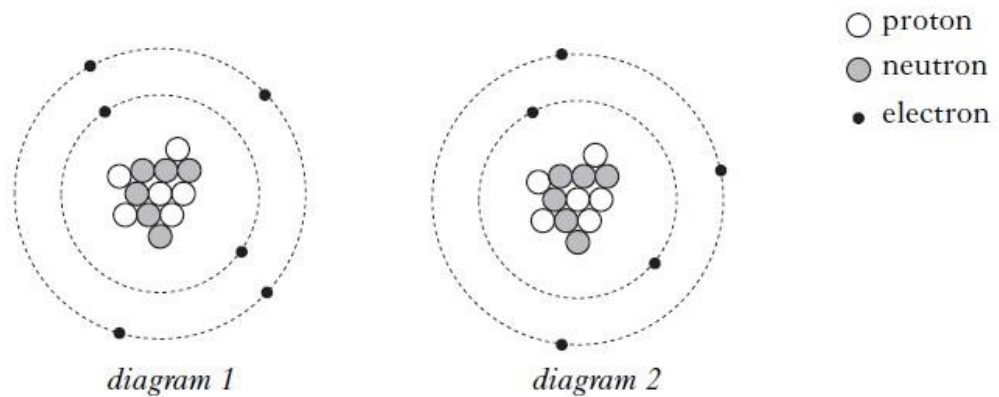
Nuclear Radiation

2011 C 6

1. A teacher is demonstrating absorption of alpha, beta and gamma radiations.
- (a) The teacher explains that when these radiations are absorbed they may cause ionisation in the absorbing material.

(i) (A) State which of the two diagrams below represents an ionised atom. 1

(B) Explain your answer. 1



(ii) State which type of radiation: alpha, beta or gamma causes most ionization. 1

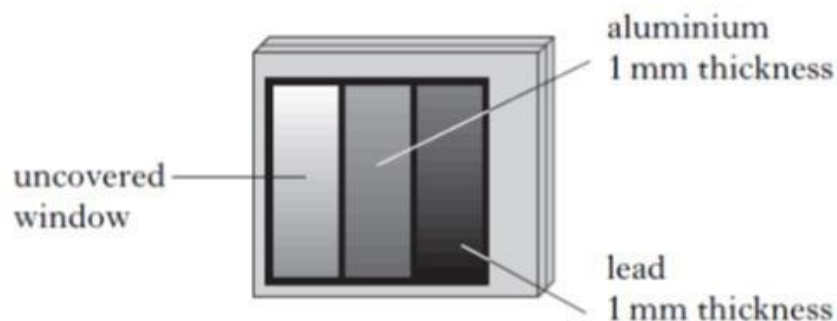
- (b) The radioactive sources are stored in lead-lined boxes. This is a safety precaution to minimise exposure of students and teacher to radiations from the sources.

State one further safety precaution that should be taken by the teacher when handling the radioactive sources. 1

- (c) Radioactive materials are used in hospitals.

(i) State one medical use of radiation where the radiation is used to destroy cells. 1

(ii) A hospital physicist is working with some radioactive materials. The physicist wears a badge containing photographic film. Light cannot reach the film.



When developed, it is found that the film behind both the uncovered window and the window covered with 1 mm thick aluminium have turned black.

State which type of radiation could cause the film in only these areas to turn black. 1

2. Activity and absorbed dose are quantities used in Dosimetry.
Which row shows the unit of activity and the unit of absorbed dose?

1

	Unit of activity	Unit of absorbed dose
A	gray	becquerel
B	becquerel	sievert
C	becquerel	gray
D	gray	sievert
E	sievert	gray

3. The table shows the count rate of a radioactive source taken at regular time intervals.
The count rate has been corrected for background radiation.

Time (minutes)	10	20	30	40	50
Count rate (counts per minute)	800	630	500	400	315

What is the half-life in minutes of the isotope?

