Triple BTEC Science Tasks

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Physics

Paper 1

SP5 Light and the Electromagnetic Spectrum

We see things when a form of radiation that we call visible light enters our eyes. But there are other forms of radiation similar to light that we cannot see.

Our skin can detect infrared radiation. All objects emit infrared radiation – the hotter the object the more infrared it emits. The thermogram of the penguins is an image made using a special camera that detects infrared radiation. White shows the warmest parts of the image, then red, orange and yellow, with green and blue showing the coldest areas.

In this unit you will learn about different forms of radiation that we cannot see, their uses and dangers.

The learning journey

Previously you will have learnt at KS3:

- that light transfers energy
- about colours and how different colours are absorbed and reflected differently.

In this unit you will learn:

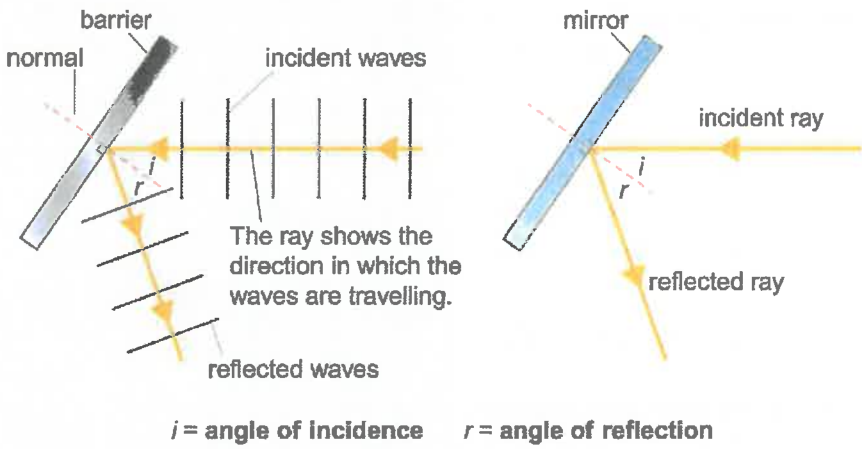
- how to use ray diagrams to explain reflection, refraction and total internal reflection
- how to make coloured light and why some objects appear coloured
- how lenses work and some things they can be used for
- that light is part of a family of waves called the electromagnetic spectrum, which all have some properties in common
- about some uses of waves in different parts of the electromagnetic spectrum
- about some of the harmful effects of waves in different parts of the electromagnetic spectrum
- about some of the factors that affect the temperature of the Earth.

SP5a Ray diagrams

Specification reference: P5.1P

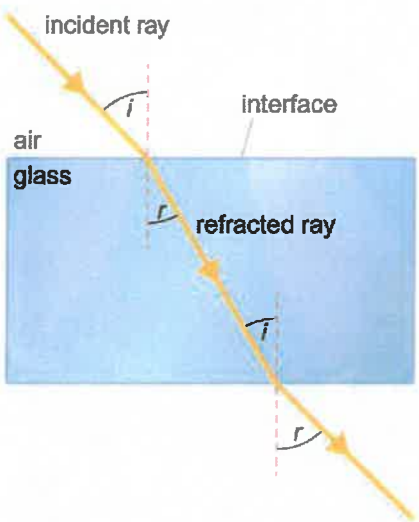
Progression questions

- How can you use ray diagrams to show reflection and refraction?
- What is the law of reflection?
- What is total internal reflection?



A water waves reflected by a barrier and light waves reflected by a mirror

A **ray diagram** is a way of modelling what happens when light is **reflected** or **refracted.** You can also use waves on water as a model for what happens to light. Diagram A shows how water and light waves are reflected. The rays are lines that show the direction the waves are travelling. A **normal** is a line drawn at right angles to the barrier or mirror. The angles of the **incident ray** and **reflected ray** are always measured from the normal.



B Light bends towards the normal if it goes into a medium where it travels more slowly. It bends away from the normal if it goes into a medium where it travels faster.

