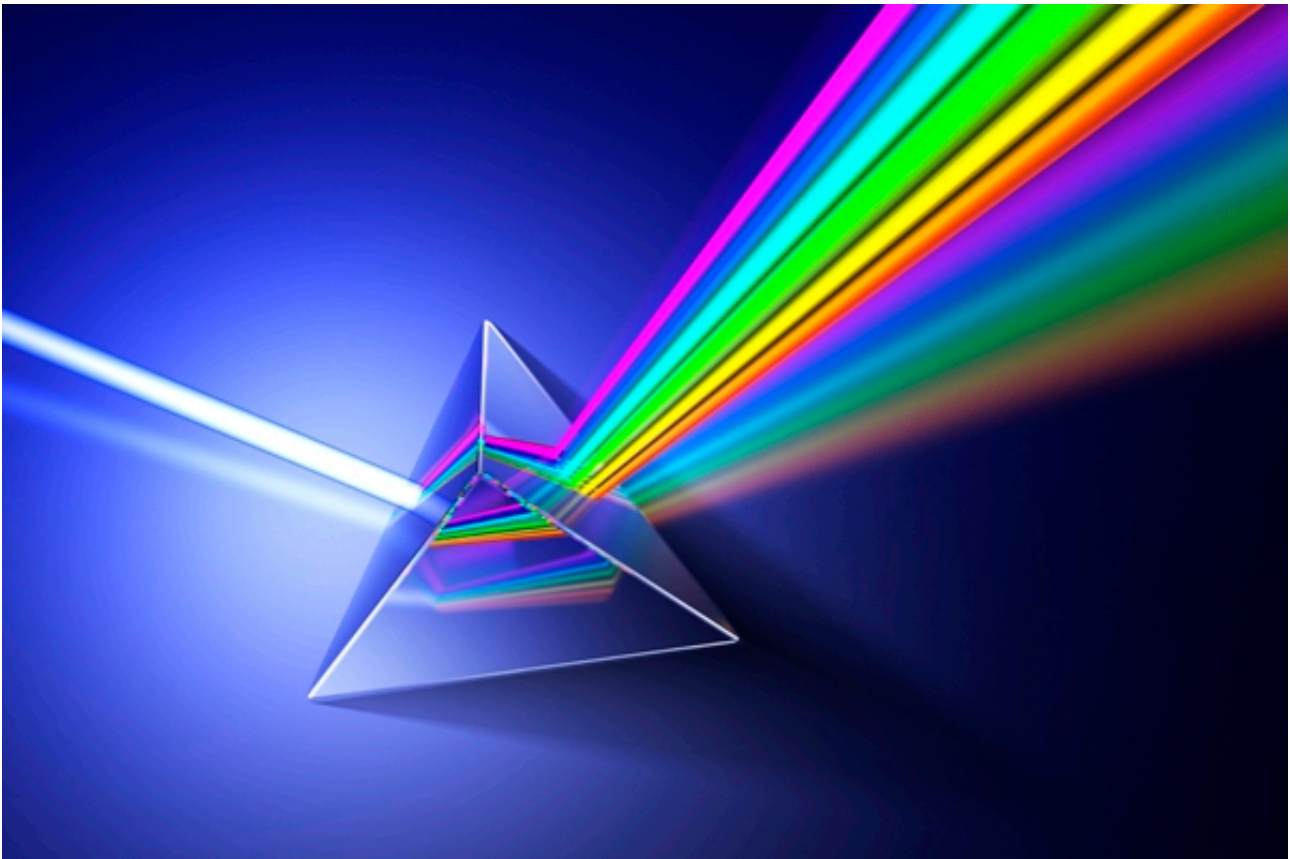


National 5 Physics

Waves and Radiation

Questions by Topic



Based on Past SQA Papers 2000 - 2008

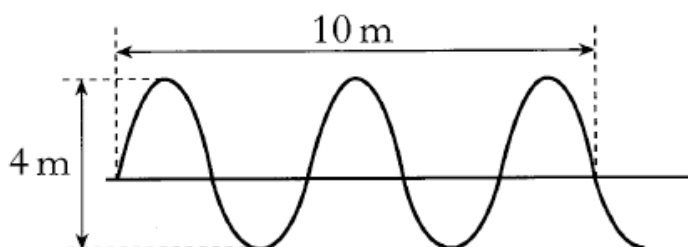
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Wave Parameters and Behaviours

2001 Int 2

16. Which of the following waves is a longitudinal wave?
- A Microwaves
 - B Radio waves
 - C Sound waves
 - D Light waves
 - E Water waves
17. The following diagram gives information about a wave.

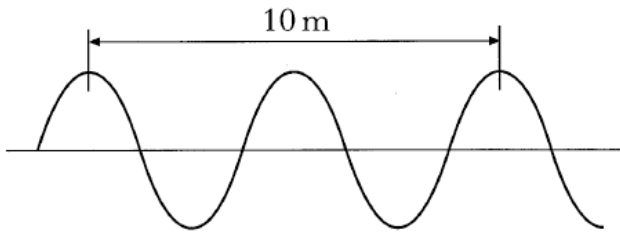


Which line in the table below correctly shows the amplitude and wavelength of the wave?

	<i>Amplitude</i> (m)	<i>Wavelength</i> (m)
A	2	2
B	2	4
C	2	5
D	4	2
E	4	4

2002 Int 2

16. A water wave is shown below.



The speed of the wave is 2.0 m/s.

The frequency of the wave is

- A 0.2 Hz
- B 0.4 Hz
- C 2.5 Hz
- D 10 Hz
- E 20 Hz.

2003 Int 2

17. In a water tank, 10 waves pass a point in 2 seconds. The speed of the waves is 0.4 m/s. The wavelength of the waves is

- A 0.005 m
- B 0.02 m
- C 0.04 m
- D 0.08 m
- E 2 m.

18. Sound is a longitudinal wave. When a sound wave travels through air the particles of air

- A move continuously away from the source
- B move continuously towards the source
- C vibrate at random
- D vibrate at 90° to the wave direction
- E vibrate along the wave direction.

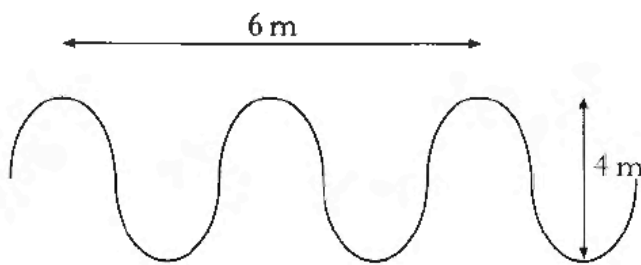
2004 Int 2

16. Which of the following is a longitudinal wave?

- A Water wave
- B Radio wave
- C Gamma ray
- D Sound wave
- E Light wave

2005 Int 2

12. The diagram shows a transverse wave.



The amplitude of the wave is

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

15. The diagram shows a girl standing at a fireworks display. There is a tall building nearby.



When a firework explodes, the girl hears two bangs 0.5 s apart.

The speed of sound is 340 m/s.

How far is the girl from the building?

- A 42.5 m
- B 85.0 m
- C 170 m
- D 340 m
- E 680 m

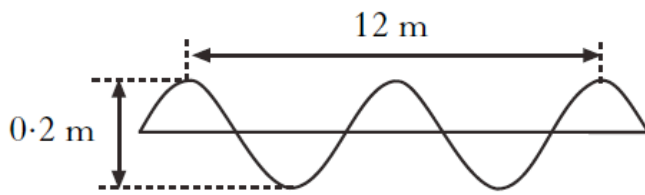
2006 Int 2

15. A beam of light has a wavelength of 4.80×10^{-7} m in air. The frequency of this light is

- A 1.60×10^{-15} Hz
- B 2.40×10^{-15} Hz
- C 7.08×10^8 Hz
- D 4.17×10^{14} Hz
- E 6.25×10^{14} Hz.

2008 Int 2

14. The following diagram shows a wave.



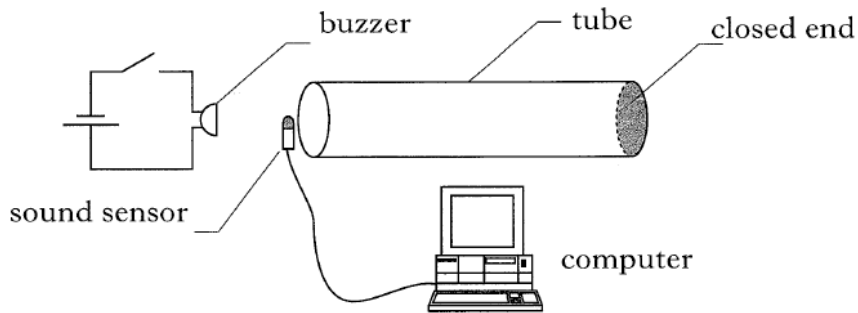
Which row in the table gives the wavelength and amplitude of the wave?

	<i>Wavelength</i> (m)	<i>Amplitude</i> (m)
A	4	0.2
B	6	0.1
C	6	0.2
D	12	0.1
E	12	0.2

2002 Int 2

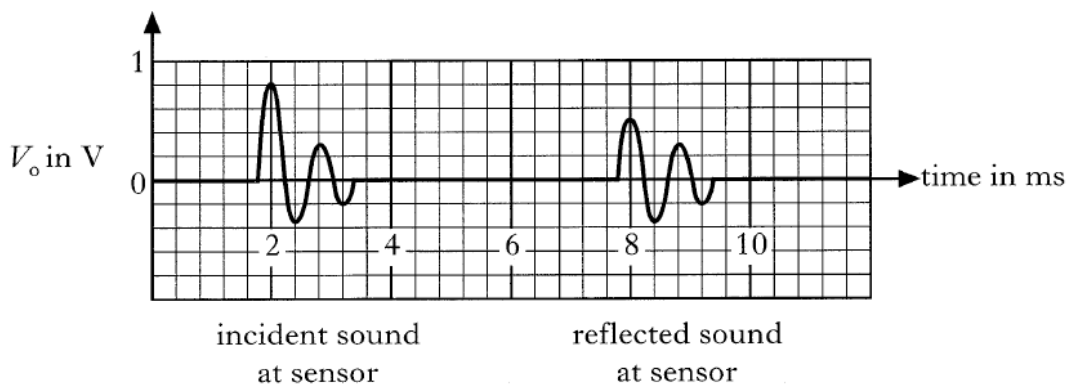
28. A buzzer is placed in front of the open end of a tube. The tube is closed at the other end.

A sound sensor linked to a computer is placed at the open end of the tube as shown.



The buzzer produces a short pulse of sound. At the instant the buzzer is operated the computer starts to record the output voltage V_o of the sound sensor.

The following graph of V_o against time is displayed on the computer screen.



(a) Explain why the amplitude of the reflected sound is less than the amplitude of the incident sound. 1

(b) State the time between the first peak of the incident sound and the first peak of the reflected sound arriving at the sound sensor. 1

(c) The speed of sound in air is 340 m/s.

Calculate the length of the tube. 3

(d) The frequency of the pulse is 1250 Hz.

Calculate the wavelength of the pulse. 2

(7)

2005 Int 2

28

(a) The student whistles into the microphone at a frequency of 400 Hz.

Calculate the wavelength of the sound emitted by the loudspeaker.

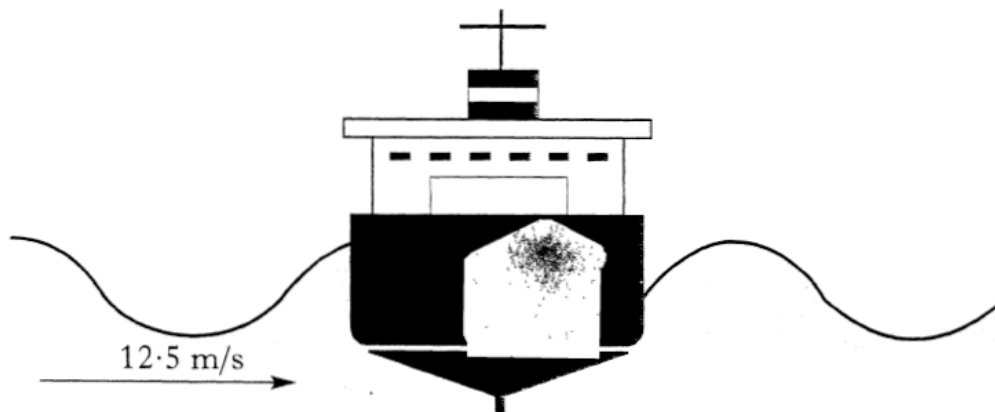
(The speed of sound in air is 340 m/s.)

2

2006 Int 2

22

(c) Out in the open sea, the side of the tanker is struck by a wave once every 16 s. The speed of the waves is 12.5 m/s.



