N4 N5

Physics department

Unit 3 Waves and Radiation

Homework Questions

Wave Characteristics Ex1

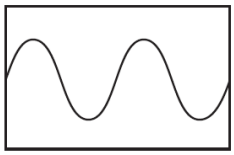
1. What is the frequency of a wave, if 20 crests pass a point in two seconds?

A 0.1 hertz
B 2 hertz
C 10 hertz
D 20 hertz
E 40 hertz

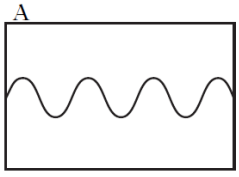
2. Which of the following will **not allow** the transmission of sound waves?

A Brick
B Vacuum
C Water
D Air
E Wood

3. When a student whistles a note into a microphone connected to an oscilloscope, the following pattern is displayed.



Without changing the oscilloscope controls, another student whistles a quieter note of higher frequency into the microphone. Which of the following shows the pattern which would be displayed on the screen?

A


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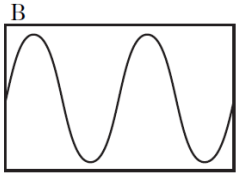

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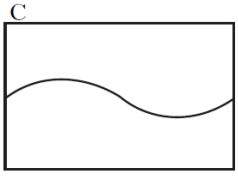

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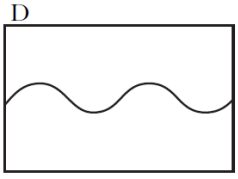

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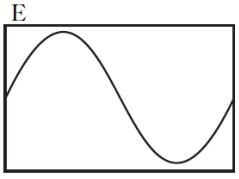
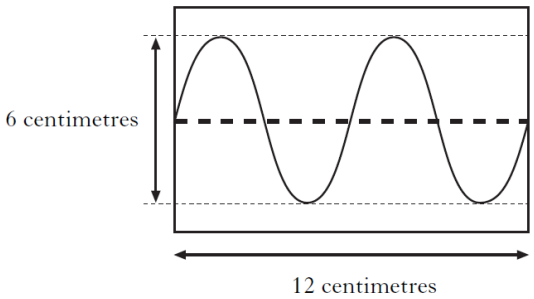


4. Electrical signals are displayed as waves on an oscilloscope.



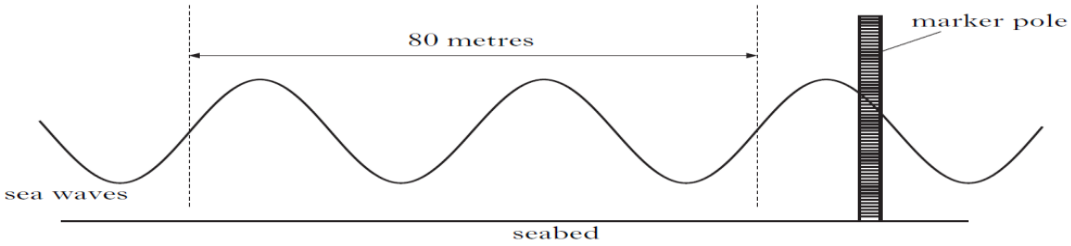
(a) Calculate the wavelength of the waves.

(b) Calculate the amplitude of the waves.

Wave Characteristics Ex2

1. A surfer rides the waves near a beach.

(a) The diagram below shows a wave some distance from the beach.

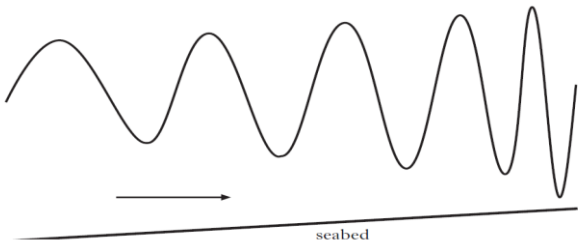


(i) Using information from the diagram, calculate the wavelength of the wave.

(ii) The time between one crest and the next crest passing the marker pole is 5 seconds. Calculate the speed of the wave.

(iii) Calculate the frequency of the wave.

(*b*) The drawing below shows changes in the wave as it approaches the beach.

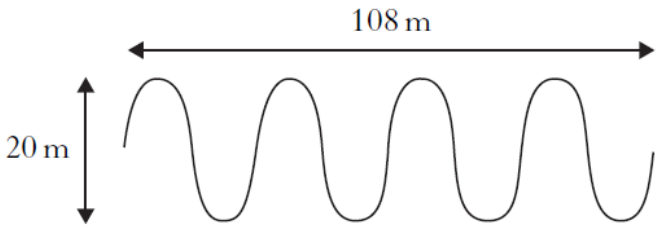


Complete the sentences below by choosing the correct answers.

(i) As the wave approaches the beach,
its wavelength { decreases / increases / stays the same } .

(ii) As the wave approaches the beach,
its amplitude { decreases / increases / stays the same } .

2. The diagram below 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?
A I only
B II only
C I and III only
D II and III only
E I, II and III

Wave Characteristics Ex3

1. 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?

(b) Calculate the wavelength of the signal

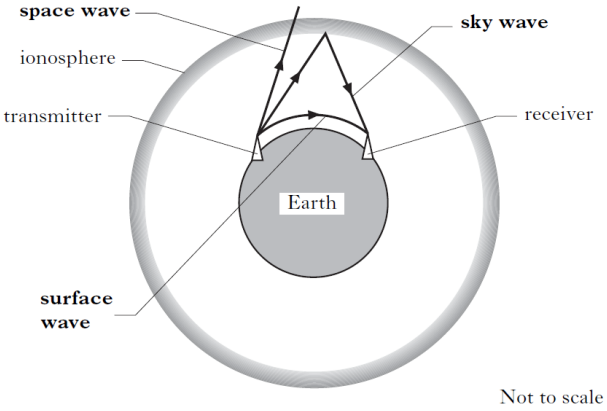
(c) The pupil sends a video message from the mobile phone. The message is transmitted by microwaves. The message travels a total distance of 72 000 km.
Calculate the time between the message being transmitted and received.