When waves are reflected, the angle of reflection is equal to the angle of incidence. This is called the **law of reflection.**

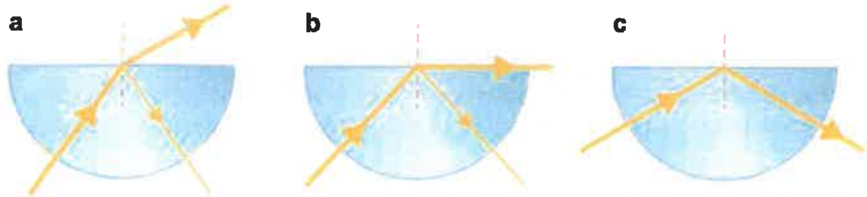
1 Light hits a mirror with an angle of incidence of 30°. What is the angle of reflection?

Light travels at different speeds in different materials. It travels faster in air than it does in water or glass. When a ray of light moves into a material where it travels at a different speed, it usually changes direction. This is called **refraction**. The angle of incidence (*i*) and **angle of refraction** (*r*) are both measured from the normal. When light meets the **interface** (boundary) at right angles to it (i.e. along the normal) there is no change in direction.

2 Describe what happens to the direction of a light ray when it goes from water into air.

Total internal reflection

When light passes from water or glass into air with small angles of incidence, most of the light passes through the interface but a little is reflected (diagram C, part a). As the angle of incidence increases, the angle of refraction also increases until the refracted light passes along the interface (diagram C, part b). If the angle of incidence increases further, the light is completely reflected inside the glass. This is called **total internal reflection** and the angle of incidence at which this starts to happen is called the **critical angle**.



a A small amount of light is reflected, but most is refracted.

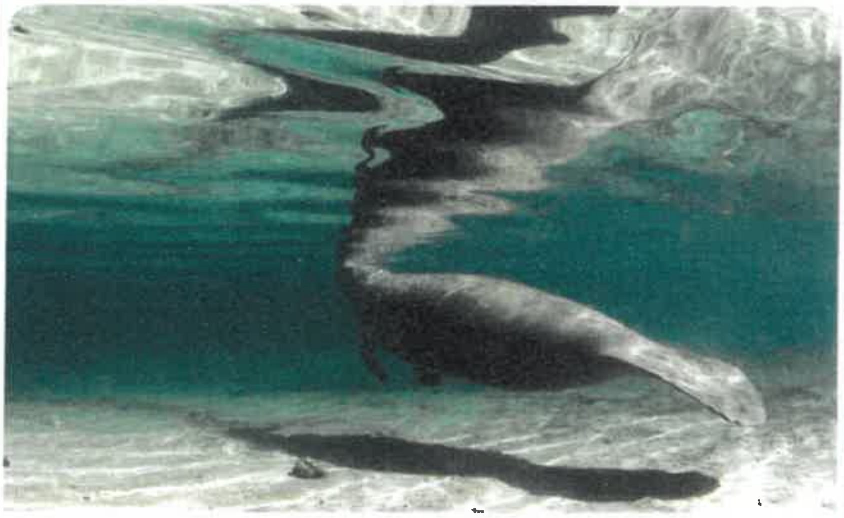
b When the angle of incidence equals the critical angle, the refracted light passes along the interface (boundary) of the glass block.

c At angles of incidence greater than the critical angle, the light is completely reflected inside the block.

C light passing through a semi-circular glass block, showing total internal reflection and the critical angle

Did you know?

If you swim underwater, you may be able to see reflections on the underside of the water. These are caused by total internal reflection.



D

5 Look at photo D. Draw a ray diagram to show how light from the manatee reaches the camera.

6 The critical angle for glass is 42°. Use diagrams to help you to explain what happens when light leaves a glass block with the following angles of incidence.

a 35° **b** 45°

Exam-style question

Compare and contrast reflection and total internal reflection. *(3 marks)*

3 You can see your reflection in a window when it is dark outside. Explain why this happens.

4 Explain why total internal reflection does not occur when light goes from air into glass.

Checkpoint

How confidently can you answer the Progression questions?

Strengthen

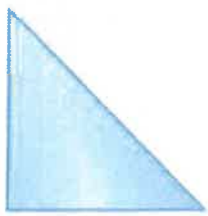
S1 Draw a ray diagram to show light being reflected by a mirror when the angle of incidence is 45°.

S2 The critical angle for glass is 42°. Explain what this means.