For these waves, calculate:

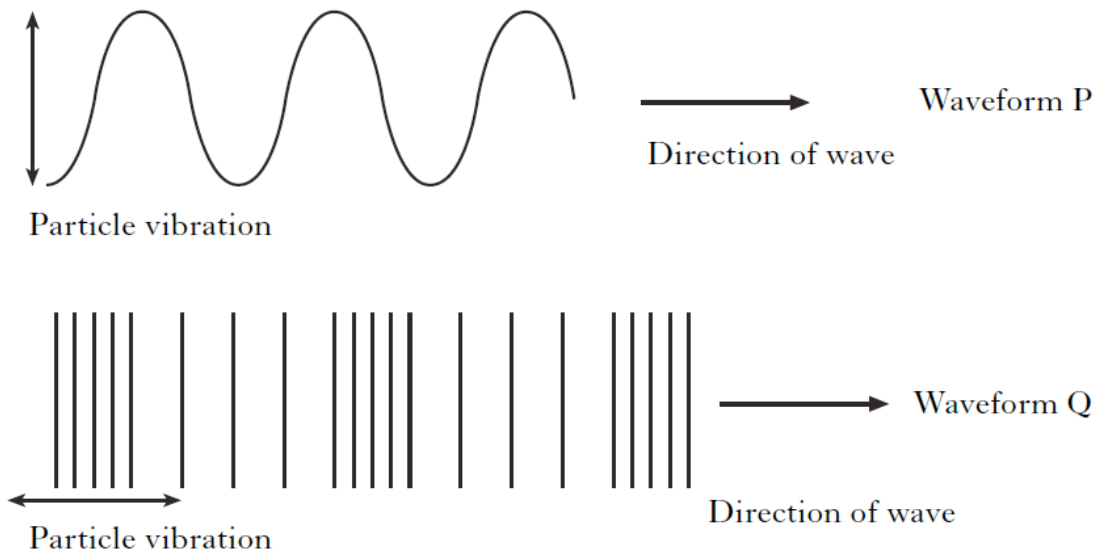
(i) the frequency;

1

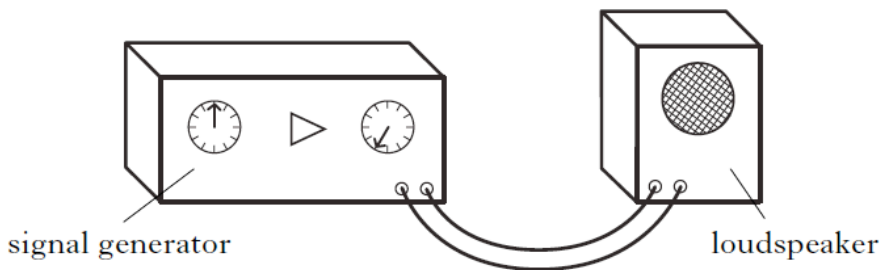
(ii) the wavelength.

2

28. (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. 2
 - (ii) The loudspeaker is placed a distance of 10.2 m from a wall. Calculate the time taken for the sound to return to the loudspeaker. 2
- (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

(8)

Electromagnetic Spectrum

2001 Int 2

15. The diagram shows part of the electromagnetic spectrum.

Radio waves	Micro-waves	Z	Visible light
-------------	-------------	---	---------------

The radiation in the region marked Z is called

- A ultraviolet
- B infrared
- C X-rays
- D sound
- E gamma rays.

2004 Int 2

15. The diagram shows part of the electromagnetic spectrum.

P	Visible light	Q	X-rays
---	---------------	---	--------

The radiations in regions P and Q are

	<i>Region P</i>	<i>Region Q</i>
A	infrared	ultraviolet
B	ultraviolet	microwaves
C	ultraviolet	infrared
D	infrared	microwaves
E	microwaves	ultraviolet

2006 Int 2

17. 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
--------	-------------	----------	---------------	------------

Which **two** of these should be exchanged to make the student's answer correct?

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

2007 Int 2

17. 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

2000 Int 2

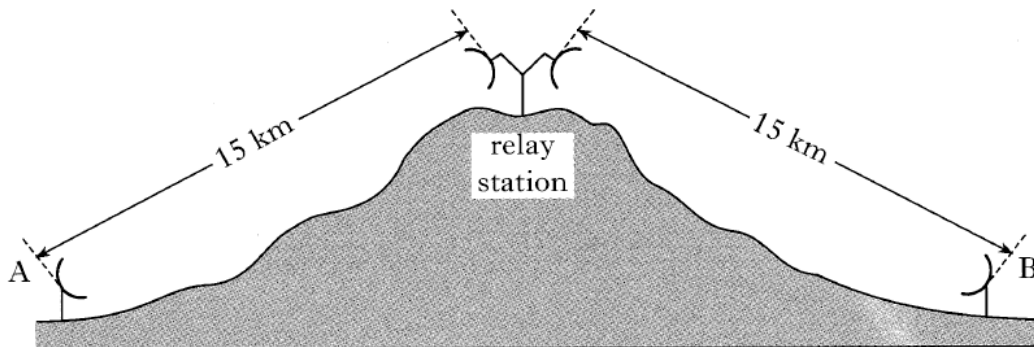
28. Typical wavelengths in air of light of different colours are given in the table below.

Colour	Wavelength in air in m
red	6.5×10^{-7}
green	5.2×10^{-7}
blue	4.0×10^{-7}

- (a) What is the speed of light in air? 1
- (b) The frequency of a certain colour of light is 4.6×10^{14} Hz.
 What colour is this light?
 You must justify your answer by calculation. 3
- (4)**

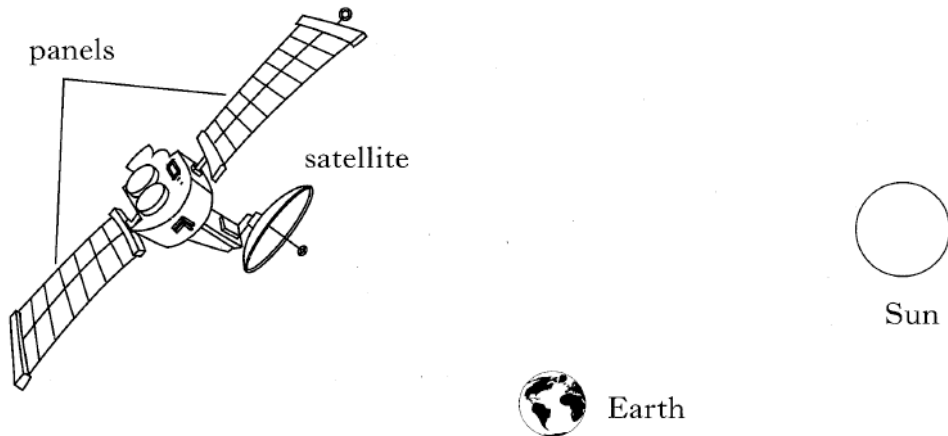
2001 Int 2

28. A telecommunications company uses microwaves to transmit information between two positions A and B separated by a range of hills. A relay station on top of the hills receives and transmits the signals using curved reflectors.



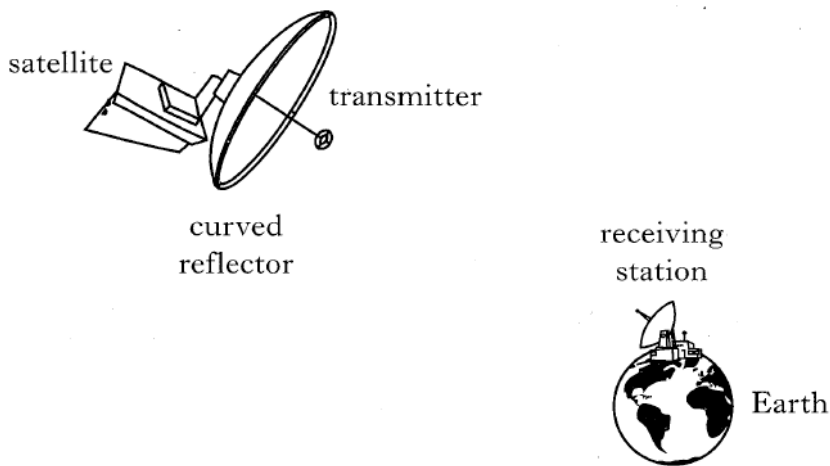
- (a) Explain why a curved reflector is used to receive a signal. Your answer should include a diagram. 2
- (b) The microwaves have a wavelength of 15 mm and a speed of 3×10^8 m/s in air.
 Calculate the frequency of the microwaves. 2
- (c) Calculate the minimum time taken by the microwaves to travel from A to B. 3
- (d) The relay station requires an energy source but is too remote to have a mains electricity supply. Suggest a possible alternative supply. 1
- (8)**

29. A satellite orbiting the earth has large panels as shown.



The panels absorb light energy from the sun and change it to electrical energy.

- (a) (i) Name a device which can change light energy to electrical energy. 1
- (ii) The panels produce a current of 4.5 A for 5 minutes.
Calculate the charge moved in this time. 2
- (b) The satellite uses electrical energy to generate microwaves which are transmitted to a receiving station on earth.

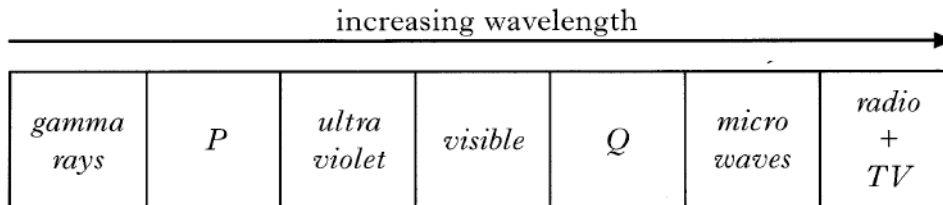


Explain how the curved reflector on the satellite aids the **transmission** of the microwaves. You must sketch a diagram as part of your answer. 2

29. (continued)

(c) Microwaves are part of the electromagnetic spectrum.

The diagram below shows the electromagnetic spectrum arranged in order of wavelength. Two parts of the spectrum, P and Q, have been omitted. Name the radiations P and Q.



1

(d) All radiations in the electromagnetic spectrum travel at a speed of 3×10^8 m/s in space.

The satellite transmits microwaves on the following three frequencies.

$$1.0 \times 10^{10} \text{ Hz}$$

$$9.0 \times 10^9 \text{ Hz}$$

$$8.0 \times 10^9 \text{ Hz}$$

Calculate the wavelength of the microwaves with the **longest** wavelength.

3
(9)

28. Radio waves are transmitted between New York and Edinburgh.

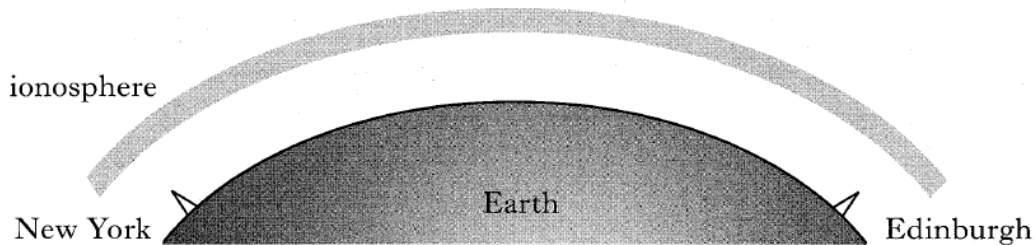
The ionosphere is a layer of charged particles above the Earth.

Radio waves with frequencies below 40 MHz are reflected by the ionosphere.

Radio waves with frequencies above 40 MHz pass through the ionosphere.



diagram not
to scale



(a) What is transferred by a radio wave? 1

(b) An aerial in New York transmits and receives signals of the following frequencies.

300 kHz 3 MHz 30 MHz 300 MHz

Which of these frequencies could be used for communication with Edinburgh by **satellite**?

You **must** give a reason for your answer. 2

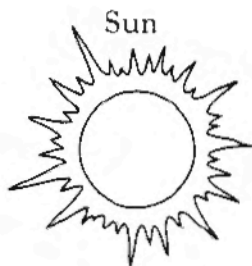
(c) A satellite is 36 000 km from both transmitting and receiving stations in New York and Edinburgh.

Calculate the minimum time for a signal to pass from New York to Edinburgh using the satellite. 3

(6)

2005 Int 2

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



- (a) What do all waves transfer? 1
- (b) Calculate the time taken for sunlight to reach Earth. 2
- (c) The diagram below shows the electromagnetic spectrum in order of increasing frequency.