2. Radio waves have a wide range of frequencies. The table gives information about different wavebands.

Waveband	*Frequency Range*	*Example*
Low frequency (LF)	30 kHz – 300 kHz	Radio 4
Medium frequency (MF)	300 kHz – 3 MHz	Radio Scotland
High frequency (HF)	3 MHz – 30 MHz	Amateur radio
Very high frequency (VHF)	30 MHz – 300 MHz	Radio 1 FM
Ultra high frequency (UHF)	300 MHz – 3 GHz	BBC 1 and ITV
Super high frequency (SHF)	3 GHz – 30 GHz	Satellite TV

(a) Coastguards use signals of frequency 500 kHz. What waveband do these signals belong to?

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



i. Which of the waves in the diagram shows diffraction?

ii. What does this indicate about the wavelength of the diffracted wave compared to the other two waves?

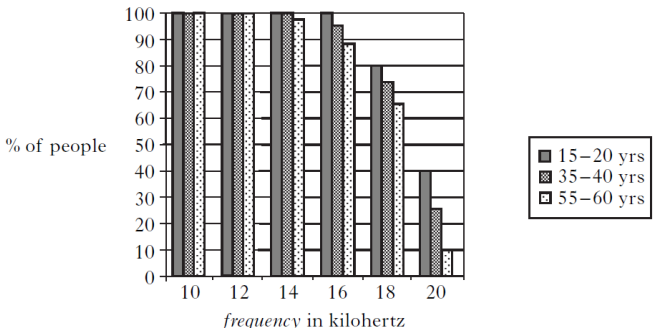
iii. The Earth's ionosphere is shown on the diagram. The ionosphere is a layer of charged particles in the upper atmosphere. High frequency waves are transmitted as sky waves. Explain how the transmitted waves reach the receiver.

iv. 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

Sound Waves Ex1

1. (a) A drummer in a rock band is exposed to sound levels of up to 110 decibels. Explain why ear protectors are used to reduce the sound level experienced by the drummer.

b) A medical researcher is measuring the upper range of hearing of people in different age groups. The bar graph shows the frequencies of sound detected by these people.



(i) State **two** conclusions which can be made from this bar graph about the hearing of different age groups.

(ii) What name is given to sound frequencies greater than 20 kilohertz?

2. An orchestra uses many different musical instruments.

The table lists the lowest and highest sound frequencies for some of these Instruments

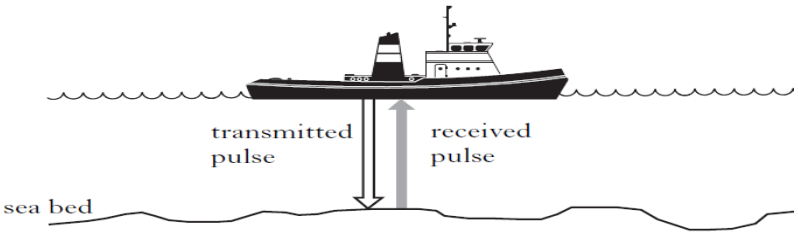
Musical Instrument	*Lowest Frequency* (hertz)	*Highest Frequency* (hertz)
Acoustic Guitar	73	1174
Piano	28	4186
Flute	261	2637
Trumpet	165	1046
Violin	196	3520
Cello	65	660
Piccolo	523	4000

(a) (i) Which instrument in the table produces the longest wavelength?

(ii) Calculate the wavelength for the lowest frequency of a piccolo.
(The speed of sound in air is 340 metres per second.)

(b) During one concert performance the sound level was measured.
State the unit of sound level measurement.

3. 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.



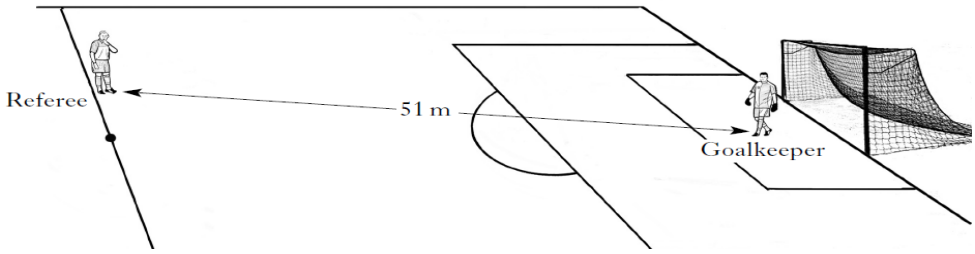
(a) What is meant by ultrasound?

(b) What is the speed of ultrasound waves in water?

(c) One pulse of ultrasound is received back at the ship 0.36 s after being transmitted.
Calculate the depth of the sea bed?

Sound Waves Ex2

1. At the kick-off in a football match, during the World Cup Finals, the referee blows his whistle. The whistle produces sound waves.



(*a*) Using information from the diagram and the data sheet, calculate the time taken for the sound waves to reach the goalkeeper.

(*b*) (i) Are sound waves transverse or longitudinal waves?
(ii) Describe **two** differences between transverse and longitudinal waves.
(iii) What is transferred by waves?

2. A student uses a sound level meter to measure some sound levels. The student records the results in the table.

Source of sound	*Sound level* (decibels)
school bell at 1 metre	100
inside a classroom	60
normal conversation	50
whisper	20

(*a*)

i. Humans can only hear sounds above a certain sound level. What is the value of this sound level in decibels?

ii. When one source of sound is twice as loud as another, the sound level increases by 10 decibels. Which one of the **above sources** is twice as loud as the level of a normal conversation?

b) The student measures the sound levels from earphones connected to an MP3 player.

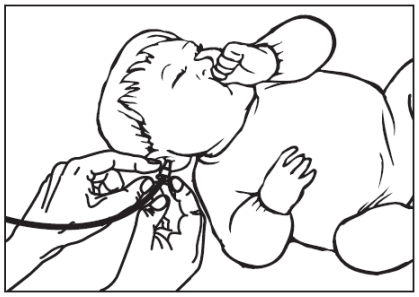
Sound levels up to 102 decibels are measured. Explain why the student should reduce the sound level to below 80 decibels before wearing the earphones.

(*c*) The student now measures the range of sound frequencies that humans can hear.