Extend

E1 A triangular glass prism has one 90° angle and two 45° angles. Draw a ray diagram to show what happens to light as it enters one of the short sides with these angles of incidence.

a 60° **b** 90°



E

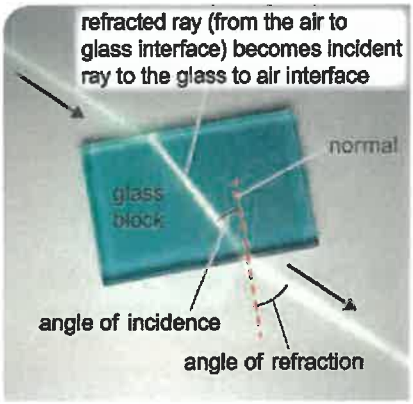
SP5a Core practical – Investigating refraction

Specification reference: P5.9

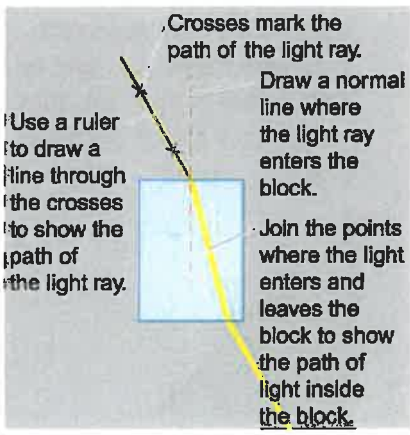
Aim

Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter.

A This photo was taken through the wall of an aquarium. Light reflected by the parts of the turtle under the water changes direction when it enters air, and makes it look as if the animal has been cut in half!



B



C

Electromagnetic waves travel at different speeds in different materials. Light slows down when it goes from air into glass or water. If the light hits the interface at an angle, it changes direction. This is called refraction.

We can investigate refraction by measuring the angles between light rays and the normal (a line at right angles to the interface). The light ray approaching the interface is called the incident ray. The angle between this ray and the normal is called the angle of incidence (*i*). The angle between the normal and the light ray leaving the interface (the refracted ray) is called the angle of refraction (*r*).

Your task

Your task is to investigate how the direction of a ray of light changes as it enters and leaves a rectangular glass block.

Method

A Place a piece of plain paper on the desk. Set up the power supply, ray box and single slit so that you can shine a single ray of light across the paper on your desk. Take care, as ray boxes can become very hot.

B Place a rectangular glass block on the paper. Draw around the block.

C Shine a ray of light into your block. Use small crosses to mark where the rays of light go.

D Take the block off the paper. Use a ruler to join the crosses to show the path of the light, and extend the lines so they meet the outline of the block. Join the points where the light entered and left the block to show where it travelled inside the block.

E Measure the angles of incidence and refraction where the light entered the block, and measure the angles where it left the block.

F Repeat steps C to E with the ray entering the block at different angles.

G Move the ray box so that the light ray reaches the interface at right angles. Note what happens to the light as it enters and leaves the block.

Exam-style questions

1 Describe the difference between the way that light travels through glass compared with the way in which it travels through air? *(1 mark)*

2 State what the following terms mean:

a normal *(1 mark)*

b angle of incidence *(1 mark)*

c angle of refraction. *(1 mark)*

3 Table D shows a student's results from this investigation.

a Draw a diagram to show the glass block and a light ray going into the glass at an angle of incidence of 30°. *(2 marks)*

b Draw in the refracted ray. *(1 mark)*

4 a Use the data in table D to plot a scatter graph to show the results for light going from air to glass. Put the angle of incidence on the horizontal axis, and join your points with a smooth curve of best fit. *(5 marks)*

b Use table D and your graph to write a conclusion for this part of the investigation. *(3 marks)*

c Use your graph to find the angle of refraction when the angle of incidence is 15°. *(1 mark)*

5 a Use the data in table D to plot a scatter graph to show the results for light going from glass to air. Put the angle of incidence on the horizontal axis, and join your points with a smooth curve of best fit. *(5 marks)*

b Use your graph to write a conclusion for this part of the investigation. *(3 marks)*

c Use your graph to find the angle of incidence when the angle of refraction is 45°. *(1 mark)*

6 If light passes through a glass block with parallel sides, the ray that comes out should be parallel with the ray that goes in. This means that the angle of incidence for air to glass should be the same as the angle of refraction from glass to air.