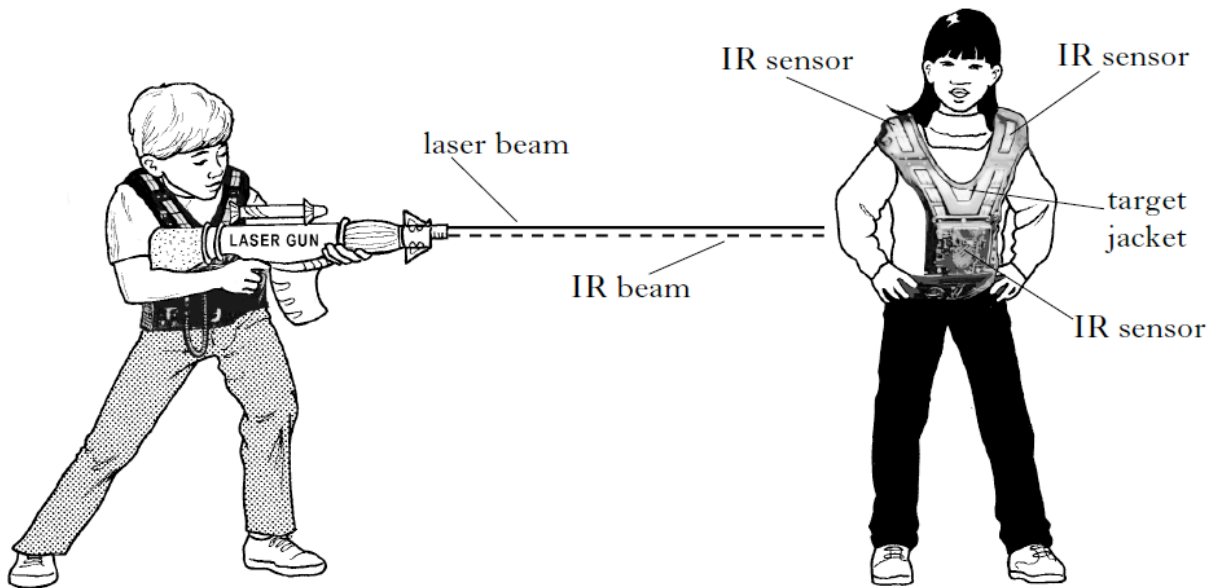
One part has been missed out.

Radio & TV		Infrared	Visible light	Ultraviolet	X-rays	Gamma rays
------------	--	----------	---------------	-------------	--------	------------

- (i) Name the missing radiation. 1
- (ii) Name an ionising radiation from the spectrum. 1
- (iii) What is meant by *ionisation*? 1
- (6)**

2007 Int 2

25. 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.

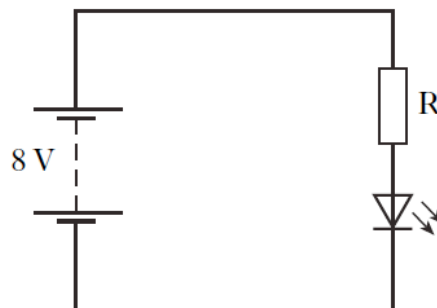


- (a) (i) What does the term IR stand for? 1
(ii) Which of the two beams arrives at the target first?
You **must** explain your answer. 2

(b) The laser gun operates from a 7.2 V rechargeable battery. The battery is charged from the mains and takes two hours to fully recharge. A current of 3 A is used in the charging circuit.

Calculate how much charge the battery stores when fully charged. 2

(c) When the IR beam hits a sensor on the target jacket, the following circuit is completed and the LED lights. The LED has an operating voltage of 2 V and an operating current of 15 mA. The circuit has an 8 V supply.



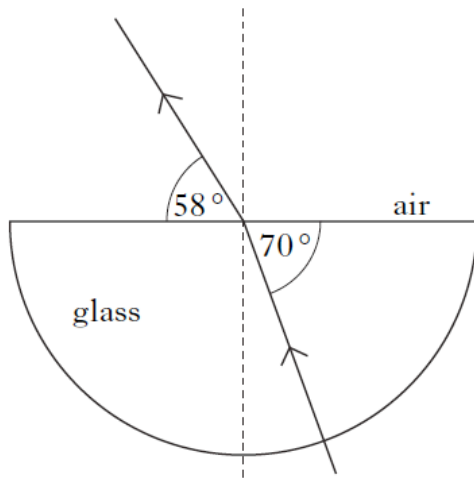
Calculate the value of resistor R.

3
(8)

Light

2000 Int 2

16. A ray of light passes through a glass block as shown below.



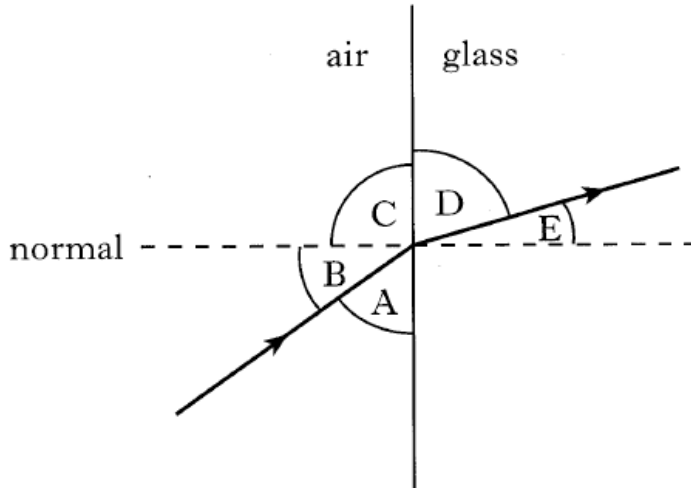
Which line correctly shows the angle of incidence in the glass and the corresponding angle of refraction?

	<i>Angle of incidence</i>	<i>Angle of refraction</i>
A	20°	32°
B	32°	20°
C	58°	70°
D	70°	32°
E	70°	58°

2001 Int 2

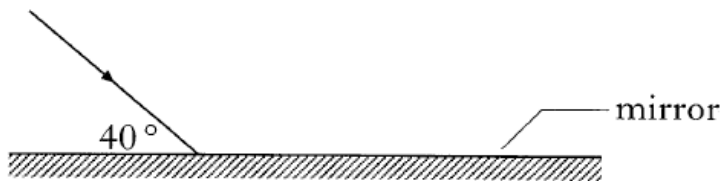
18. A ray of light passes from air into glass as shown.

Which letter marks the angle of refraction?



2002 Int 2

18. A ray of light strikes a plane mirror at an angle of 40° to the mirror surface.

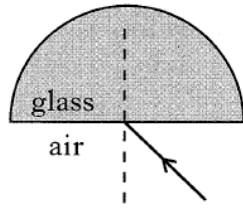


Which row shows the correct values of angle of incidence and angle of reflection for this ray?

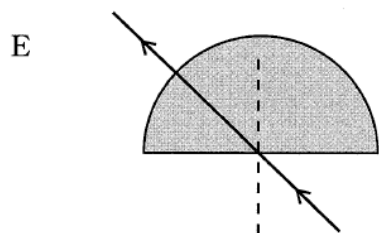
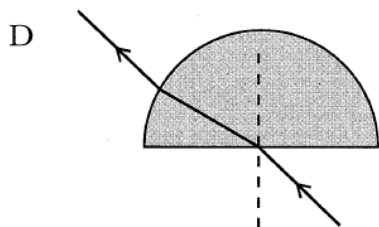
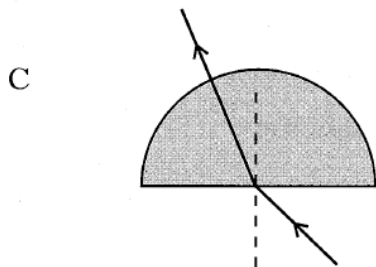
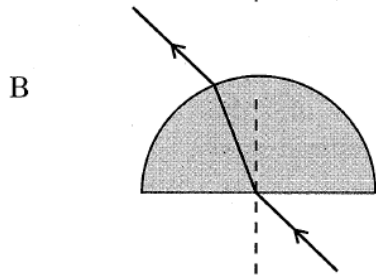
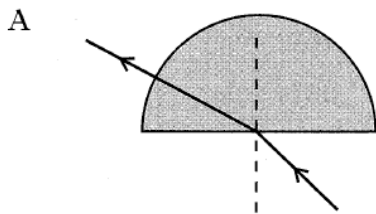
	<i>Angle of incidence in degrees</i>	<i>Angle of reflection in degrees</i>
A	40	40
B	40	50
C	40	140
D	50	40
E	50	50

2004 Int 2

17. The diagram shows a ray of light incident on the centre of the straight edge of a semicircular glass block.



Which diagram shows the path of the ray through the block?



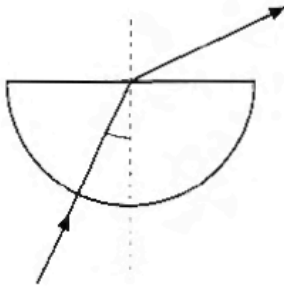
2005 Int 2

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

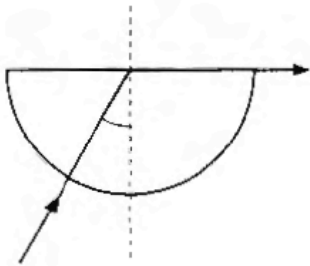
In each case one angle has been marked.

In which diagram is this angle the critical angle?

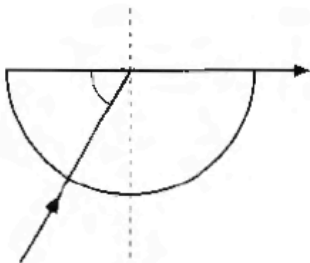
A



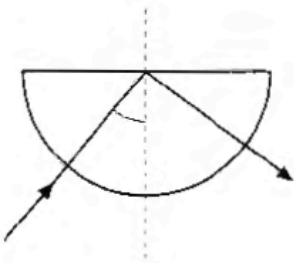
B



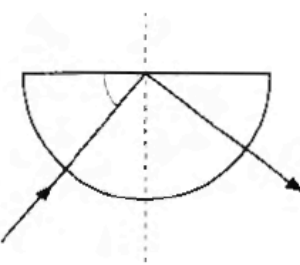
C



D

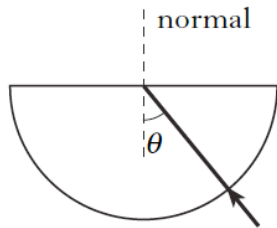


E



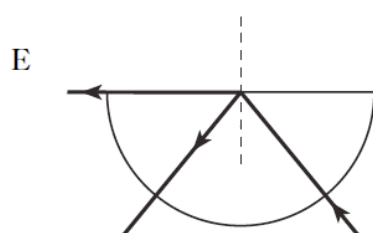
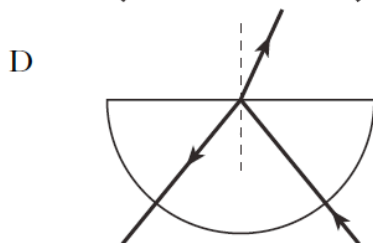
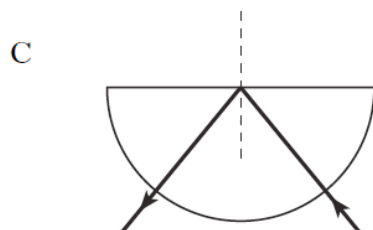
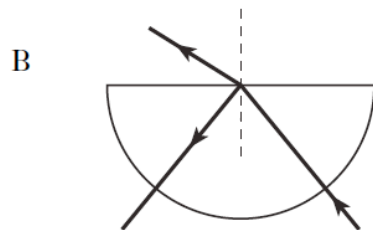
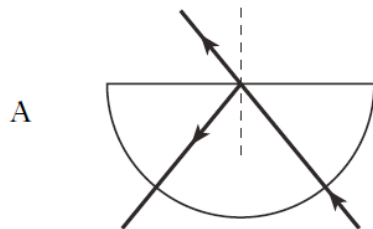
2007 Int 2

15. The diagram below shows a ray of red light entering a block of perspex.

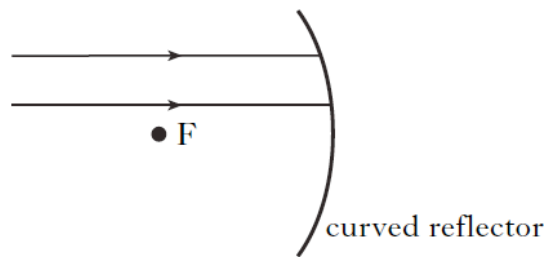


The angle θ is greater than the critical angle in the perspex for this light.

Which of the following diagrams shows the path of the ray of red light after striking the straight surface of the perspex block?



16. The diagram shows two rays of light incident on a curved reflector. The focal point, F, of the reflector is shown.

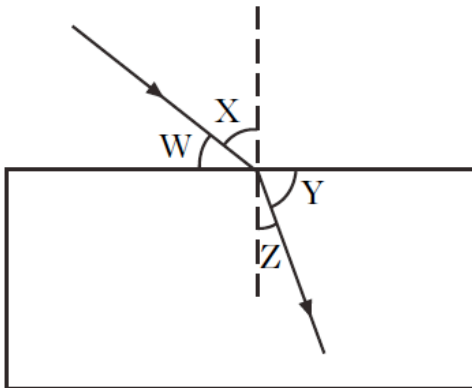


Which of the following diagrams shows the paths of the rays of light after reflection?

- A
-
- Diagram A shows the two incident rays reflecting off the curved surface. The reflected rays are shown as lines with arrows pointing away from the surface. They converge at the focal point 'F' on the principal axis.
- B
-
- Diagram B shows the reflected rays converging at a point on the principal axis that is further to the left (further from the reflector) than the focal point 'F'.
- C
-
- Diagram C shows the reflected rays converging at a point on the principal axis that is closer to the reflector than the focal point 'F'.
- D
-
- Diagram D shows the reflected rays as parallel horizontal lines, indicating that the focal point is at infinity.
- E
-
- Diagram E shows the reflected rays as parallel horizontal lines, indicating that the focal point is at infinity.