1

- A 10
B 15
C 20
D 30
E 40

4. In the following passage some words have been replaced by letters X and Y.

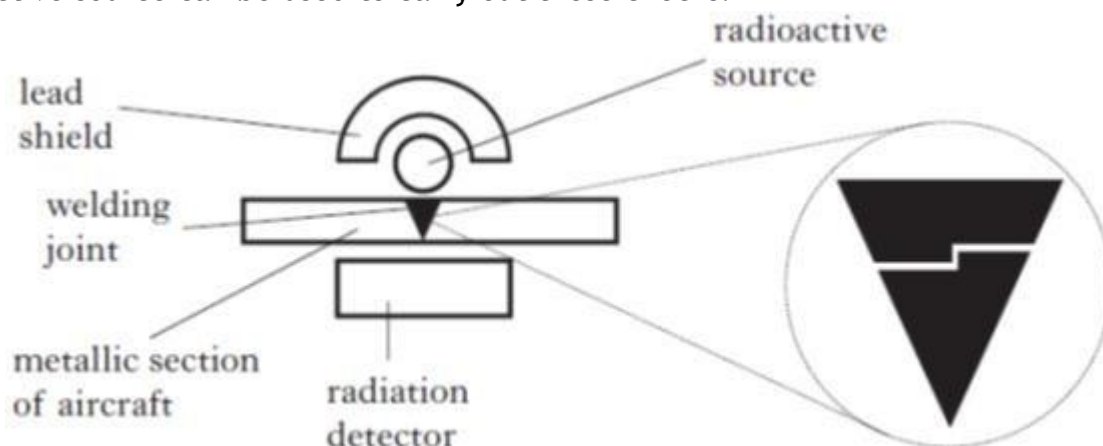
*In a nuclear reactor, fission is caused by X bombardment of a uranium nucleus.
This causes the nucleus to split releasing neutrons and Y.*

Which row gives the words for X and Y?

1

	X	Y
A	neutron	energy
B	proton	energy
C	electron	protons
D	neutron	protons
E	electron	energy

5. Aircraft welding joints must be checked regularly for cracks and other faults. A radioactive source can be used to carry out these checks.



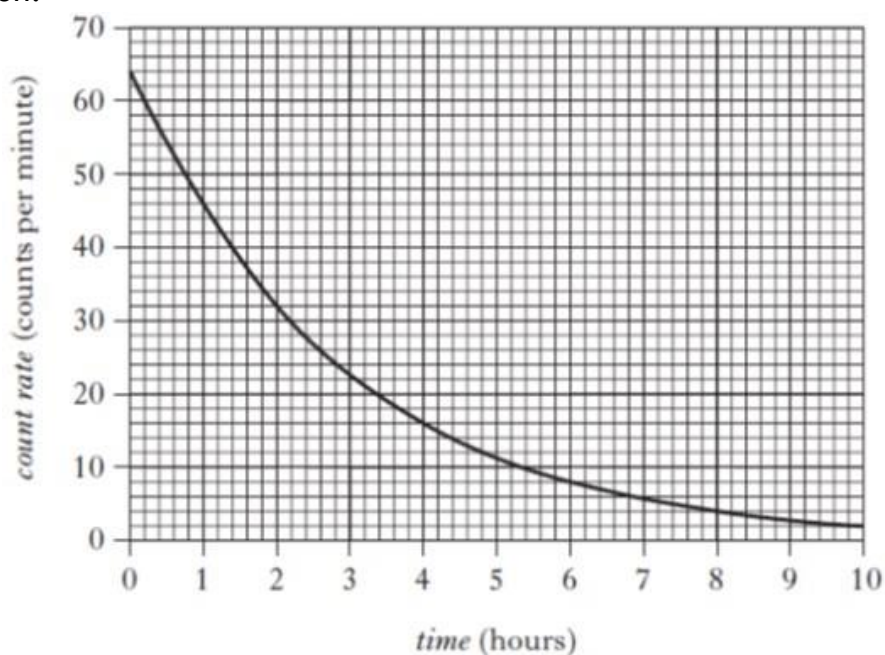
The radiation detector monitors the amount of radiation passing through the section of the aircraft being checked.