Look at table D. Suggest one source of random error that may have caused the differences in these angles. *(1 mark)*

Air to glass		Glass to air	
i	*r*	*i*	*r*
10°	6°	6°	9°
20°	13°	13°	20°
30°	20°	20°	31°
40°	25°	25°	40°
50°	30°	30°	50°
60°	34°	34°	58°
70°	38°	38°	69°
80°	40°	40°	78°

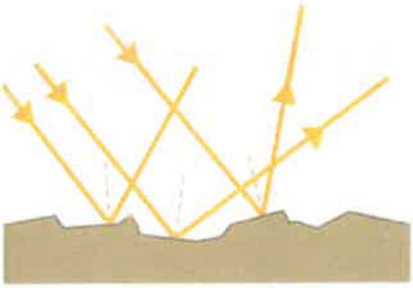
D

SP5b Colour

Specification reference: P5.2P; P5.3P

Progression questions

- What are specular and diffuse reflection?
- Why do surfaces have different colours?
- How do filters make coloured light?



A diffuse reflection

You see **luminous** objects when light from them enters your eyes. You see non-luminous objects because they reflect light.

Most materials have rough surfaces if you examine them closely, so the reflected light is scattered in all directions. This is called **diffuse reflection**. Very smooth surfaces, such as mirrors, reflect the light evenly. This is called **specular reflection**.

1 'The law of reflection applies to all surfaces'. Look at diagram A and explain why this statement is correct.

The light from the Sun or from lamps is called **white light**. White light is actually a mixture of different colours of light that our eyes see as white. White light can be split up into the colours of the **visible spectrum** using a prism.

When white light hits a coloured surface, some of the colours that make it up are absorbed and some are reflected. A yellow object looks yellow because it reflects yellow light and **absorbs** all the other colours. A white object looks white because it reflects all of the colours.

B These powders are used in the Indian 'Festival of Colours'. Each powder reflects different colours of light.

2 Look at photo B. Explain why some of the powders appear these colours.

a yellow

b blue

3 **a** Explain why a white shirt looks white.

b Suggest why black objects look black.

Theatres use spotlights to produce effects on stage. Spotlight lamps produce white light but this can be made into coloured light using a **filter**. Filters are pieces of transparent material that absorb some of the colours in white light. For example a blue filter **transmits** (allows through) blue light and absorbs all the other colours.

4 Explain which colours in white light are transmitted and absorbed by:

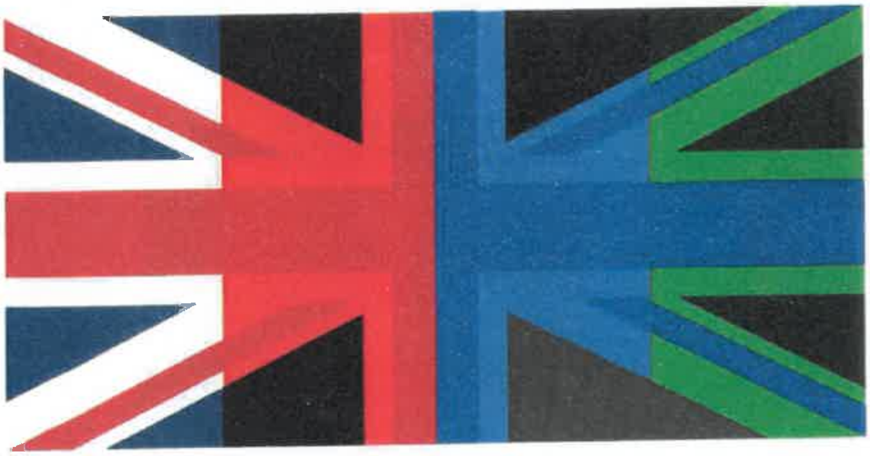
a the kind of glass used to make house windows

b red glass in stained glass windows.

Did you know?

You see different colours because you have three types of cone cells in the part of your eyes that detects light (the retina). Each cone detects red, green or blue light which are the primary colours of light (not the same as the primary colours for paint). If red cones and green cones both detect light, you see the light as yellow. If all three sets of cones detect light, you see it as white.