(i) What name is given to high frequency sounds beyond the range of human hearing?

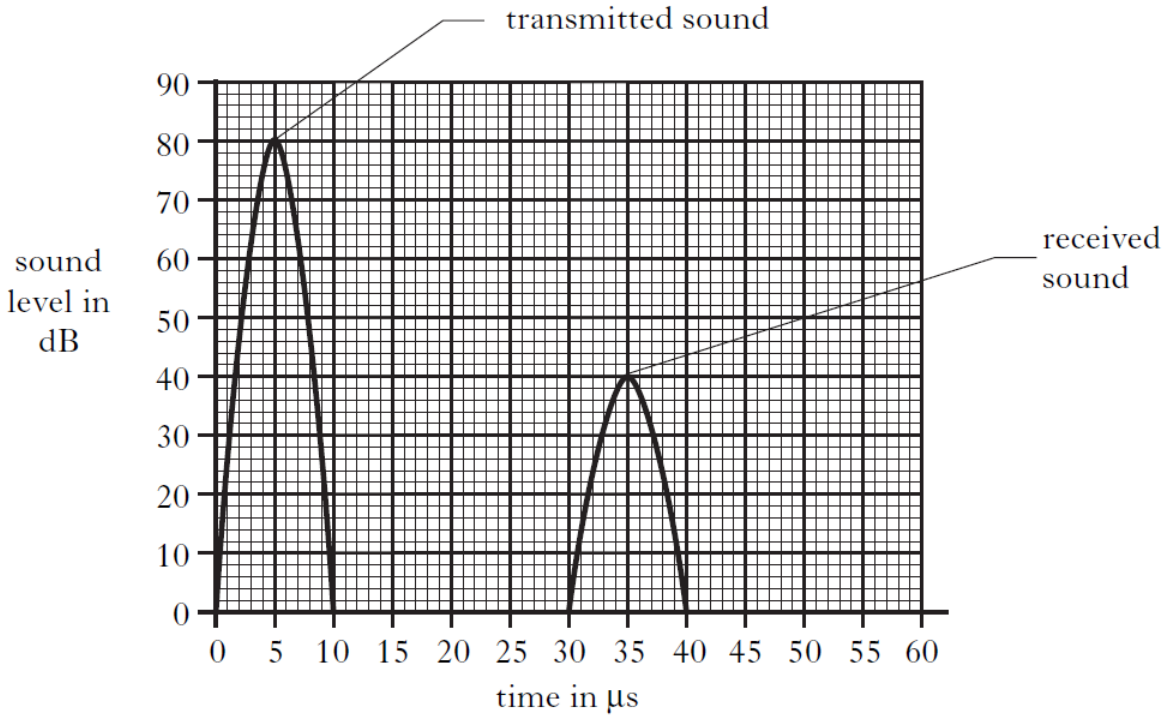
(ii) Give **one** example of a use of these high frequency sounds in medicine.

3. A newborn baby is given a hearing test. A small device, containing a loudspeaker and a microphone, is placed in the baby's ear.



(a) A pulse of audible sound lasting 10s is transmitted through the loudspeaker. The sound is played at a level of 80dB. Give a reason why this pulse of sound does not cause damage to the baby's hearing.

(b) The transmitted pulse of sound makes the inner ear vibrate to produce a new sound, which is received by the microphone. Signals from the transmitted and received sounds are viewed on an oscilloscope screen, as shown below.



i. The average speed of sound inside the ear is 1500 m/s. Calculate the distance between the device and the inner ear.

ii. Suggest a frequency that could be used for the hearing test.

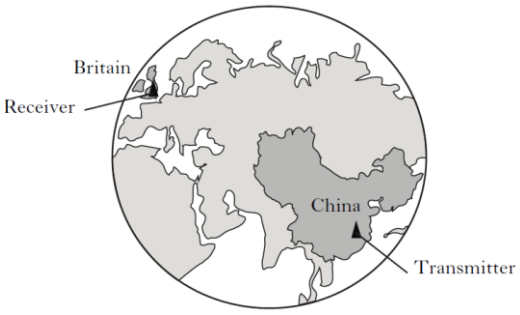
iii. An ultrasound scan can be used to produce an image of an unborn baby. Explain how the image of an unborn baby is formed by ultrasound.

Sound Waves Ex3

1. A television company is making a programme in China. Britain receives television pictures live from China. The television signals are transmitted using microwaves. The microwave signals travel from China **via** a satellite, which is in a geostationary orbit.

   a) State what is meant by a geostationary orbit.

   b) The diagram shows the position of the transmitter and receiver. Complete the diagram to show the path of the microwave signals **from** China **to** Britain.

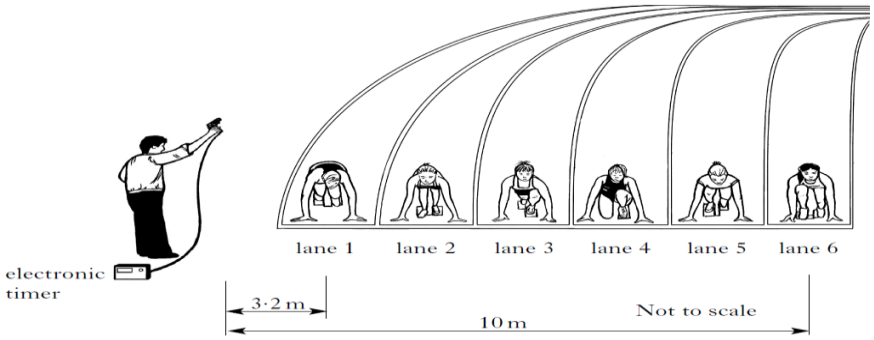


   c) **The frequency of the microwave signals being** used for transmission is 8 GHz.

      i) What is the speed of the microwaves?

      ii) Calculate the wavelength of these microwaves.

2. 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 3.2m from the starting pistol. The runner in lane 6 is 10 m from the starting pistol

a) 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.

b) A sensor detects each runner crossing the finishing line to record their time.
The table gives information about the race.

Place	*Lane*	*Time* (s)
1st	1	13·11
2nd	6	13·12
3rd	3	13·21

Using your answer to part (*a*), explain why the runner in lane 6 should have been awarded first place.