- (a) Explain how a crack in the section of the aircraft would be detected. 1
- (b) The aircraft has to be checked regularly. These checks take 24 hours to complete. The following radioactive sources are available.

Source	Half-life	Radiation Emitted
W	20 years	alpha
X	15 hours	beta
Y	30 years	gamma
Z	3 hours	gamma

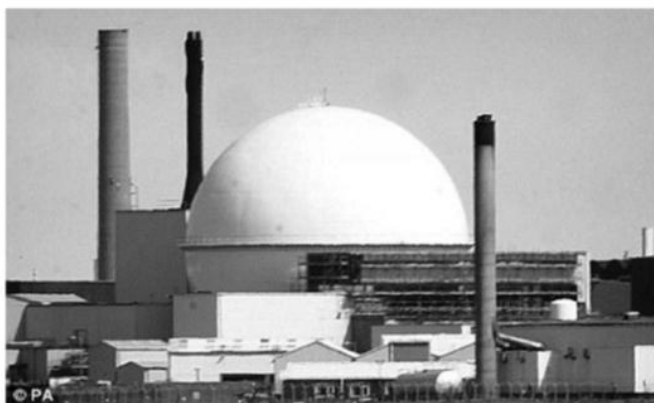
- (i) State what is meant by the term half-life. 1
- (ii) Explain which source would be most suitable for the purpose of detecting cracks in the aircraft. 3
- (c) The lead shield is used as a safety precaution to prevent workers being exposed to a large dose of radiation. State one other safety precaution that is necessary when working with radioactive sources. 1
- (d) A different radioactive source has a half life of 12 hours. The source has an initial activity of 128 MBq. Calculate its activity after 2 days. 3

6. A technician checks the count rate of a radioactive source. A graph of count rate against time for the source is shown. The count rate has been corrected for background radiation.



- | | | |
|-----|--|---|
| (a) | Use the graph to determine the half-life of the source. | 2 |
| (b) | State two factors which can affect the background radiation level. | 2 |
| (c) | The source emits gamma rays. State what is meant by a gamma ray. | 1 |

7. An ageing nuclear power station is being dismantled.



During the dismantling process a worker comes into contact with an object that emits 24 000 alpha particles in five minutes.

Calculate the activity of the object.

3

8. A student makes the following statements.

I In an atom there are neutrons and electrons in the nucleus and protons which orbit the nucleus.

II An alpha particle consists of two neutrons and two electrons.

III A beta particle is a fast moving electron.

Which of the statements is/are correct?

1

- A I only
- B II only
- C III only
- D I and III only
- E I, II and III

2012 Int2 19 MC

9. A radioactive source emits alpha, beta and gamma radiation. A detector, connected to a counter, is placed 10 mm in front of the source. The counter records 400 counts per minute.

A sheet of paper is placed between the source and the detector. The counter records 300 counts per minute.

The radiation now detected is

- A alpha only
- B beta only
- C gamma only
- D alpha and beta only
- E beta and gamma only

1

2012 Int2 20 MC

10. A radioactive tracer is injected into a patient to study the flow of blood. The tracer should have a

- A short half-life and emit alpha particles
- B long half-life and emit beta particles
- C long half-life and emit gamma particles
- D long half-life and emit alpha particles
- E short half-life and emit gamma particles

2013 Int2 30c

11. In a medical procedure, a radioactive chemical is injected into a patient. The chemical is prepared by the technician from a source which has an activity of 320 MBq.