2008 Int 2

15. 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?

	<i>Angle of incidence</i>	<i>Angle of refraction</i>
A	W	Z
B	W	Y
C	X	Z
D	X	Y
E	Z	X

2000 Int 2
22

- (b) Some modern aircraft are controlled by on-board computer systems linked by optical fibres.

The diagram below shows a ray of light inside an optical fibre.



- (i) (A) Copy and complete the diagram to show the path of the ray of light in the fibre.

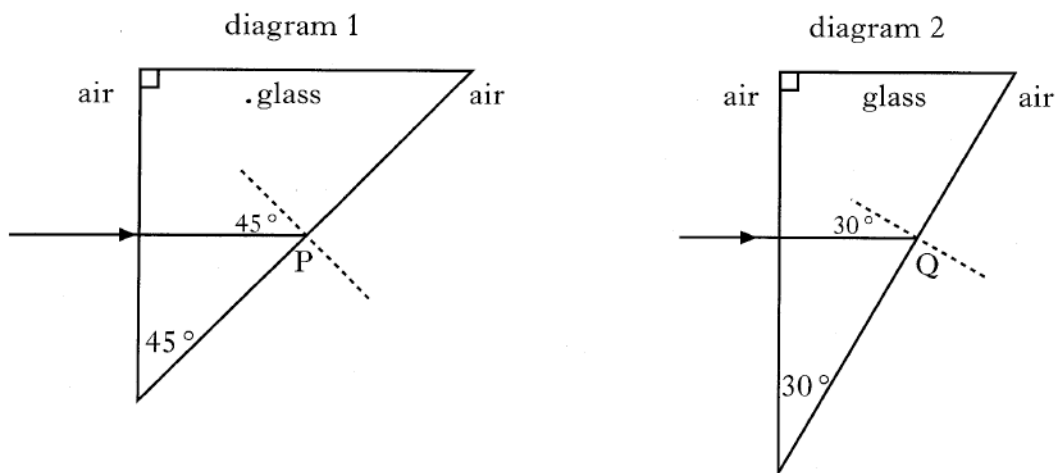
- (B) Name the effect that occurs when the ray hits the inside surface of the fibre.

- (ii) In an optical fibre link in an aircraft, light travels a distance of 62 m. Calculate the time taken for a light signal to travel along this fibre. (speed of light in fibre = 2.0×10^8 m/s)

4

2002 Int 2

29. Rays of light enter glass prisms as shown in diagrams 1 and 2.



The critical angle for glass is 42° .

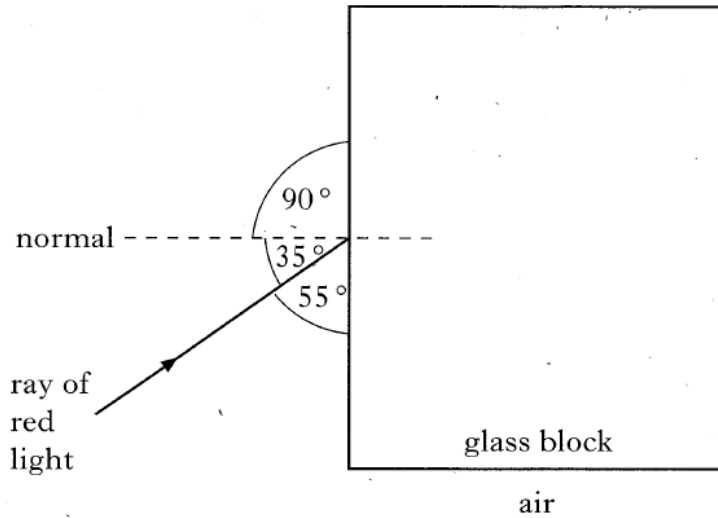
- (a) Using **Worksheet Q29**, complete diagram 1 to show the path of the ray after it strikes point P.
- (b) Using **Worksheet Q29**, complete diagram 2 to show the path of the ray after it strikes point Q.

2

2

(4)

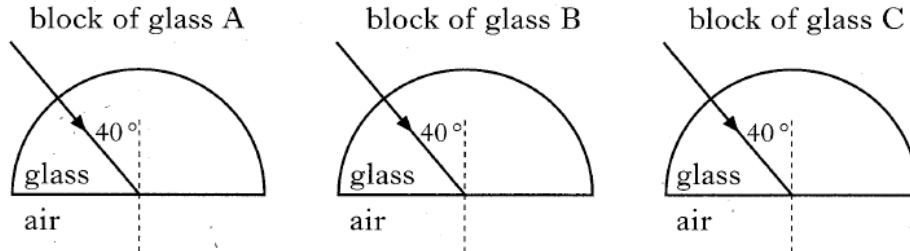
28. (a) A ray of red light is incident on a glass block as shown below.



(i) State the size of the angle of incidence. 1

(ii) Copy the diagram and complete it to show the path of the ray inside the glass block. 1

(b) In another experiment, rays of red light are incident on three semi-circular blocks of glass as shown. Each block is made of a different type of glass.



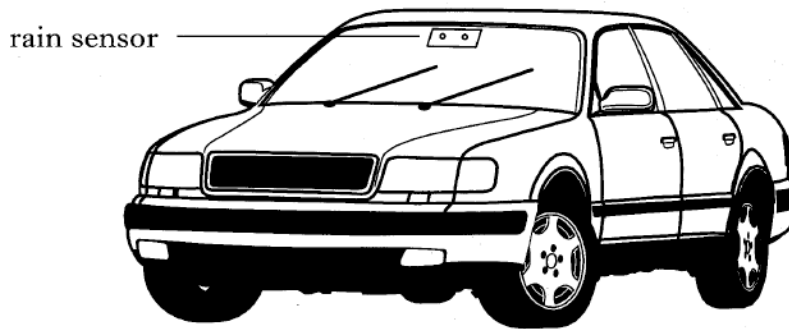
The critical angle for each block of glass is given below.

<i>Glass type</i>	<i>Critical angle</i>
A	38°
B	42°
C	44°

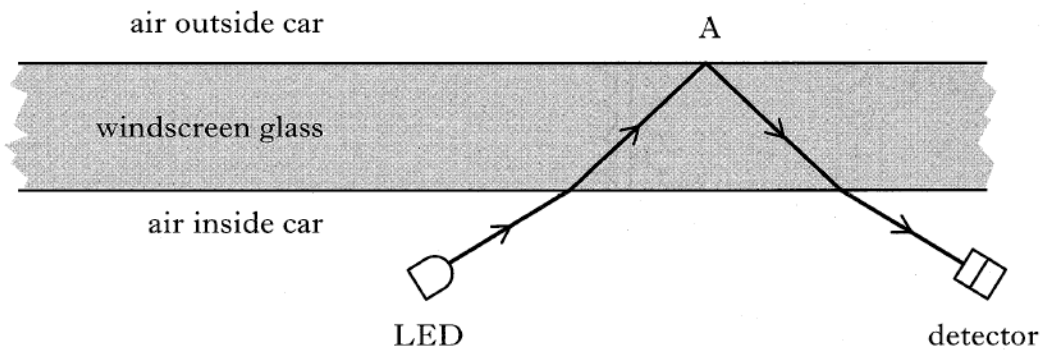
From which block(s) does a ray of light refract through the straight edge?
Explain your answer. 2

2004 Int 2

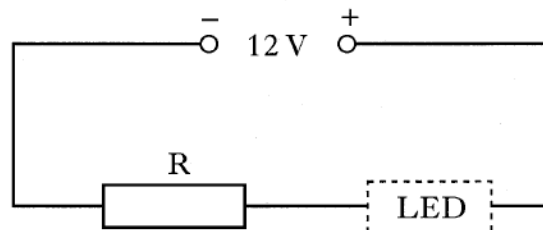
26. A car has a system that switches on the windscreen wipers when rain is detected on the windscreen.



The rain sensor contains an LED which emits a beam of infrared radiation inside the car. In dry conditions this beam travels through the glass and is picked up by a detector as shown below.



- (a) (i) Name the effect on the beam at A. 1
(ii) Draw the symbol for an LED. 1
(iii) The LED circuit is shown below.



The voltage across the LED is 1.8 V and the current in the LED is 100 mA.

Calculate the resistance of R.

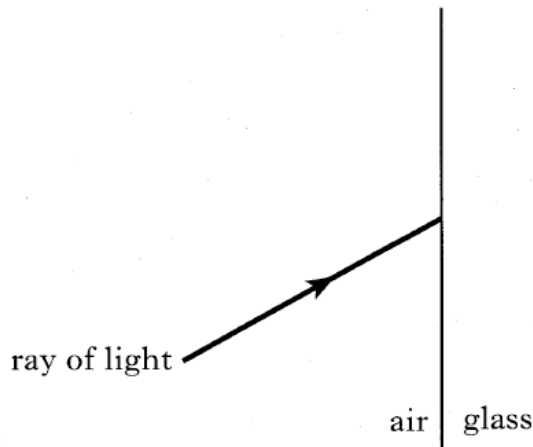
3

(b) The diagram below shows a ray of light incident on a glass surface.

Copy the diagram and complete it to show the normal and the refracted ray.

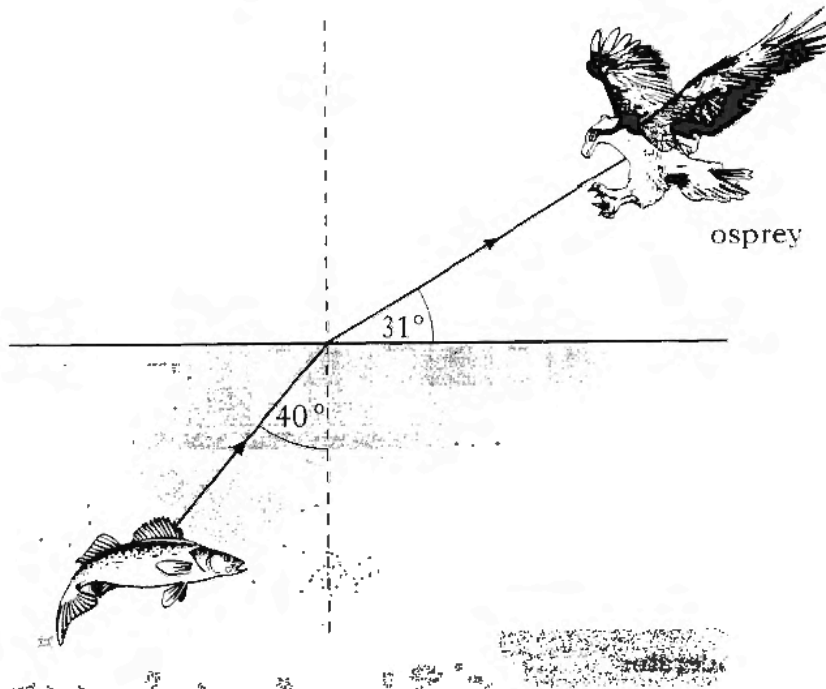
On your diagram, label the angle of incidence i and the angle of refraction r .

2



30. (a) An osprey sees a fish in a loch.

The diagram shows the path of a light ray from the fish to the osprey.



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

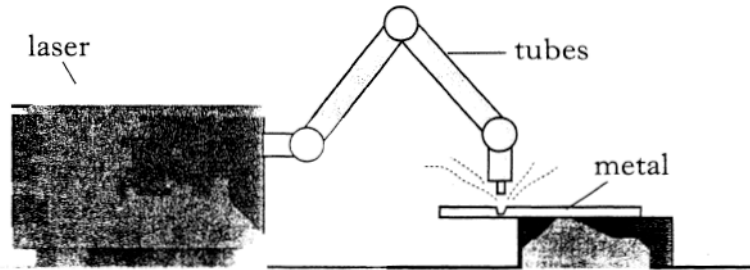
1

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

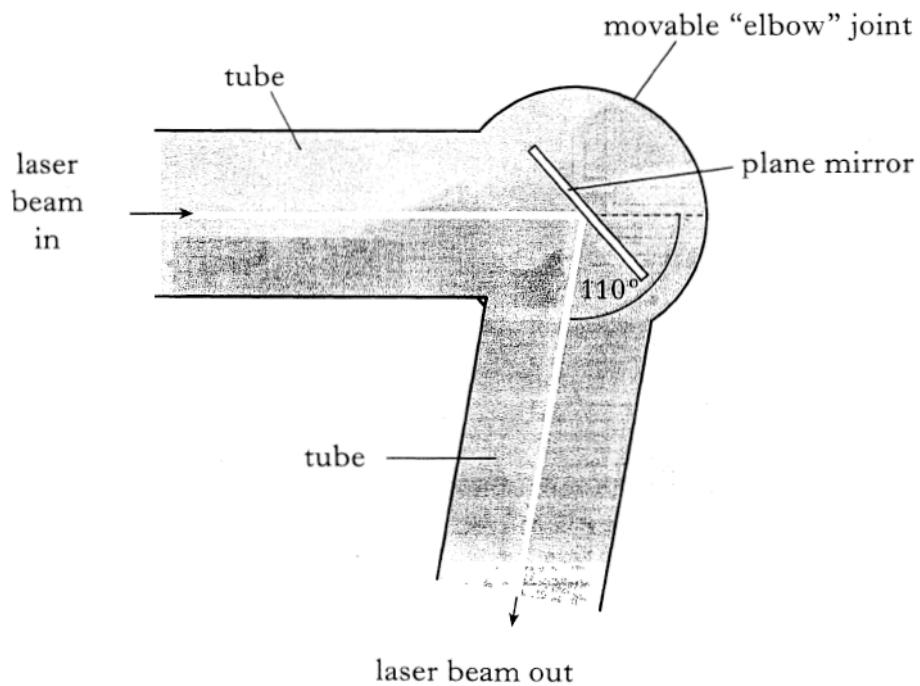
1

2006 Int 2

29. (a) A large industrial laser is used to cut metal sheets in a factory. For safety, the laser beam travels to the metal along hollow tubes with jointed "elbows". There is a plane mirror inside each "elbow" joint.