3. A Guitar tuner is used to measure the frequency of six guitar strings. The number and frequency of each string is given in the table below.

Number of string	*Frequency* (Hz)
1	330·0
2	247·0
3	196·0
4	147·0
5	110·0
6	82·5

The tuner has an output socket which has been connected to an oscilloscope. The trace for string 5 is shown in Figure 1.

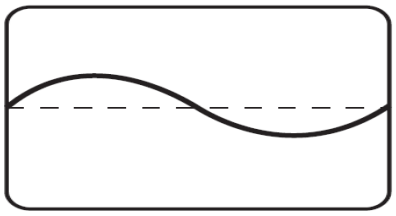


Figure 1

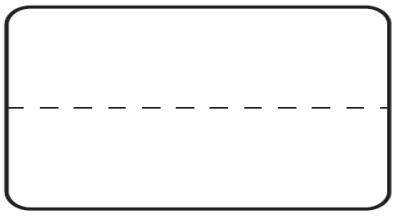


Figure 2

(i) The controls of the oscilloscope are **not** altered. Copy Figure 2 into your jotter, draw the trace obtained if string 1 is played **louder** than string 5.

(ii) String 3 is plucked. What is the frequency of the output signal from the amplifier if the gain is set at 150?

4. The controls of the signal generator are set up to produce a sound wave from the loudspeaker. An oscilloscope is now connected across the loudspeaker.
The oscilloscope trace is shown in Figure 1. Complete Figure 2 to show the trace obtained when the frequency is **doubled**, but the amplitude remains unchanged.
The oscilloscope controls are unchanged

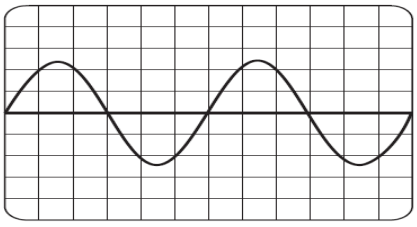


Figure 1

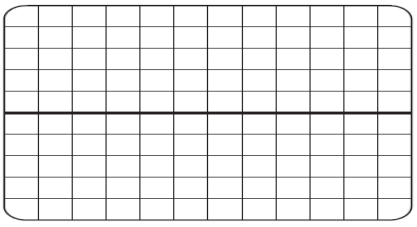
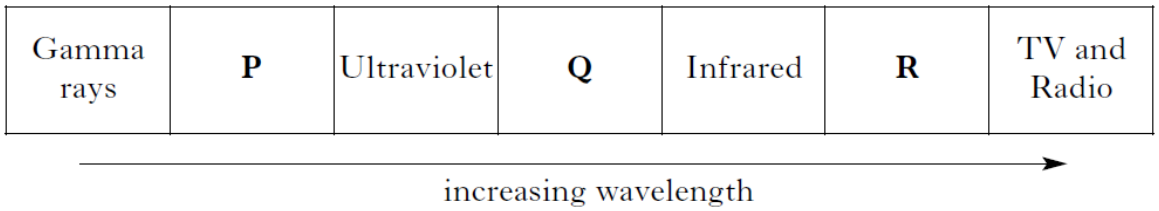


Figure 2

EM Spectrum Ex1

1. The diagram represents the electromagnetic spectrum in order of increasing wavelength. Some of the radiations have not been named.

Electromagnetic Spectrum



(*a*) (i) Name radiation: **P** .....

Q .....

R .....

(ii) Which radiation in the electromagnetic spectrum has the highest frequency?

.....

(*b*) Stars emit **ultraviolet** and **infrared** radiation.

Name a detector for **each** of these two radiations.

Infrared.....

Ultraviolet.....

2. The electromagnetic spectrum is shown below.

radio & tv	microwaves	infrared	visible light	ultraviolet	X-rays	gamma rays

electromagnetic spectrum

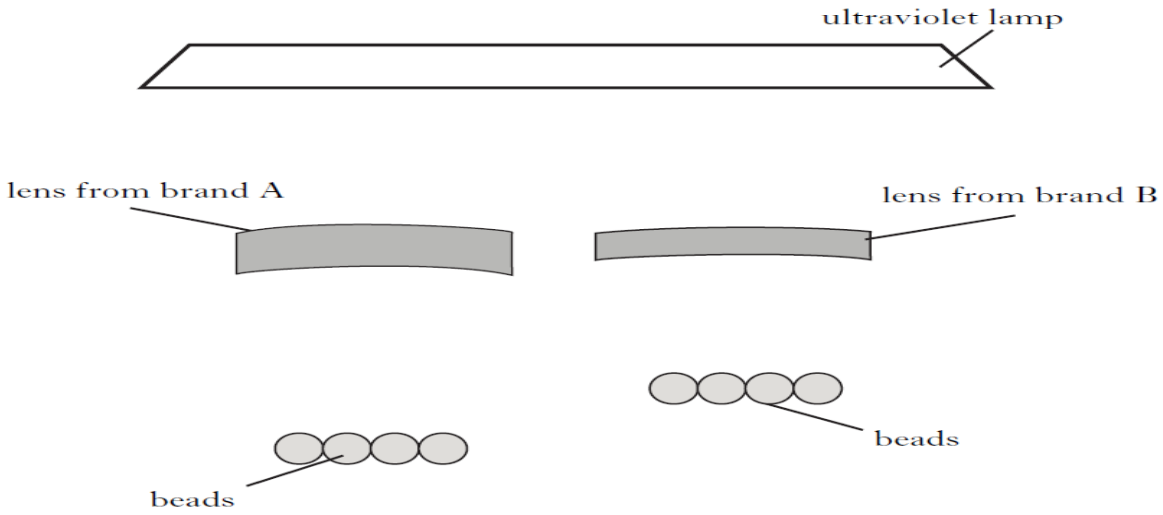
Different types of waves in the spectrum are used in medicine.

a) What property do all electromagnetic waves have in common?
b) Describe **one** use of X-rays in medicine
c) Gamma radiation is used in medicine as a tracer. A tracer is a radioactive substance injected into the body. The gamma radiation then given off from the body is monitored

i. Explain why gamma radiation is used rather than alpha or beta radiation.
ii. What is the unit for the activity of the gamma radiation?

d) Light can be produced by lasers. Describe the use of the laser in **one** application of medicine

e) A student sets up the following experiment to compare how two different brands of sunglasses protect from ultraviolet radiation. The student uses beads which change colour when exposed to ultraviolet radiation. The student covers one set of beads with a lens from brand A and another with a lens from brand B. The ultraviolet lamp is switched on for 30 minutes. The apparatus is set up as shown.