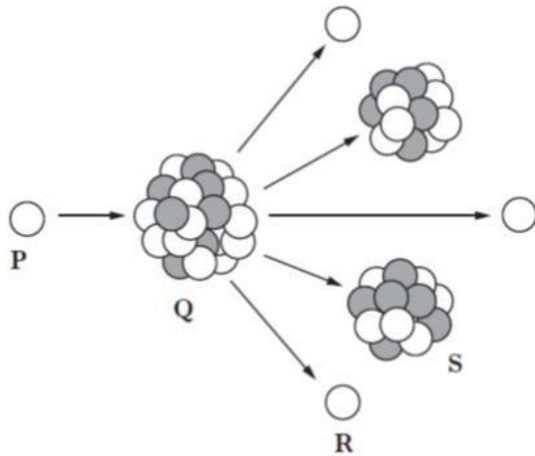
The source has a half-life of 6 hours.

Calculate the activity of the source 18 hours later

3

2013 Int2 31a

12. A student is researching information on nuclear reactors. The following diagram is found on a website.
It illustrates a type of reaction that takes place in a reactor.



- (a) Name the type of nuclear reaction is shown in the diagram. 1
- (b) The labels have been omitted at positions P, Q, R and S on the diagram.
State clearly what each of these labels should be. 2

2013 Int2 17 MC

13. A student makes the following statements.
- | | | |
|----|---|-----|
| I | The nucleus of an atom contains protons and electrons. | |
| II | Gamma radiation produces the greatest ionisation density. | III |
| | Beta particles are fast moving electrons. | |

Which of the statements is/are correct? 1

- A I only
B II only
C III only
D I and III only
E II and III only

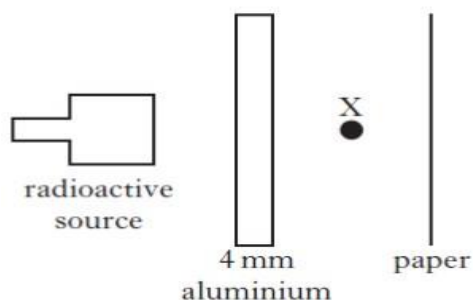
2013 Int2 19 MC

14. Which of the following describes the term ionisation?
- A An atom losing an orbiting electron
B An atom losing a proton
C A nucleus emitting an alpha particle
D A nucleus emitting a neutron
E A nucleus emitting a gamma ray

1

2013 Int2 18 MC

15. A radioactive source emits α , β and γ radiation.
Sheets of aluminium and paper are placed close to the source as shown.



Which row in the table shows the radiation(s) from the source detected at points X and Y?

1

	Radiation(s) detected at X	Radiation detected at Y
A	α , γ	γ
B	β , γ	α
C	α	β
D	β	γ
E	γ	γ

2013 Int2 20 MC

16. A student makes the following statements about radiation.
- I The half life of a radioactive source is half of the time it takes for its activity to reduce to zero.
 - II The activity of a radioactive source is the number of decays per minute.
 - III The risk of biological harm from radiation depends on the type of tissue exposed.

Which of the statements is/are correct?

1

- A I only
- B II only
- C III only
- D II and III only
- E I, II and III

2010 Int2 17 MC

17. A student makes the following statements about a carbon atom.
- I The atom is made up only of protons and neutrons.
 - II The nucleus of the atom contains protons, neutrons and electrons.
 - III The nucleus of the atom contains only protons and neutrons.

Which of the statements is/are correct?

1

- A I only
- B II only
- C III only
- D I and II only
- E I and III only

18. Human tissue can be damaged by exposure to radiation.
On which of the following factors does the risk of biological harm depend? 1

I The absorbed dose.
II The type of radiation.
III The body organs or tissue exposed.