C Stained glass windows are filters.



D Coloured objects look different when different coloured light shines on them.

5 Diagram D shows a union flag illuminated with different coloured lights. Explain why:

a the white parts look blue in blue light

b the blue parts look black in red light

c the red and blue parts look black in green light.

Exam-style question

Compare and contrast the way light is reflected by a mirror and by a sheet of paper. *(2 marks)*

Checkpoint

How confidently can you answer the Progression questions?

Strengthen

S1 Describe what happens to light from the Sun when it hits a red flower.

S2 Describe what a filter is and what it does.

Extend

E1 Explain how you see a post box and why it looks red.

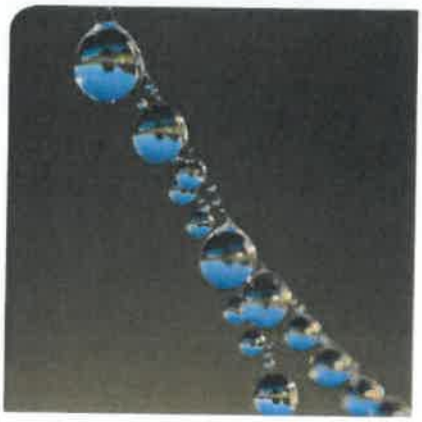
E2 Explain what colour the post box will appear if it is illuminated by a blue spotlight.

SP5c Lenses

Specification reference: P5.4P; P5.5P; P5.6P

Progression questions

- What factors affect the power of a lens?
- How do different shaped lenses refract light?
- How do lenses produce real and virtual images?



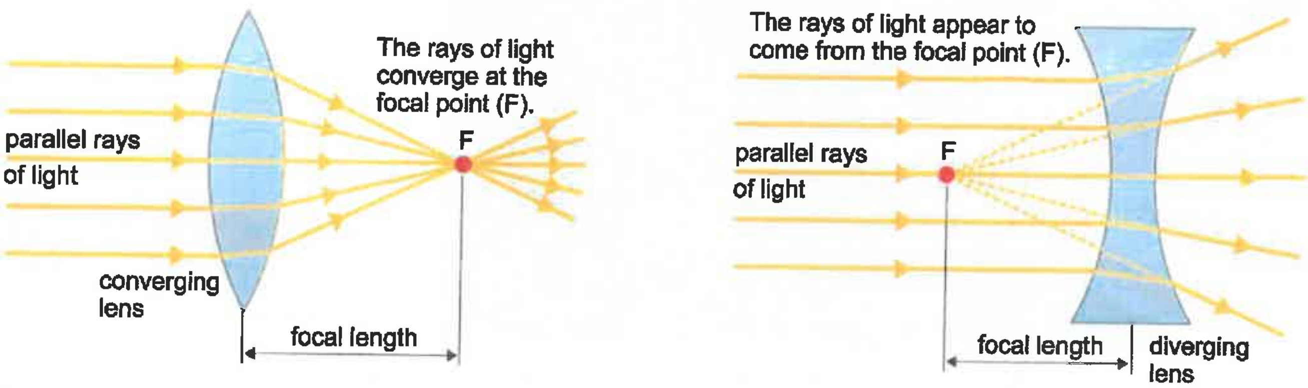
A Raindrops on this spider's web are acting as lenses.

A lens is a piece of transparent material shaped to refract light in particular ways. The **power** of a lens describes how much it bends light that passes through it. A more powerful lens is more curved and bends the light more.

1 What does the power of a lens describe?

2 State which is the most powerful: a ×10 magnifying glass or a ×20 one.

A **converging lens** is fatter in the middle than at the edges. It makes parallel rays of light converge (come together) at the **focal point**. The **focal length** is the distance between the focal point and the centre of the lens. A **diverging lens** is thinner in the middle than at the edges. The focal point is the point from which the rays seem to be coming after passing through the lens.