(i) Give **one** reason why this test is not a fair one.
(ii) Why can exposure to ultraviolet radiation be harmful to humans?

EM Spectrum Ex2

1. Different types of radiation are used to detect and treat illnesses and injuries. Four of these radiations are;

infrared	laser light	ultraviolet	X-rays

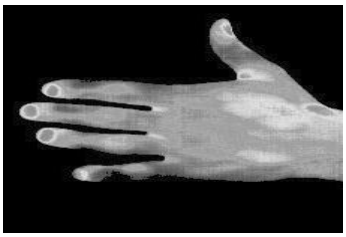
(a) What type of radiation is used to treat skin conditions such as acne?

(*b*)

(i) State **one** medical use of X-rays.

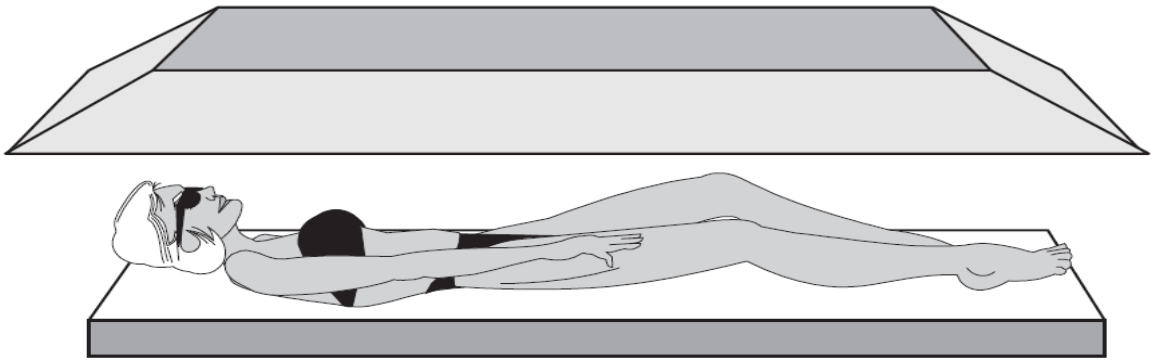
(ii) What can be used to detect X-rays?

(*c*)



Colour photographs called thermograms are used to find the temperature variation in a patient's body. Name the radiation used to make thermograms.

(*d*)



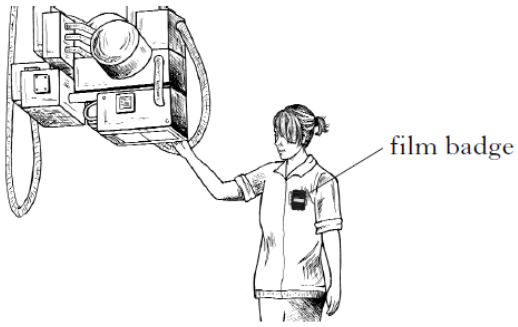
Explain why people need to be protected from overexposure to ultraviolet radiation.

2. Read the following passage.

In a hospital, a new digital X-ray imaging system is being used to replace photographic film. In the digital system, X-rays are detected by sensors and an image displayed on a computer screen. Photographic film, which contains silver, is expensive and hazardous chemicals are used to develop the film. The digital system is less expensive, does not use hazardous chemicals and the X-ray image is obtained in a shorter time.

a) Using information **given in the passage** state **two** advantages of the digital X-ray imaging system.

(b) (i) Hospital staff who operate X-ray machines wear film badges.



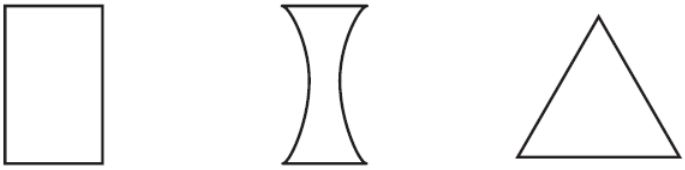
A film badge contains photographic film sealed in a plastic holder. Light cannot enter the film badge. What effect does X-ray radiation have on photographic film?
ii) Suggest a reason why hospital staff wear film badges

(c) Another imaging system makes use of the invisible heat rays given out by the human body. The images produced by this system are called thermograms.

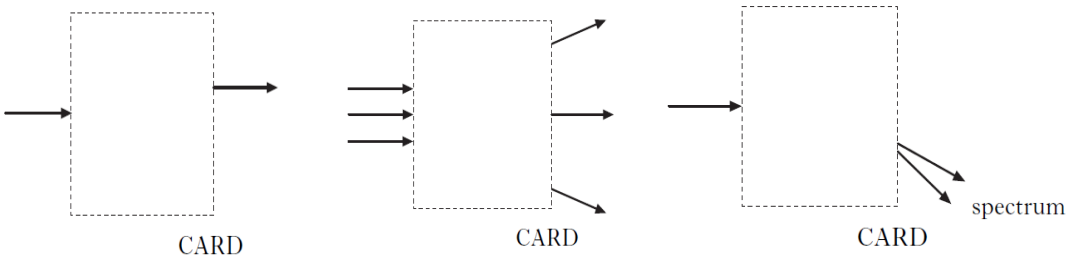
State the radiation used to make thermograms

Light Ex1

1. A class investigates the effects of the following shapes of glass on rays of white light



The teacher sets up three experiments, covering the glass shape with card. The paths of the light rays entering and leaving the different shapes of glass are shown. For each of the three experiments, draw the **shape** and **position** of the glass block that was used.



2. A short-sighted person has difficulty seeing the picture on a cinema screen. Figure 1 shows rays of light from the screen entering an eye of the person until the rays reach the retina.