- A I only
B I and II only
C II only
D II and III only
E I, II and III

19. Information about a radioactive source is given in Table 1.

Table 1

Activity	Energy absorbed per kilogram of tissue	Radiation weighting factor
500 MBq	0.2 μ J	10

Which row in Table 2 gives the correct information for the radioactive source? 1

Table 2

	<i>Absorbed Dose</i>	<i>Equivalent Dose</i>
A	0.2 μ Gy	2 μ Sv
B	500 MGy	10 Sv
C	10 Gy	0.2 μ Sv
D	20 μ Gy	50 MSv
E	2 μ Gy	0.2 μ Sv

20. In 1908 Ernest Rutherford conducted a series of experiments involving alpha particles.



- (a) State what is meant by an alpha particle. 1
- (b) Alpha particles produce a greater ionisation density than beta particles or gamma rays. What is meant by the term ionisation? 1
- (c) A radioactive source emits alpha particles and has a half-life of 2.5 hours. The source has an initial activity of 4.8 kBq. Calculate the time taken for its activity to decrease to 300 Bq. 2
- (d) Calculate the number of decays in the sample in two minutes, when the activity of the source is 1.2 kBq. 3
- (e) Some sources emit alpha particles and are stored in lead cases despite the fact that alpha particles cannot penetrate paper. Suggest a possible reason for storing these sources using this method. 1

Various

2011 C 1

1. A mountain climber carries a device which receives radio signals from satellites to determine the climber's position.

The device can also be used to send the climber's position to the emergency services in the event of an accident.



(a) One satellite sends a radio signal that is received by the device 0.068 s after transmission.

(i) State the speed of the radio signal. 1

(ii) Calculate the distance between this satellite and the climber. 3

(b) The device sends a radio signal to the emergency services.

The frequency of the signal is 2100 MHz.

Calculate the wavelength of this signal. 3

2012 C 1b

2. In the summer of 2012 the Olympic Games were held in London. Television pictures of the Games were transmitted from London to Washington via a satellite. Television signals are transmitted using microwaves.

The diagram shows the signals being transmitted from London to the satellite. This satellite transmitted these signals to a ground station in Washington.



The frequency of the microwaves used for transmission was 12 GHz.

(a) State the speed of microwaves. 1

(b) Calculate the wavelength of these microwaves. 3

NATIONAL 5 PHYSICS

Unit 2 Waves and Radiation



ANSWERS

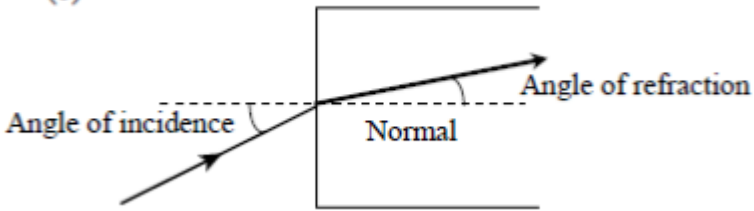
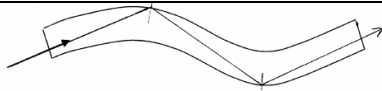
Exam Questions