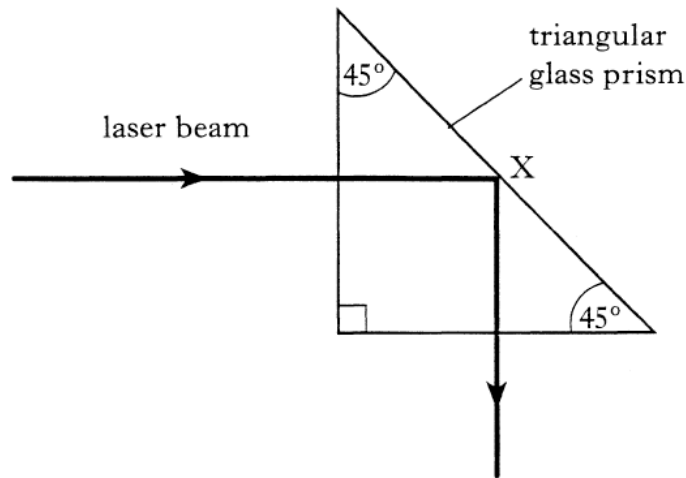
At one joint in the tube, the laser beam must change direction by 110° .



- (i) What is the angle of incidence of the laser beam at the mirror? **1**
- (ii) What is the angle of reflection of the laser beam at the mirror? **1**

29. (continued)

- (b) A student aims a laser beam at a triangular glass prism as shown. The beam changes direction at point X.



- (i) Name the optical effect which occurs at point X. 1
- (ii) Suggest a suitable value of the critical angle for the type of glass used for this prism. 2

You **must** explain your answer. 2

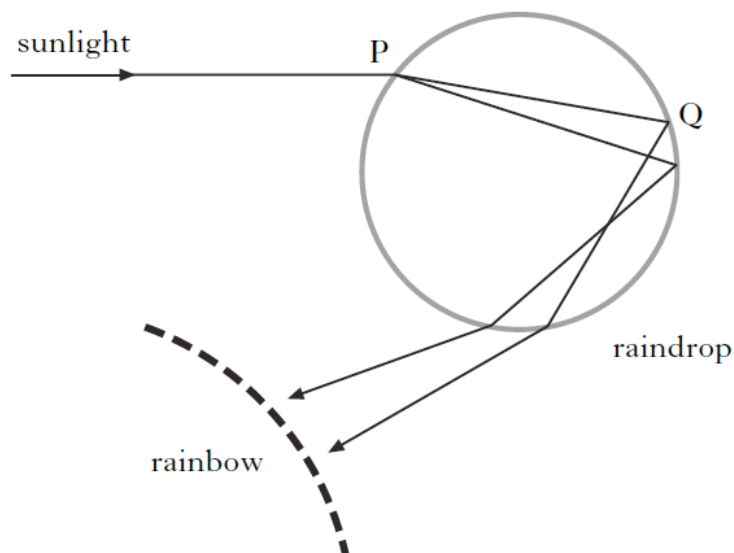
(5)

2007 Int 2

27. When the sun shines during a shower of rain, a rainbow can sometimes be seen.



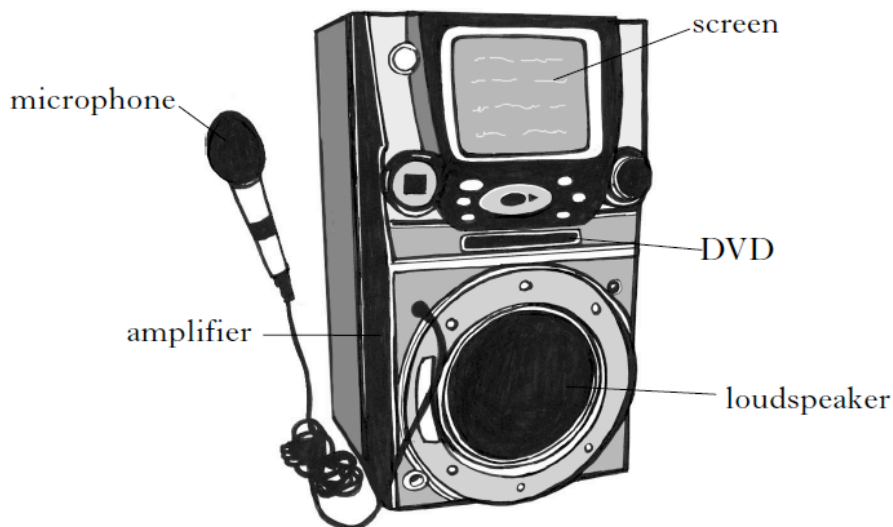
The diagram shows what happens to sunlight when it enters a raindrop.



- (a) (i) Name the wave effect that happens at point P. 1
- (ii) Name the wave effect that happens at point Q. 1
- (iii) Which colour of the rainbow has the longest wavelength? 1
- (b) As a raindrop falls it reaches a steady speed.
- Using Newton's laws of motion, explain why it falls at a steady speed. 2
- (5)**

2008 Int 2

26. A karaoke machine consists of a microphone, amplifier, loudspeaker, DVD player and screen.



(a) What energy change takes place in the microphone? 1

(b) The amplifier processes the signal from the microphone.

What effect does the amplifier have on the signal's

(i) frequency; 1

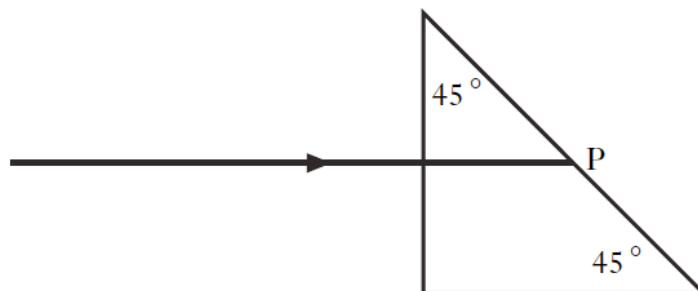
(ii) amplitude? 1

(c) A singer produces a note of frequency 850 Hz. The speed of sound in air is 340 m/s.

Calculate the wavelength of this note in air. 2

(d) The DVD player contains a laser.

Light from this laser enters a small glass prism as shown.



The glass has a critical angle of 40° .

(i) Explain what is meant by the term "critical angle". 1

(ii) Copy and complete the diagram to show the path of the ray after it strikes point P. 2

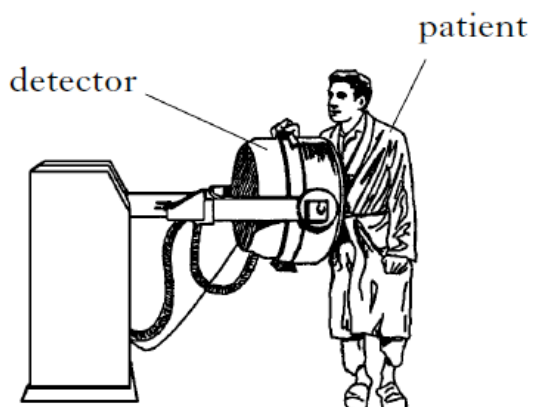
(8)

Nuclear Radiation

2000 Int 2

18. An atom of helium consists of electrons, neutrons and protons.
The nucleus contains
- A electrons only
 - B neutrons and electrons
 - C protons and electrons
 - D protons and neutrons
 - E protons, neutrons and electrons.
19. The activity of a radioactive source is measured in
- A joules
 - B becquerels
 - C sieverts
 - D grays
 - E watts.

20. A radioactive substance is to be injected into a patient so that blood flow can be monitored.



A number of different substances which emit either β or γ radiation are available.

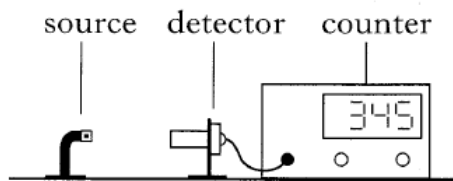
The substances have different half-lives.

Which substance, A, B, C, D or E is the most suitable?

<i>Substance</i>	<i>Radiation emitted</i>	<i>Half-life</i>
A	β	2 days
B	β	2 years
C	γ	2 seconds
D	γ	2 days
E	γ	2 years

2001 Int 2

19. Measurements of the count rate from a radioactive source were taken using the apparatus shown below.



A sheet of paper, 2 mm of aluminium and 15 mm of lead were placed in turn between the radioactive source and the detector.

Information about the count rate obtained with and without the absorbers is given in the following table.

<i>Absorber</i>	<i>Corrected count-rate</i> (counts per second)
none	80
1 sheet of paper	65
2 mm of aluminium	35
15 mm of lead	5

The radiation emitted by the source is

- A α only
- B β only
- C α and β only
- D β and γ only
- E α , β and γ .

20. Which row in the table below shows the correct units for activity and dose equivalent?

	<i>Activity</i>	<i>Dose equivalent</i>
A	becquerel	gray
B	becquerel	sievert
C	gray	sievert
D	gray	becquerel
E	sievert	gray

2002 Int 2

19. A student makes the following three statements.

- I Alpha particles produce much greater ionisation density than beta particles or gamma rays.
- II Alpha particles are fast moving electrons.
- III Alpha particles can be stopped by a piece of paper.

Which of these statements is/are correct?

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

20. Measurements are made of the absorbed dose and dose equivalent received by workers in the nuclear industry. The relationship between absorbed dose and dose equivalent is

A $Q = DH$

B $D = HQ$

C $H = DQ$

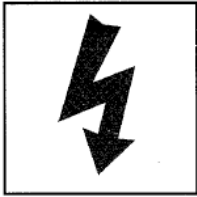
D $H = \frac{Q}{D}$

E $H = \frac{D}{Q}$

2003 Int 2

19. Which sign is used to indicate the presence of radioactive material?

A



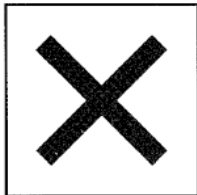
B



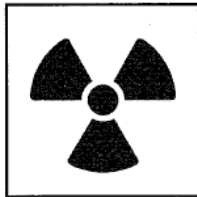
C



D



E



20. A student writes the following statements.

I Alpha radiation is part of the electromagnetic spectrum.

II Alpha radiation is more ionising than beta or gamma radiation.

III Alpha radiation is more penetrating than beta or gamma radiation.

Which of the statements is/are true?

A I only

B II only

C III only

D I and II only

E I and III only

18. An alpha particle has
- A the same mass as a helium nucleus, positive charge and is strongly ionising
 - B the same mass as an electron, negative charge and is weakly ionising
 - C the same mass as a helium nucleus, negative charge and is weakly ionising
 - D the same mass as an electron, negative charge and is strongly ionising
 - E the same mass as a helium nucleus, positive charge and is weakly ionising.
19. A patient's thyroid gland is exposed to radiation. Information about the radiation and the dose received by the gland is shown.

Absorbed dose = $500 \mu\text{Gy}$

Energy absorbed = $15 \mu\text{J}$

Quality factor = 20

The mass of the thyroid gland is

- A 0.01 kg
- B 0.03 kg
- C 0.04 kg
- D 0.33 kg
- E 0.75 kg.

20. The activity of a sample of a radioactive substance is 80 Bq. The half-life of the substance is 4 hours.

The time for the activity to fall to 10 Bq is

- A 4 hours
- B 6 hours
- C 8 hours
- D 12 hours
- E 20 hours.

2005 Int 2

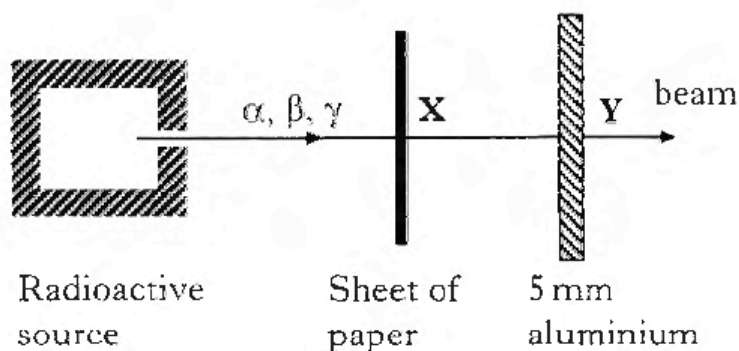
17. Which row correctly describes alpha, beta and gamma radiations?