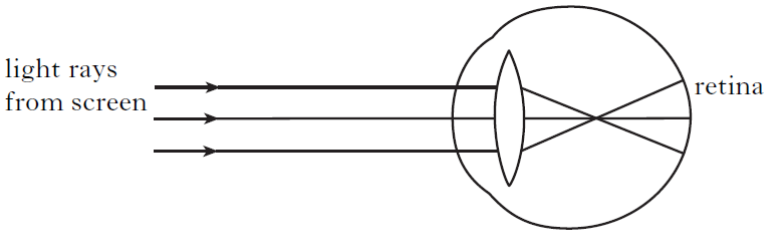


Figure 1

(a) (i) In the dotted box in Figure 2, draw the shape of lens that would correct this eye defect.

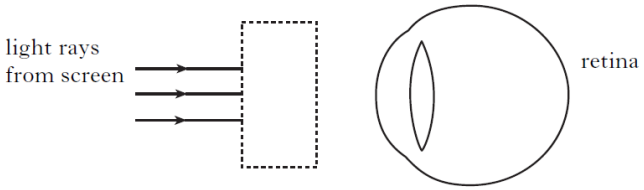
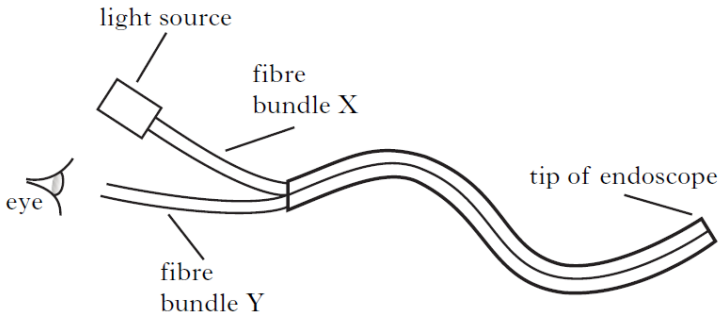


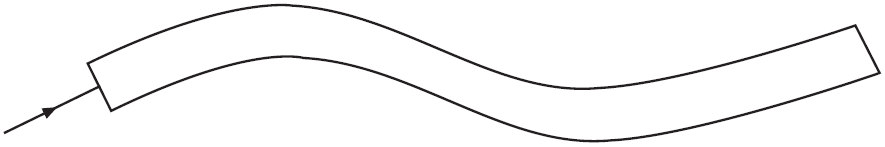
Figure 2

(ii) In Figure 2, complete the path of the rays of light from this lens until they reach the retina.

(iii) Doctors can use an endoscope to examine internal organs of a patient. The endoscope has two separate bundles of optical fibres that are flexible.



3. A section of optical fibre used in the endoscope is shown below.



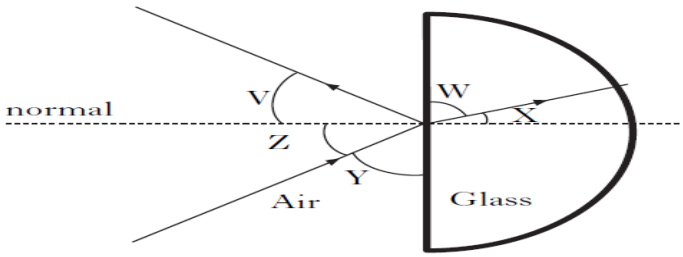
(i) Copy and complete the diagram to show how light is transmitted along the optical fibre.

(ii) Explain the purpose of each bundle of optical fibres in the endoscope.

(iii) The tip of the endoscope that is inside the patient is designed to be very flexible. Suggest **one** reason for this.

Light Ex2

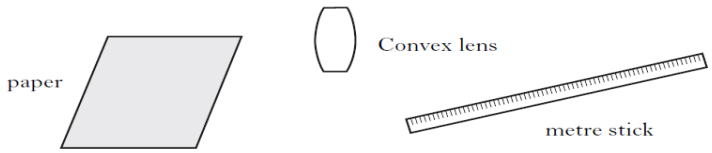
1. The diagram shows what happens to a ray of light when it strikes a glass block.



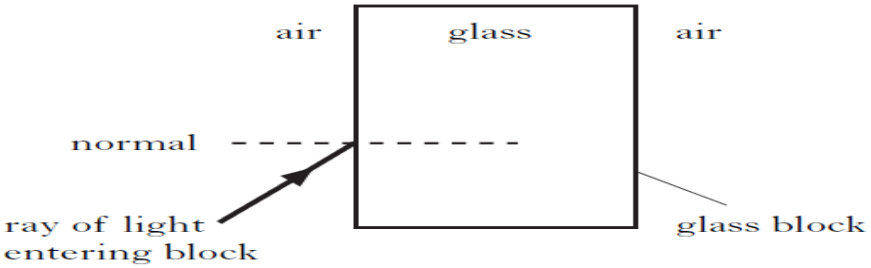
Which row in the table identifies the angle of incidence and the angle of refraction?

	Angle of Incidence	*Angle of Refraction*
A	V	W
B	Y	W
C	Y	X
D	Z	W
E	Z	X

2. In a physics laboratory, a student wants to find the focal length of a convex lens. The student is given a sheet of white paper, a metre stick and a lens.



a) Explain how the student could measure the focal length of the lens using this equipment.
b) Refraction of light occurs in lenses. What is meant by the term refraction?
c) The following diagram shows a ray of light entering a glass block.
   (i) Complete the diagram to show the path of the ray of light through the block and after it emerges from the block.



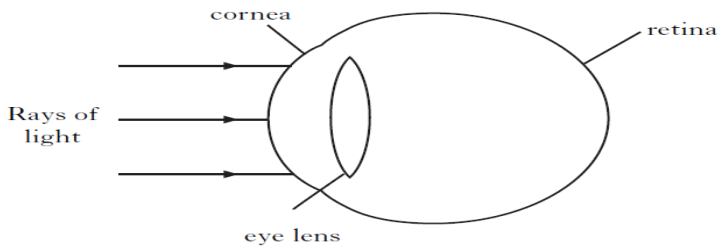
   (ii) On your diagram indicate an angle of refraction, **r**.