WAVE PARAMETERS AND BEHAVIOUR				
1		B	1	
2		FM waveband has short(er) wavelength (1) These radio waves do not diffract around hills (1)	2	First mark for describing FM as short(er) wavelength/higher frequency Second mark for indicating that short wavelength/higher frequency waves do not diffract as much. Answer can be given in the context of A and B. Do not accept: Waves “bend” These are independent marks. Candidates can still achieve (1) mark for correct description of long wavelengths/low frequencies diffracting. Answer can be given in the context of A and B.
3	(a)	1500 m s ⁻¹	1	(1) OR (0) must show correct unit
	(b)	$v = d/t$ (1) $1500 = 25/t$ (1) $t = 0.0167 \text{ s}$ (1) Total time = $2 \times 0.0167 = 0.0334 \text{ s}$ (1) Sig fig range 0.03, 0.033, 0.0333	4	Must use value for speed from (b)(i) OR correct value for speed of sound waves in water Multiplication by 2 can happen at any stage *check significant figures Check calculations to see if candidate has doubled distance at start or double time at end. This could have an impact on significant figure issues. Watch intermediate rounding issues (eg pupil may round to $0.02\text{s} \times 2 = 0.04\text{s}$) – this is acceptable
	(c)	Time interval is unchanged	1	Any indication that changing the frequency has no effect on the time
	(i)			
	(ii)	Speed (of sound in water) is same/unchanged. Frequency has no effect (on the time taken for the wave to travel the 50m)	1	
4		$V = f \lambda$ (1) $5200 = 15 \times 10^6 \times \lambda$ (1) $\lambda = 3.5 \times 10^{-4} \text{ m}$ (1)	3	sig. fig. range 1–4 $3 \times 10^{-4} \text{ m}$, $3.5 \times 10^{-4} \text{ m}$ $3.47 \times 10^{-4} \text{ m}$, $3.467 \times 10^{-4} \text{ m}$
5		C	1	
6	(a)	$v = f \lambda$ (1)		
	(i)	$f = 3 \times 10^8 / 0.06$ (1) $= 5 \times 10^9 \text{ Hz}$ (1)	3	
	(ii)	$T = 1/f$ (1) $T = 1/5 \times 10^9$ (1) $= 2 \times 10^{-10} \text{ s}$ (1)	3	
	(b)	Signals received at same time (1) Radio waves and microwaves have same speed (1)	2	
7	(a)	Energy (1)	1	

	(b)	$d = vt$ (1) $1.5 \times 10^{11} = 3 \times 10^8 \times t$ (1) $t = 500 \text{ s}$ (1)	3	
8		A (1)	1	
9		B (1)	1	

10	(a)	$3 \times 10^8 \text{ ms}^{-1}$	1	Unit required
	(b)	$\lambda = v/f$ (1) $= 3 \times 10^8 / 1900 \times 10^6$ (1) $= 0.16 \text{ m}$ (1)	3	significant figure range: 0.2 0.16 0.158 0.1579
	(c)	$t = d/v$ $= 72000000 / 3 \times 10^8$ $= 0.24 \text{ s}$	3	
11	(a)	Surface waves	1	
	(b)	Longer wavelength	1	accept: bigger/larger/greater/higher/ large/high not: "wider", any answer based on frequency
	(c)	The radio waves are reflected by the ionosphere	1	accept: reflection, (total internal) reflection do not accept: "bounce (off ionosphere)", refraction
	(d)	mention of satellite (1) + any valid function of satellite (1) "signals transmitted back to Earth" "signals amplified/focussed" "signal frequency altered"	2	
12		$t = d/v$ (1) $= 6.8 / 340$ (1) (1) for data selection of 340 ms^{-1} $= 0.02 \text{ s}$ (1)	4	
13	(a)	1500 ms^{-1} (1)	1	
	(b)	$d = v \times t$ (1) $= 1500 \times 0.36$ (1) $= 540 \text{ (m)}$ (1) So depth = $540 \div 2$ $= 270 \text{ m}$ (1)	4	If correct speed (1500) is used in (c) but 2(b) is incorrect, can still get full marks. Note: 1 mark is allocated for division by two: the division of time or distance by two can occur at any point
14	(a)	Q (1)	1	
	(i)			
	(a)	Q (1)	1	
	(ii)			
	(b)	$v = f \lambda$ (1) $340 = 2 \times 10^3 \times \lambda$ (1) $\lambda = 0.17 \text{ m}$ (3)	3	
	(i)			
15	(b)	$d = v t$ (1) $20.4 = 340 \times t$ (1) $t = 0.06 \text{ s}$ (1)	3	
	(ii)			
	(c)	Wavelength decreased (1) Speed of sound slower (1)	2	
	(a)	$v = d/t$ (1) $340 = d / 2 \times 10^{-3}$ (1) $d = 0.68 \text{ m}$ (1) $\therefore d = 0.34 \text{ m one way}$ (1)	4	
	(b)	$f = 1/T$ (1) $f = 1/0.125$ (1) $f = 8 \text{ Hz}$ (1)	3	