	α	β	γ
A	electrons from the nucleus	helium nucleus	electromagnetic radiation
B	electromagnetic radiation	helium nucleus	electrons from the nucleus
C	helium nucleus	electromagnetic radiation	electrons from the nucleus
D	helium nucleus	electrons from the nucleus	electromagnetic radiation
E	electromagnetic radiation	electrons from the nucleus	helium nucleus

18. Which of the following increases the dose equivalent from a radioactive source?

- A Increasing distance
- B Handling with tongs
- C Standing beside it for a long time
- D Storing in a lead container
- E Storing under water

19. A radioactive source emits α , β and γ radiations in a beam as shown.



The main radiation(s) in the beam at **X** and **Y** are

	<i>Position X</i>	<i>Position Y</i>
A	α and β	β
B	β and γ	β
C	α and γ	γ
D	α and β	α
E	β and γ	γ

20. The following is an extract from a student's notes on nuclear fission.

- I The nucleus splits into two parts.
- II Neutrons are emitted.
- III Two nuclei join together.

Which of the statements is/are correct?

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

2006 Int 2

18. Below are three 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 harm from radiation is not the same for all types of tissue.

Which statement or statements is/are true?

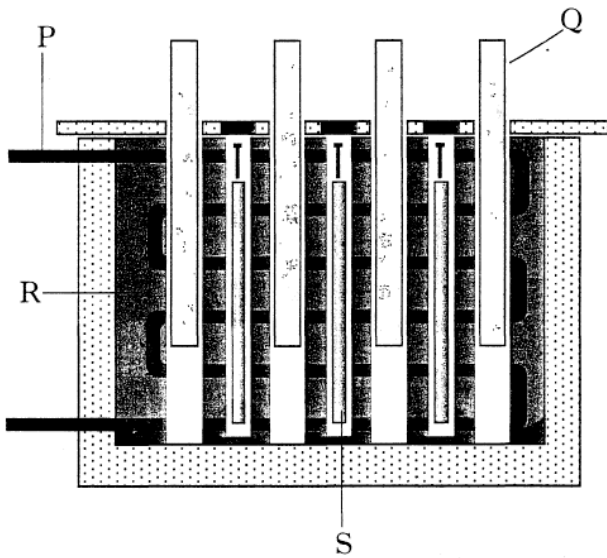
- A I only
 - B II only
 - C III only
 - D II and III only
 - E I, II and III
19. A worker in a nuclear power station is accidentally exposed to 3.0 mGy of gamma radiation and 0.50 mGy of fast neutrons.

The radiation weighting factor for gamma radiation is 1 and for fast neutrons is 10.

The total equivalent dose received by the worker, in mSv, is

- A 3.50
- B 8.00
- C 11.0
- D 35.0
- E 38.5.

20. The diagram shows a nuclear reactor in a power station.



Which row shows the parts of the reactor?

	P	Q	R	S
A	moderator	fuel rod	coolant	control rod
B	control rod	moderator	coolant	fuel rod
C	moderator	control rod	coolant	fuel rod
D	coolant	control rod	moderator	fuel rod
E	coolant	fuel rod	moderator	control rod

2007 Int 2

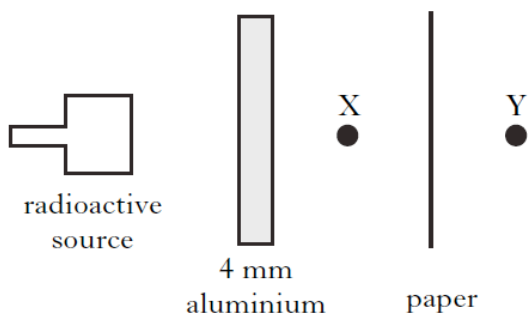
18. Which of the following statements is/are true about fission?

- I A large nucleus is split into two smaller nuclei.
- II Two smaller nuclei join together to form a larger nucleus.
- III Fission can result in a chain reaction.

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

19. 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?

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

20. Which of the following statements about the function of parts of a nuclear reactor is/are correct?

- I The coolant removes heat from the core of the reactor.
- II Control rods contain the fuel used for the nuclear reaction.
- III The moderator slows down neutrons.

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

2008 Int 2

17. Which row in the table describes an alpha particle, a beta particle and a gamma ray?

	<i>Alpha particle</i>	<i>Beta particle</i>	<i>Gamma ray</i>
A	neutron	helium nucleus	electromagnetic radiation
B	helium nucleus	electron	electromagnetic radiation
C	hydrogen nucleus	electromagnetic radiation	electron
D	helium nucleus	electromagnetic radiation	neutron
E	hydrogen nucleus	electron	electromagnetic radiation

18. For a particular radioactive source, 1800 atoms decay in a time of 3 minutes. The **activity** of this source is

- A 10 Bq
- B 600 Bq
- C 1800 Bq
- D 5400 Bq
- E 324 000 Bq.

19. One gray is equal to

- A one becquerel per kilogram
- B one sievert per second
- C one joule per second
- D one sievert per kilogram
- E one joule per kilogram.

20. A student makes the following statements about nuclear reactors.

- I Fission takes place in the fuel rods.
- II The material in the control rods slows down neutrons.
- III The material in the moderator absorbs neutrons.

Which of the statements is/are correct?

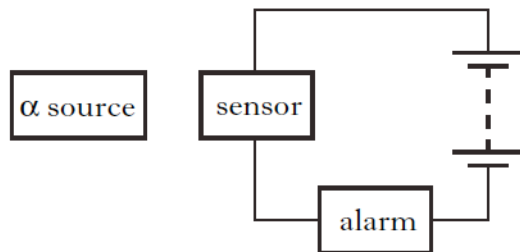
- A I only
- B I and II only
- C I and III only
- D II and III only
- E I, II and III

2000 Int 2

26. Some smoke alarms use a radioactive source which emits α -particles.

The detector operates because of ionisation caused by the α -particles in the space between the α source and the sensor.

If smoke or dust enters the space, the alarm operates.



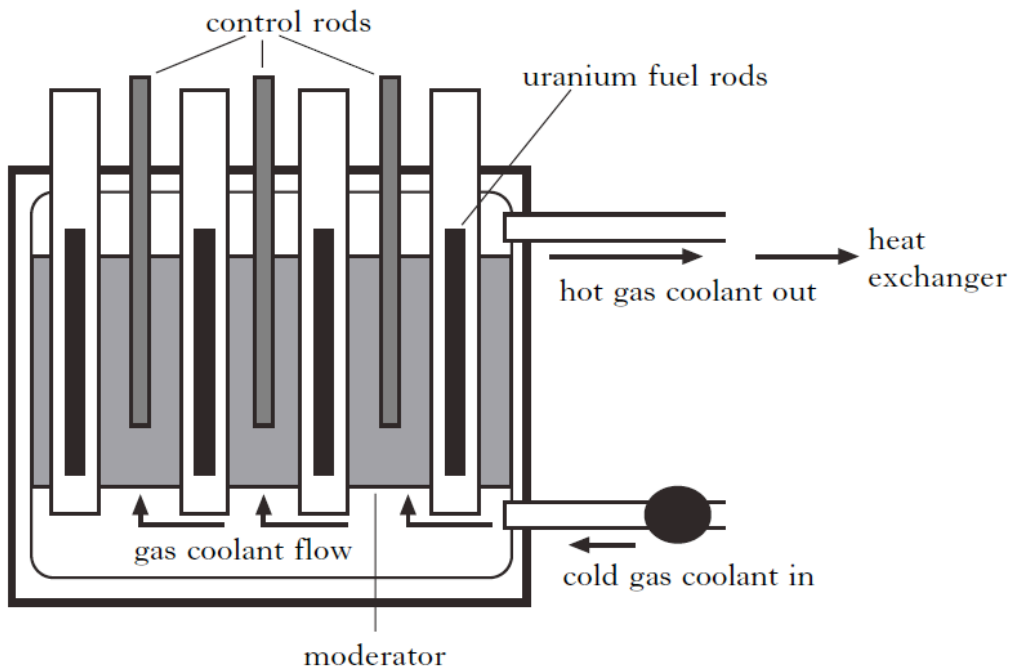
- (a) (i) What is an α -particle?
 (ii) What is meant by “ionisation”?
 (iii) Why is an α source used instead of a source which emits β -particles or γ -rays?
 (iv) The smoke alarm manufacturer has to choose from three α emitting sources. The half-life of each source is shown in the table.

<i>Source</i>	<i>Half-life</i>
A	4 hours
B	4 weeks
C	400 years

Which source should the manufacturer choose?
 Explain your answer.

5

30. A drawing of the core of a nuclear reactor is shown below.

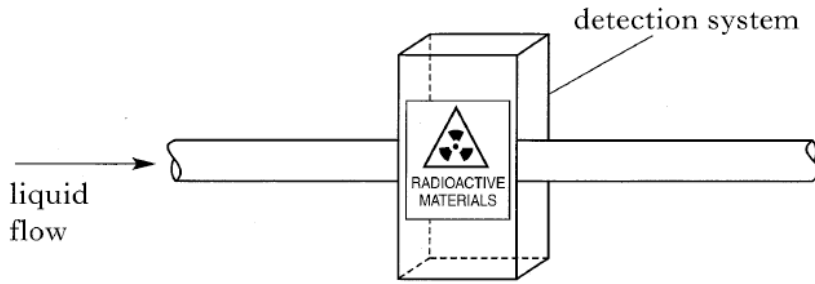


The fuel rods contain uranium-235.

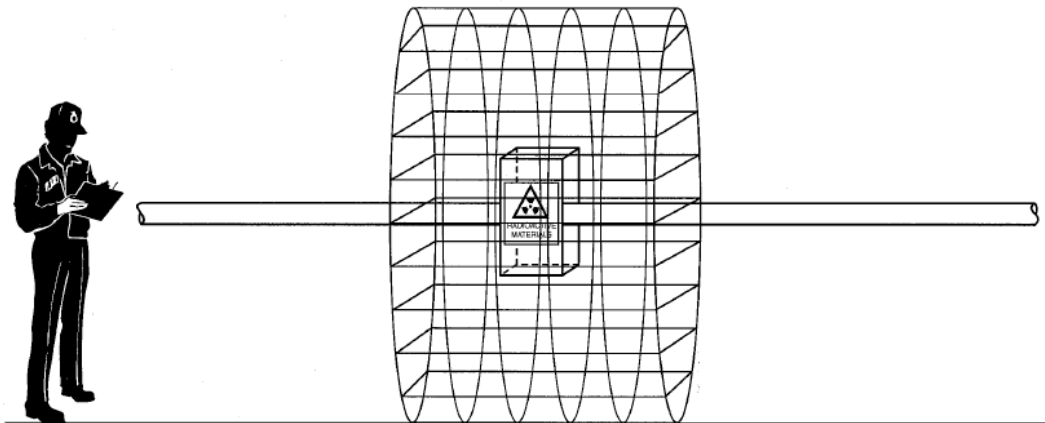
- (a) Describe what happens when a slow (thermal) neutron is absorbed by the nucleus of an atom of uranium-235. 2
- (b) The control rods are raised out of the core slightly.
Explain the effect of this action on the temperature of the coolant gas leaving the core of the reactor. 3
- (c) A research scientist at a nuclear reactor has a mass of 70.0 kg.
The scientist receives a dose equivalent of $336\mu\text{Sv}$ due to slow neutrons.
The energy absorbed by the scientist from the neutrons is $8.40 \times 10^{-3}\text{ J}$.
Calculate the quality factor for slow neutrons. 3
- (8)**

2001 Int 2

30. The oil industry uses radioactive sources to monitor the flow of liquids in pipes. The complete detection system is attached to the outside of the pipe as shown.

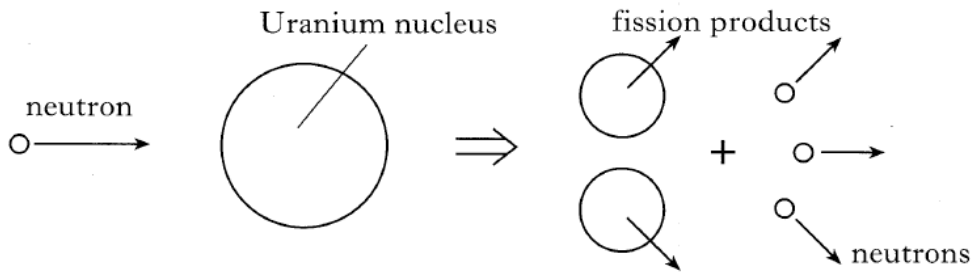


- (a) The source used has an activity of 1.11 GBq .
Explain what is meant by this statement. 2
- (b) A sample of tissue exposed to this radiation receives an absorbed dose of 0.13 mGy .
The quality factor of the radiation is 9. Calculate the dose equivalent for this sample. 2
- (c) The system is surrounded by a large cage as shown in the diagram.