Light Ex3

1. A student is short sighted.

(*a*) (i) What does the term "short sighted" mean?
(ii) What type of lens is required to correct this eye defect?
(iii) The focal length of the lens needed to correct the student's short sight is 180 mm. Calculate the power of this lens.

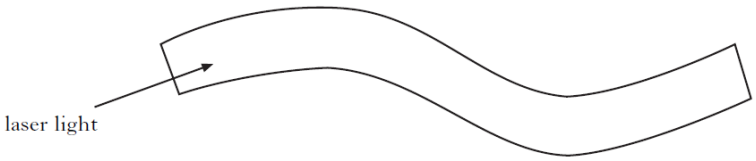
(*b*) In the eye, refraction of light occurs at both the cornea and the lens. Some eye defects can be corrected using a laser. Light from the laser is used to change the shape of the cornea.



(i) State what is meant by refraction of light.
(ii) The laser emits light of wavelength 7×10^{-7} m.
Calculate the frequency of the light.

(*c*) Lasers can be used in optical fibres for medical purposes.

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



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

Nuclear Ex1

1. Which of the following statements is **always** true about the structure of the atom?
   A It has more electrons than protons.
   B It has more protons than neutrons.
   C It has an equal number of protons and electrons.
   D It has more neutrons than protons.
   E It has an equal number of neutrons and electrons

2. Which row in the table describes the correct configuration for an atom?

	orbiting the nucleus	*inside the nucleus*
A	protons only	electrons and neutrons
B	electrons and protons	neutrons only
C	neutrons and protons	electrons only
D	electrons only	neutrons and protons
E	neutrons only	electrons and protons

3. The table gives information about radioactive substances used in medicine.

Radioactive substance	*Type of ionising radiation emitted*	*Half-life*
iodine-131	beta and gamma	8 days
technetium-99 m	gamma	6 hours
cobalt-60	beta and gamma	5·3 years

(*a*) (i) State what is meant by the term ionisation.
(ii) State a type of ionising radiation **not** given in the table above.

(*b*) A sample of iodine-131 is delivered to a hospital 24 days before it is given to a patient. The activity of the iodine-131 when it is given to the patient is 6MBq. Calculate the initial activity, in MBq, of the sample when it was delivered to the hospital.

(*c*) (i) Equivalent dose measures the biological effect of radiation.
State the unit of equivalent dose.

(ii) For living material the biological effect of radiation depends on a number of factors. State **two** of these factors.

Nuclear Ex2

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

(*a*) State what is meant by an alpha particle.

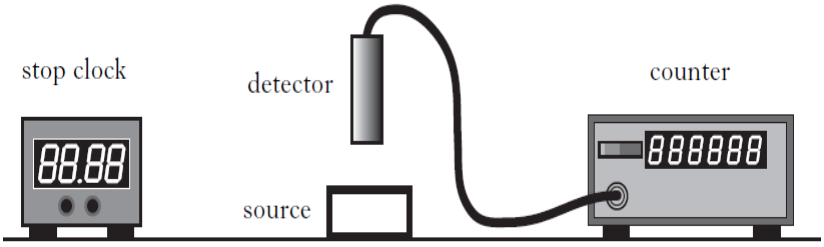
(*b*) Alpha particles produce a greater ionisation density than beta particles or gamma rays. What is meant by the term *ionisation*?

(*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.

(*d*) Calculate the number of decays in the sample in two minutes, when the activity of the source is 1·2 kBq.

(*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.

2. Students observe an experiment with radioactive sources. The radiation is measured using a detector and counter. The background count rate is measured.



Different absorbing materials are then placed, in turn, between source and detector and readings for each material are recorded. This is repeated for each source. The results are shown in the table.

	Corrected Count Rate (Counts per minute)			
Source	*No absorbing material*	*Paper*	*2 cm of Aluminium*	*2 cm of Lead*
A	480	480	480	200
B	720	300	300	180
C	600	580	0	0

One source emits beta radiation only, one emits gamma only and one emits both alpha and gamma radiation.

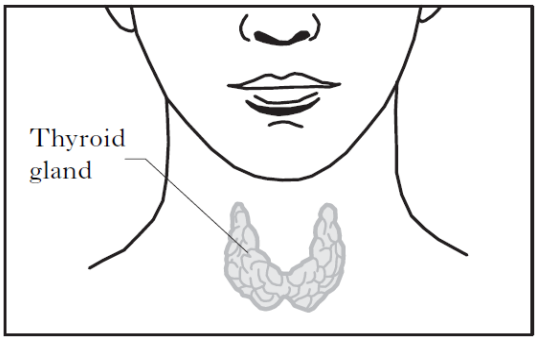
a) Complete the following table to identify the source

Type of radiation	*Source*
beta only	
both alpha and gamma	

b) One source has a half-life of 30 minutes. The source has an initial activity of 18000 Bq. Calculate its activity after 2 hours.

Nuclear Ex3

1. The thyroid gland, located in the neck, is essential for maintaining good health.



(*a*)

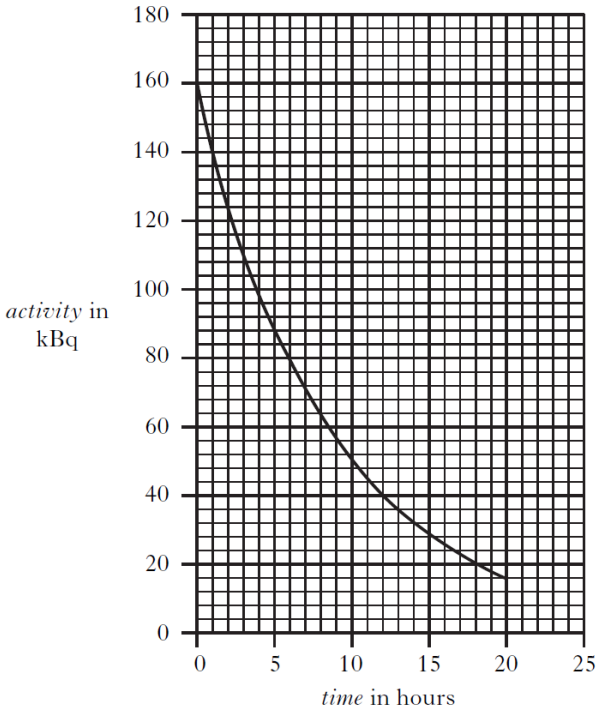
(i) A radioactive source, which is a gamma radiation emitter, is used as a radioactive tracer for the diagnosis of thyroid gland disorders. A small quantity of this tracer, with an activity of 20 MBq, is injected into a patient's body. After 52 hours, the activity of the tracer is measured at 1.25MBq. Calculate the half life of the tracer.