THE ELECTROMAGNETIC SPECTRUM				
1		Phototransistor/photodiode/CCD (1)	1	NOT thermometer/thermopile/thermogram - not suitable for given context NOT Infra red camera OR Infra red detector
2	(a)	P = X-rays Q = Ultra violet/UV	1	
	(b)	(Black bulb) thermometer OR photodiode OR phototransistor (1)	1	Accept: <ul style="list-style-type: none"> • thermofilm • thermistor • thermopile • thermocouple • thermographic film • heat sensitive paper • IR film • CCD Do not accept: <ul style="list-style-type: none"> • skin • IR camera • photographic film • thermogram
3		B (1)	1	
4		A (1)	1	
5	(a)	• Radio (signals/waves) have a longer wavelength than television (signals/waves) (1) • Longer wavelengths diffract more (1)	2	Must mention both points for full marks If 'radio diffracts more than TV signals' only then (1) max.
	(b)	$3 \times 10^8 \text{ ms}^{-1}$ (1) OR $3\,000\,000\,000 \text{ ms}^{-1}$	1	Must have correct value and unit NOT: 'same as speed of light' alone
6		C (1)	1	
7	(a)	Infrared (1)	1	
	(b)	both arrive at the same time (1) both travel at the same speed (or speed of light or $3 \times 10^8 \text{ m/s}$) (1)	2	
8		B (1)	1	

LIGHT				
1		E	1	
2		C	1	
3	(a)	Greater	1	Accept bigger, larger, longer but not higher
	(b) (i)	Correct drawing and change of direction (b) 	1	Arrows not required.
	(ii)	All 3 labels correctly shown	1	
4		B (1)	1	
5		C (1)	1	
6	(a)	59° (1)	1	
	(b)	40° (1)	1	
7	(a)	Total internal reflection (1)	1	
	(b)	Any angle <u>less than</u> 45° (1) Angle of incidence must be more than critical angle (1)	2	First mark only available if explanation attempted
8		C (1)	1	
9		E (1)	1	
10	(a)	 Ray must obey the law of reflection (1) Appropriate number of reflections (1) line not straight (-1)	2	
	(b)	(total internal) reflection (TIR) (1)	1	

NUCLEAR RADIATION				
1	(a)	Diagram 2 (represents ionized atom)	1	
	(i)A			
	(i)B	An electron has been removed (from the atom)	1	For this mark must explain that: Electron has been removed OR Fewer electrons than protons
	(ii)	Alpha (accept symbol α)	1	Accept: <ul style="list-style-type: none"> • Wash hands • Do not eat • Wear protective clothing • Use shielding • Return to container as soon as demo is finished Or other <i>suitable</i> alternative
	(b)	Use forceps/don't point at eyes/wear gloves etc	1	
	(c)	Instrument sterilisation/treatment of cancer	1	
	(i)			
	(ii)	Beta (radiation) (accept symbol β)	1	
2		C	1	
3		D	1	
4		A	1	
5	(a)	The radiation detector would detect a higher level of radiation OR count rate would be higher where there was a crack in the aircraft	1	Some indication that there would be an increase in the reading on the detector.
	(b)			
	(i)	Time taken for the (radio) activity (of a radioactive source) to reduce by half.	1	Do not accept: Time for radiation/count rate to half.
	(ii)	Source Y (1) gamma can penetrate through the metal aircraft (1) Long half life (1).	3	Y only acceptable answer. Additional (1) marks can only be obtained if Y is selected.
	(c)	Point away from face / people OR use tongs/ forceps OR Use lead (lined) aprons/gloves etc.	1	Accept: <ul style="list-style-type: none"> • Wash hands • Do not eat • Wear protective clothing • Goggles • Film badge to monitor exposure • Limit exposure time • Increased distance from source. • Return to container as soon as demo is finished Or any other <i>sensible</i> alternative NOT: <ul style="list-style-type: none"> • "Film badge" on its own • "wear gloves" or "gloves" alone
	(d)	48/12 = 4 (half lives) (1) 128 → 64 → 32 → 16 → 8 (MBq) (1) for halving (1) for final answer	3	Unit not required but deduct (1) if wrong unit given in final answer Halving process (1) mark is independent of the calculation of the number of half lives.