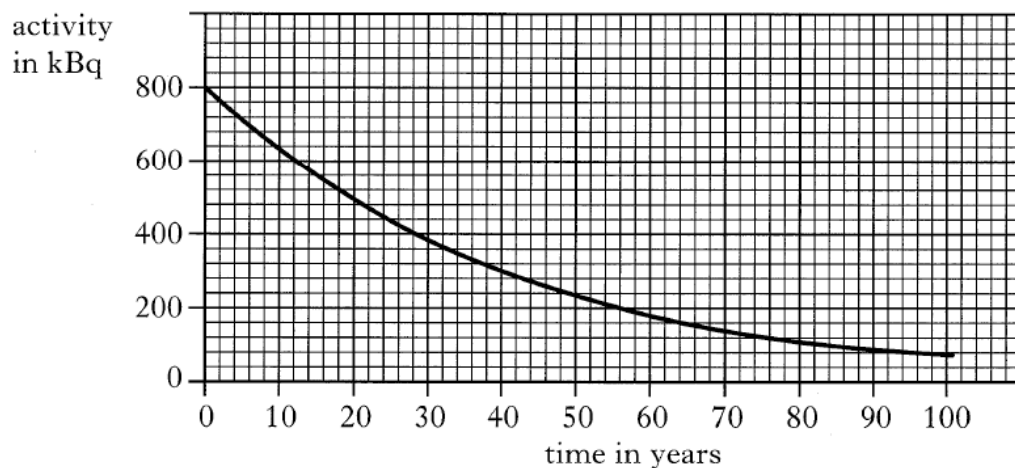


What is the purpose of this cage? 2
(6)

31. In a nuclear reactor, uranium nuclei are bombarded by neutrons. Fission products and additional neutrons are produced. Energy is also released.



- (a) In a reactor, what is the purpose of
- the coolant? 1
 - the moderator? 1
- (b) Explain how the additional neutrons can cause a chain reaction. 2
- (c) A graph of activity against time for a sample of one of the fission products is shown below.



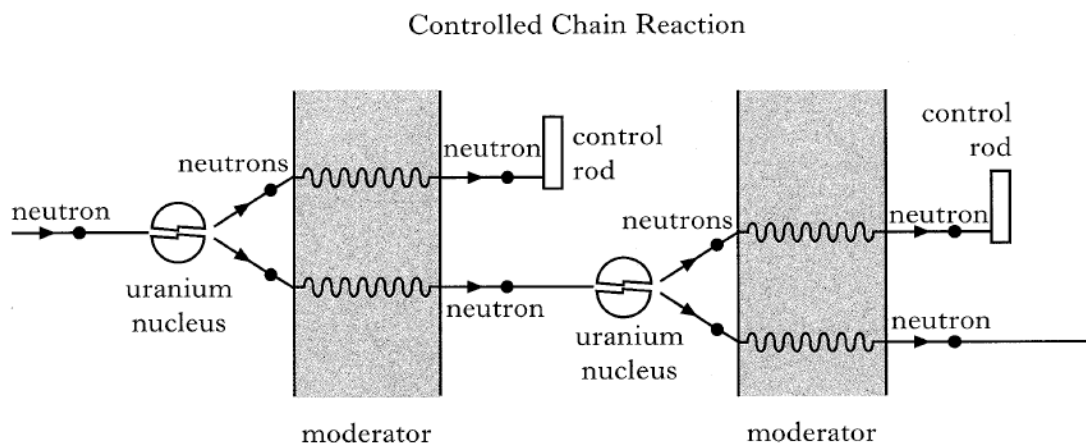
- From the graph, determine the half life of the fission product. 2
- A scientist states that the sample will be safe only when the activity falls to 120 kBq. How long will it take for the activity to fall to this level? 1
- State a suitable method of storing the sample during the time it takes for the activity to fall to the safe level. 1

(8)

30. The following table contains information about two radioactive sources used in medicine.

<i>Radioactive source</i>	<i>Activity (MBq)</i>	<i>Half-life (days)</i>
R	1600	8
S	80	74

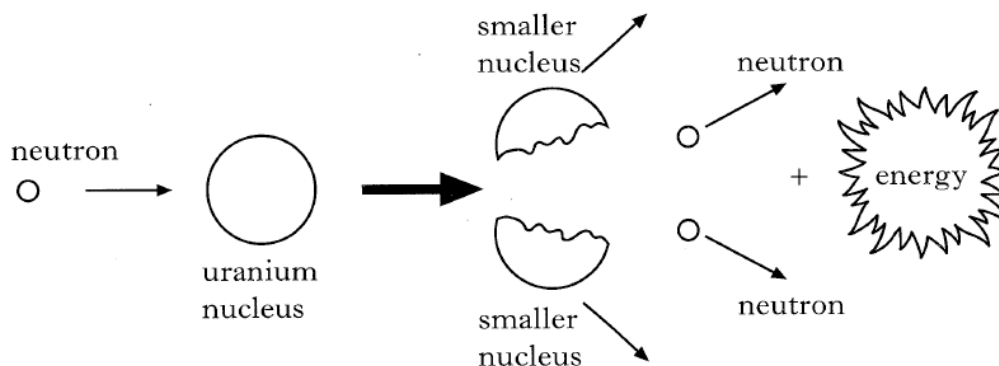
- (a) Calculate the number of decays of source R in 30 s. 2
- (b) These radioactive sources can be disposed of after their activity has fallen below 40 MBq.
Show, by calculation, which source, R or S, will be the first to reach an activity of 40 MBq. 3
- (c) State **two** safety precautions which should be taken when handling radioactive sources. 2
- (7)**
31. A simplified model of a controlled chain reaction in a nuclear reactor is shown below.



- (a) (i) Name the type of nuclear reaction that takes place in the reactor. 1
- (ii) State the purpose of the moderator. 1
- (iii) How could the chain reaction process be stopped? 1
- (b) State **one advantage** and **one disadvantage** of using nuclear power for the generation of electricity. 2
- (5)**

27. A student reads the following article about nuclear power.

“In a nuclear reactor, uranium nuclei in fuel rods are bombarded with neutrons. A uranium nucleus may absorb a neutron and then break up into two smaller nuclei releasing further neutrons and energy.”



- (a) (i) A **nucleus** contains 2 types of particle. Name these particles. 1
- (ii) What is the name given to the process shown in the diagram? 1
- (iii) Explain why fuel rods have to be replaced after a certain time. 1
- (iv) Explain why the fuel rods that are removed from the reactor are a safety hazard. 1
- (b) In a nuclear reactor, 166 MJ of energy is transferred to 2000 kg of coolant. All of this energy is absorbed by the coolant which has a specific heat capacity of 830 J/kg°C. Assuming the coolant does not change state, calculate the rise in temperature of the coolant. 2
- (6)**

30. Companies delivering radioactive sources have to follow strict safety rules. One rule is that sources must be labelled. The following information is displayed on a label on a radioactive source.

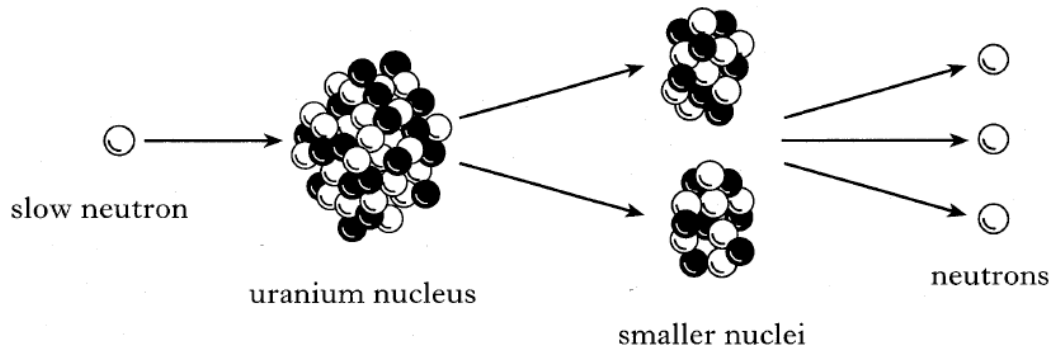
RADIOACTIVE SOURCE	
Source:	beta and gamma emitter
Year of delivery:	2003
Half life:	10 years
Activity:	20 000 Bq

- (a) (i) What is meant by the activity of a source? 1
- (ii) Calculate the activity of the source in year 2043. 2
- (b) After delivery, the source is placed in a thick walled aluminium storage box. Which type of radiation from the source, if either, could penetrate the storage box? You must explain your answer. 2
- (c) A technician handling an **alpha-emitting** source estimates that his hand receives an absorbed dose of 5×10^{-5} Gy. The mass of the technician's hand is 500 g.
- (i) Calculate the total energy absorbed by the technician's hand. 2
- (ii) Using information from the table below, calculate the dose equivalent received by his hand.

<i>Type of radiation</i>	<i>Quality factor</i>
Alpha	20
Beta	1
Gamma	1
X rays	1
Slow neutrons	2.3

2
(9)

30. In the reactor of a nuclear power station a uranium nucleus is bombarded by a slow neutron as shown below.



(a) State the name of this type of nuclear reaction. 1

(b) In this reaction neutrons are released.
Why are these neutrons important to the operation of the reactor? 1

(c) The reactor also contains boron control rods.
Explain the purpose of these rods. 1

(d) A worker in the power station is exposed to the following absorbed doses.
2.0 mGy of slow neutrons
5.0 μGy of fast neutrons

The table below gives quality factors of various types of radiations.

<i>Radiation</i>	<i>Quality factor</i>
X-rays	1
gamma rays	1
slow neutrons	3
fast neutrons	10
alpha particles	20

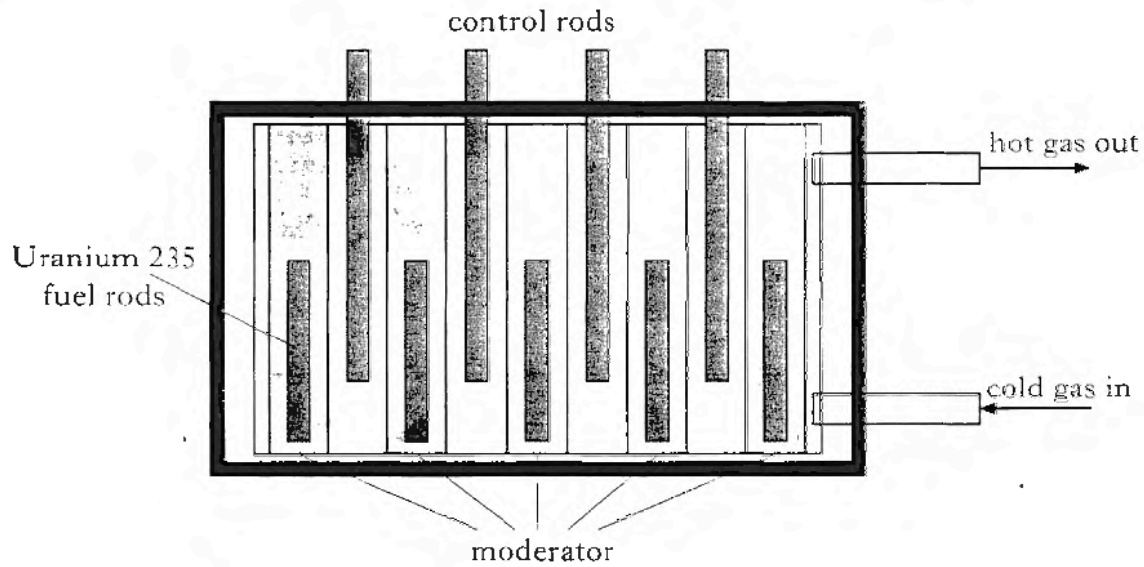
Calculate the total dose equivalent received by the worker. 3

(e) (i) State **one** advantage of using nuclear power for the generation of electricity. 1

(ii) State **one** disadvantage of using nuclear power for the generation of electricity. 1

(8)

31. A diagram of the core of a gas cooled nuclear reactor is shown below.

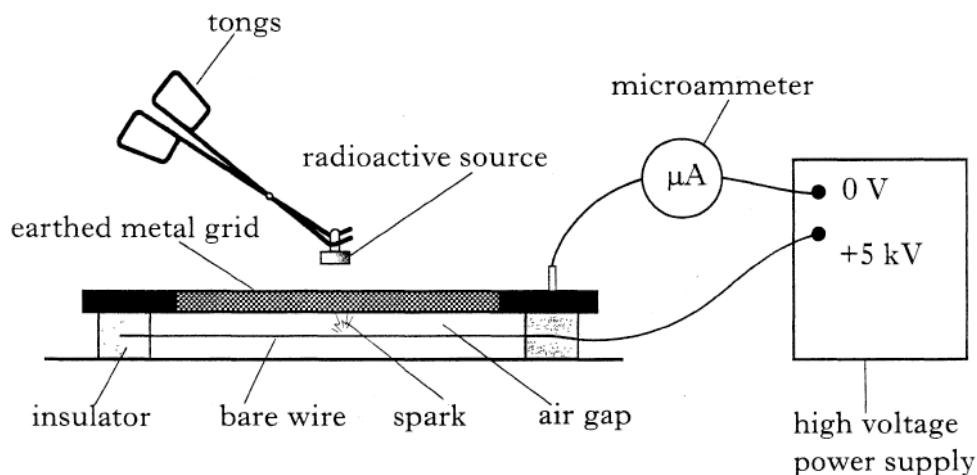


- (a) Explain the purpose of
- (i) the moderator 1
 - (ii) the control rods. 1
- (b) One of the waste products produced in the nuclear reactor is caesium.
 The caesium in the waste products removed from the reactor has an activity of 16×10^{12} Bq.
 Caesium has a half-life of 30 years.
- (i) State what is meant by the activity of a radioactive source. 1
 - (ii) State what is meant by the half-life of a radioactive source. 1
 - (iii) Calculate the activity of the caesium 150 years after its removal from the reactor. 2
- (c) A worker at the nuclear power station has a mass of 90 kg and receives a dose equivalent of $276 \mu\text{Sv}$ from slow neutrons. The quality factor for slow neutrons is 2.3.
- (i) What does the quality factor tell us about a radiation? 1
 - (ii) How much energy has the worker absorbed from the slow neutrons? 3
- (10)**

2006 Int 2

30. A spark counter consists of a thin bare wire at a high voltage, mounted on insulators beneath an earthed metal grid. There is an insulating air gap between the wire and the grid. The apparatus is connected to a sensitive microammeter and a high voltage supply as shown. The voltage of the supply is 5 kV.