(ii) Another radioactive source is used to **treat** cancer of the thyroid gland. This source emits only beta radiation. Why is this source unsuitable as a **tracer**?

(iii) The equivalent dose is much higher for the beta emitter than for the gamma emitter. Why is this higher dose necessary?

(d) What are the units of equivalent dose?

2. A hospital technician is working with a radioactive source. The graph shows the activity of the source over a period of time.



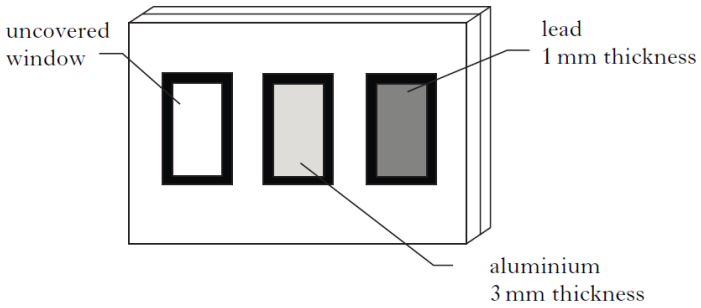
a)

(i) State what is meant by the term *half-life*.

(ii) Use information from the graph to calculate the half-life of the radioactive source.

(iii) The initial activity of the source is 160 kBq. Calculate the activity, in kBq, of the radioactive source after four half-lives.

b) As a safety precaution the technician wears a film badge when working with radioactive sources. The film badge contains photographic film. Light cannot enter the badge.



Describe how the film badge indicates the **type** and **amount** of radiation received.

3. Radioactive sources are used in the treatment of many illnesses. The table below gives some properties of three radioactive sources used in medicine.

Name of Source	*Type of Source*	*Half-life of Source*
Radium – 226	Alpha	1600 years
Iodine – 131	Beta	8 days
Technetium – 99	Gamma	6 hours

(i) One type of treatment requires a source that produces high ionisation. Which source should be used?

(ii) Which source would be most suitable for use in diagnostic tests where a tracer is injected into the body?

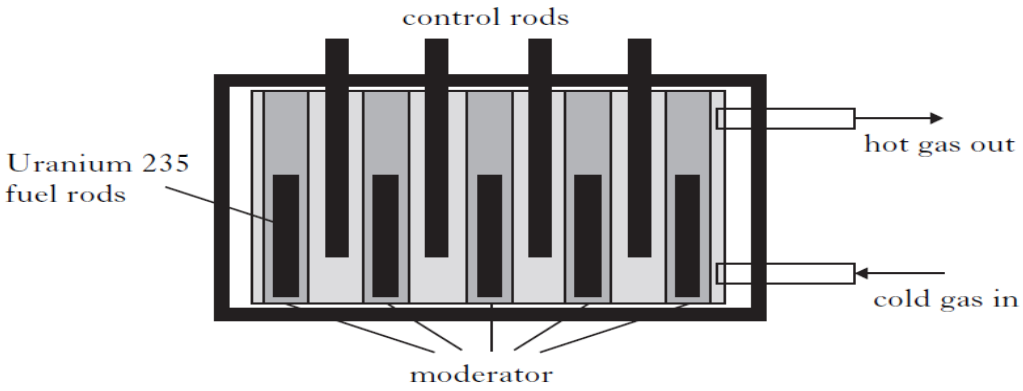
(iii) Which source should not be stored in an aluminium box for safety reasons?

Nuclear Ex4

1. In the reactor of a nuclear power station, neutrons split uranium nuclei to produce heat in what is known as a "chain reaction".

   a) Explain what is meant by the term "chain reaction".

2. Many countries use nuclear reactors to produce energy. A diagram of the core of a nuclear reactor is shown.



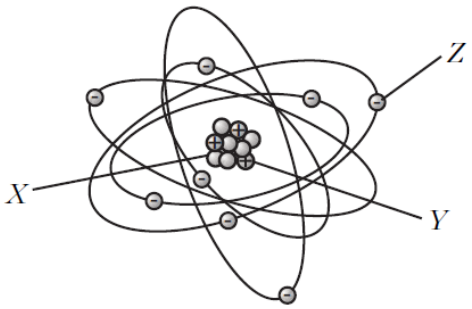
(*a*) State the purpose of:

i. *the moderator;*
ii. *the control rods.*

(*b*) One nuclear fission reaction produces $2{\cdot}9 \times 10^{-11}$J of energy. The power output of the reactor is 1·4GW. How many fission reactions are produced inone hour?

(*c*) State **one advantage** and **one disadvantage** of using nuclear power for the generation of electricity.

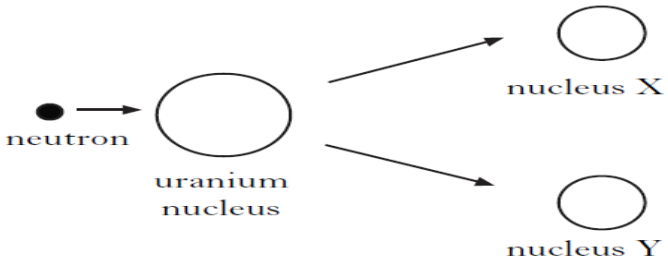
3. The diagram below shows a simple model of an atom.



	X	*Y*	*Z*
A	electron	proton	neutron
B	proton	neutron	electron
C	neutron	electron	proton
D	electron	neutron	proton
E	neutron	proton	electron

Which row in the table identifies particles *X*, *Y* and *Z*?

4. During fission, a neutron splits a uranium nucleus into two nuclei, X and Y, as shown below.



For a chain reaction to occur which of the following **must** also be released?

A Protons
B Electrons
C Neutrons
D Alpha particles
E Gamma radiation