6	(a)	Any two correct count rate values from the graph, i.e. second = half of the first. (1) Half-life = 2 hours (1)	2	
	(b)	Any two valid answers. 2 x (1)	2	Weapons, atmosphere, rocks etc must be qualified in terms of radioactivity.
	(c)	A type of electromagnetic radiation / wave/ ray	1	Don't accept EM
7		$A = \frac{N}{t}$ (1) $= \frac{24,000}{(5 \times 60)}$ (1) $= 80 \text{ Bq}$ (1)	3	If time not/wrongly converted max (2)
8		C	1	
9		E	1	
10		E	1	
11		Time (hr) 0 6 12 18 Activity MBq 320 160 80 40 halving (1) halving activity 3 times (1) Answer = 40 MBq (1)	3	Accept other methods if correct Answer not made clear (– 1)
12	(a)	Fission	1	Accept induced fission Chain reaction 0 marks Must be spelt correctly
	(b)	P (slow) neutron Q (fissionable) nucleus R (fast) neutron S fission fragment/daughter product	2	Smaller nucleus
13		C	1	
14		A	1	
15		E	1	
16		C	1	
17		C	1	
18		E	1	
19		A	1	
20	(a)	A particle containing two protons and two neutrons OR A helium nucleus (1)	1	
	(b)	The gain/loss of electrons by an atom (1)	1	
	(c)	$4800 \xrightarrow{1} 2400 \xrightarrow{2} 1200 \xrightarrow{3} 600 \xrightarrow{4} 300$ or equivalent (1) $4 \times 2.5 = 10 \text{ hours}$ (1)	2	
	(d)	$A = N/t$ (1) $N = 1200 \times 2 \times 60$ (1) $= 144,000 \text{ (decays)}$ (1)	3	
	(e)	Source may also emit β and/or γ radiation (accept other valid non-standard answer eg neutrons, positrons) (1)	1	

VARIOUS				
1	(a) (ii)	$3 \times 10^8 \text{ m s}^{-1}$ OR $3\ 00\ 000\ 000 \text{ m s}^{-1}$	1	Must have correct value and unit marks (1 or 0) NOT: 'same as speed of light' alone
	(ii)	$d = v t$ (1) $= 3 \times 10^8 \times 0.68$ (1) $= 20\ 400\ 000 \text{ m}$ (1)	3	Must use value for speed from (a) OR correct value for speed of radio signals If $v = 340$, then $d = 23.12 \text{ m}$
	(b)	$v = f \lambda$ (1) $3.0 \times 10^8 = 2100 \times 10^6 \times \lambda$ (1) $\lambda = \frac{3.0 \times 10^8}{2100 \times 10^6}$ $= 0.14 \text{ m}$ (1)	3	Must use value for speed from (a) OR correct value for speed of radio signals Sig. fig range: 0.1, 0.14, 0.143, 0.1429 If $v = 340$, then $\lambda = 1.62 \times 10^{-7} \text{ m}$
2	(a)	$3 \times 10^8 \text{ m s}^{-1}$ OR $300\ 000\ 000 \text{ m s}^{-1}$	1	(1) OR (0) must show correct unit Do not accept: "The speed of light"
	(b)	$v = f \lambda$ (1) $3 \times 10^8 = 12 \times 10^9 \times \lambda$ (1) $\lambda = 0.025 \text{ m}$ (1)	3	Must use value for speed from (a) OR correct value for speed of microwave signals deduct for wrong/missing unit (1) If $v = 340$, then $\lambda = 2.83 \times 10^{-8} \text{ m}$