When a student brings a radioactive source close to the spark counter, the air between the wire and grid is ionised and sparks jump between the wire and the grid.



- (a) The radioactive source emits alpha particles and beta particles.
State what is meant by:
- (i) an alpha particle; 1
 - (ii) a beta particle. 1
- (b) The student finds that if the source is 3 cm from the grid, there is almost continuous sparking. When the distance is increased to 6 cm, there are very few sparks.
- (i) Explain what is meant by *ionisation*. 1
 - (ii) Which of the two types of radiation in (a) above is more effective at producing sparks? Explain your answer using the student's results. 2
- (c) The student now fixes the source 5 cm above the grid. Over a period of 1 minute, the student counts 87 sparks. During this period the average reading on the microammeter is $0.29 \mu\text{A}$.
- Calculate the average quantity of charge which is transferred from the wire to the grid by each spark. 3

(8)

31. The table shows properties of some isotopes of the element iodine.

<i>Isotope</i>	<i>Radiation emitted</i>	<i>Half-life</i>
Iodine-127	none	–
Iodine-128	beta	25 minutes
Iodine-129	beta	16 million years
Iodine-131	beta	8.1 days
Iodine-135	beta	6.7 hours

(a) Explain what is meant by the term *half-life*. 1

(b) The activity of a sample of iodine-131 is 56.0 MBq.
How long will it take for its activity to reach 1.75 MBq? 2

(c) A patient suffers from cancer of the thyroid gland. This cancer is treated with an injection of a radioactive iodine isotope, which becomes concentrated in the thyroid gland. The thyroid receives a large dose of radiation for several hours, but surrounding tissues receive much less. Next day, when the activity of the isotope has decreased to a safe level, the patient can return home.

Which of the above isotopes would be the most suitable to treat the patient?

Explain your answer. 2

(d) Iodine is a necessary mineral in the diet. Some people do not receive sufficient iodine in their diet to remain healthy.

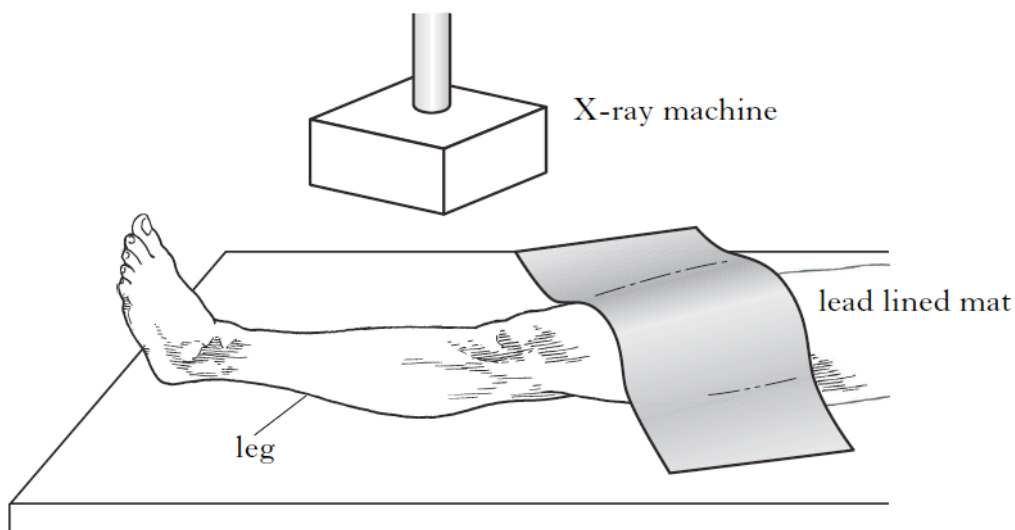
Which of the above iodine isotopes should be given to such people to supplement their diet?

Explain your answer. 2

(7)

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29. A football player injures his leg while playing in a match.

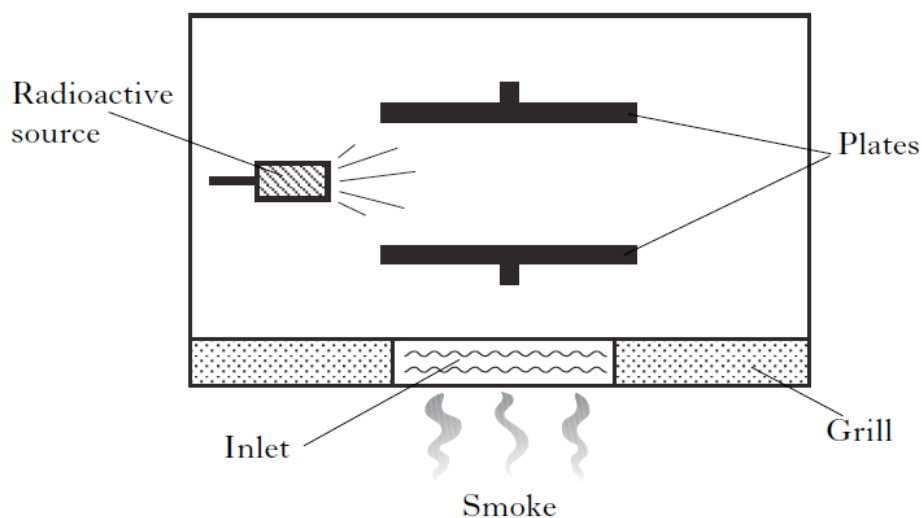


In hospital the player has three X-rays, each producing an absorbed dose of $50\mu\text{Gy}$.

- (a) The mass of the player's leg is 6 kg. Calculate the energy absorbed by the leg from the X-rays. 2
- (b) Why is the rest of the player's leg covered with a lead lined mat? 1
- (c) Apart from absorbed dose, name **one** other factor that contributes to biological harm. 1

(4)

30. A simplified diagram of a smoke detector is shown. Radiation from the source causes ionisation of the air molecules between the plates. This produces a small current in a circuit. When smoke particles pass between the plates, the current decreases and a buzzer sounds.



- (a) (i) What is meant by *ionisation*? 1
- (ii) Should the source be an alpha, beta or gamma emitter?
Explain your answer in terms of ionisation. 2
- (iii) A manufacturer is choosing a new source for its smoke detectors. From the following information, select the most suitable source to use.
Explain your answer. 2

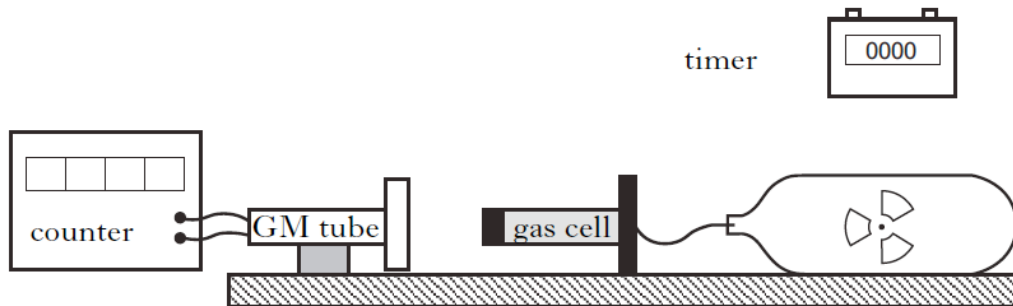
<i>Source</i>	<i>Half-life (years)</i>	<i>Range (metres)</i>
W	1	0.05
X	10	2.0
Y	100	0.05
Z	1000	2.0

- (b) The smoke detector circuit contains a 9 V battery. When there is no smoke present the operating current in the circuit is 30 mA.
- (i) Calculate the resistance of the circuit. 2
- (ii) State the energy change which takes place in the buzzer. 1

(8)

31. An experiment is carried out in a laboratory to determine the half-life of a radioactive source. A Geiger-Müller tube and counter are used to measure the background radiation over a period of 10 seconds. This is repeated several times and an average value of 4 counts in 10 seconds is recorded.

The apparatus shown is used to measure the count rate over a period of time. The readings are corrected for background radiation.



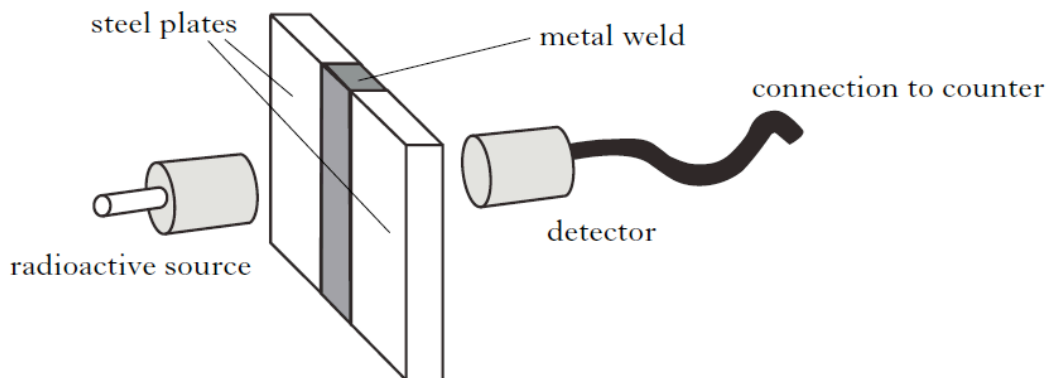
<i>Time (minutes)</i>	<i>Corrected count rate</i>
0	168
2	120
4	84
6	60
8	42
10	30
12	21

- (a) Name **two** factors that affect the background count rate. 2
- (b) Calculate the activity of the background radiation. 2
- (c) Calculate the half-life of the radioactive source. 2
- (6)**

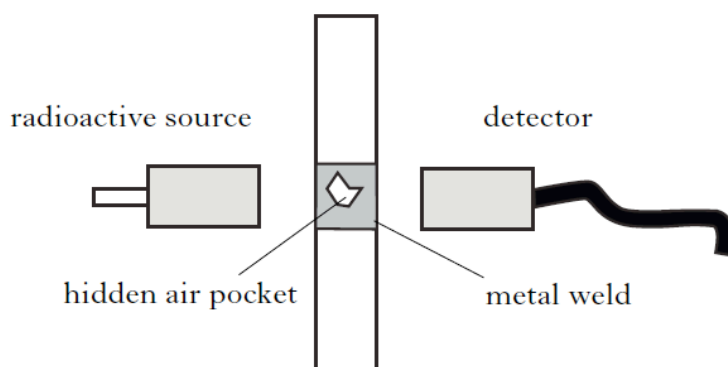
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30. When welders join thick steel plates it is important that the joint is completely filled with metal. This ensures there are no air pockets in the metal weld, as this would weaken the joint.

One method of checking for air pockets is to use a radioactive source on one side of the joint. A detector placed as shown measures the count rate on the other side.



View from above



- (a) The radioactive source and detector are moved along the weld. How would the count rate change when the detector moves over an air pocket?

Explain your answer.

2

- (b) Which of the radiations alpha, beta or gamma must be used?

Explain your answer.

2

- (c) X-rays are sometimes used to detect air pockets.

How does the wavelength of X-rays compare with gamma rays?

1

(5)

31. Gold-198 is a radioactive source that is used to trace factory waste which may cause river pollution.

A small quantity of the radioactive gold is added into the waste as it enters the river. Scanning the river using radiation detectors allows scientists to trace where the waste has travelled.

Gold-198 has a half-life of 2.7 days.

- (a) What is meant by the term “half-life”? 1
- (b) A sample of Gold-198 has an activity of 64kBq when first obtained by the scientists.
Calculate the activity after 13.5 days. 2
- (c) Describe two precautions taken by the scientists to reduce the equivalent dose they receive while using radioactive sources. 2
- (d) A scientist receives an absorbed dose of 10 mGy of alpha radiation.
- (i) Calculate the equivalent dose received. 2
- (ii) The risk of biological harm from radiation exposure depends on the absorbed dose and the type of radiation. Which other factor affects the risk of biological harm? 1
- (8)**