B

3 Look at the converging lens in diagram B.

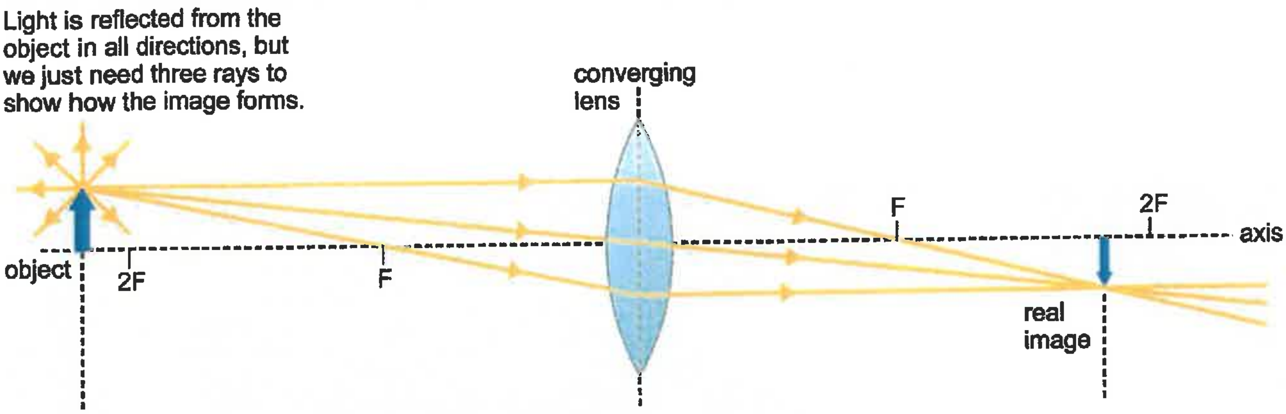
a How would this lens look different if it were less powerful?

b How would its focal length be different if it were more powerful?

4 Look at the lenses in diagram B. Describe one similarity and one difference in the way they affect light.

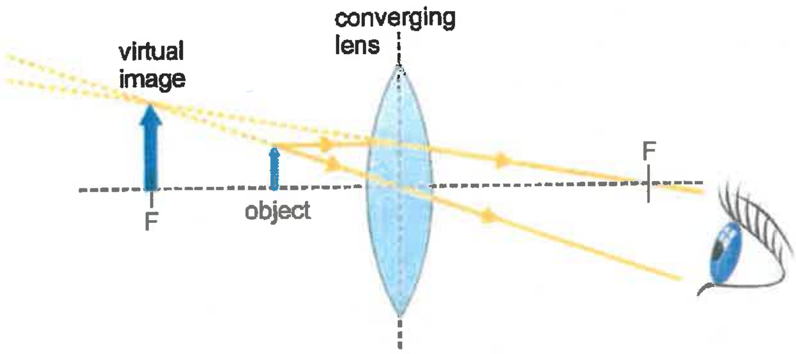
The kind of image formed by a converging lens depends on where the **object** is. A converging lens can be used to focus rays of light onto a screen. An image that can be projected onto a screen in this way is called a **real image**. Real images can only be formed by light rays that come together.

Diagram C shows how a converging lens forms a real image. This image is also inverted (upside down) and smaller than the object.



C A converging lens forms a real image of a distant object.

An object close to a converging lens will form a **virtual image**. It is called virtual because it cannot be projected onto a screen. The image appears to be on the same side of the lens as the object, and is upright and magnified. A magnifying glass is a converging lens.



D a ray diagram showing a converging lens being used as a magnifying glass

Diverging lenses always produce virtual images that are the same way up, much smaller and closer to the lens than the object.

5 You can start a fire by using a lens to focus energy from the Sun onto paper. Explain which kind of lens you need to use.

6 Cinema projectors use lenses to project images on the film. Explain whether these projectors use converging or diverging lenses.

Exam-style question

Describe how a converging lens can be used to form a virtual image, and describe one use for a lens used in this way. *(2 marks)*

Did you know?

The largest lens in use today has a diameter of 102 cm and a focal length of 19.4 m. It is used in a telescope in the USA.

Checkpoint

How confidently can you answer the Progression questions?

Strengthen

S1 Explain how the power of a lens depends on its shape.

S2 A camera uses lenses to focus light. Explain whether cameras have converging or diverging lenses.

Extend

E1 'Converging lenses only produce real images'. Explain what real and virtual images are and why this statement is not correct.

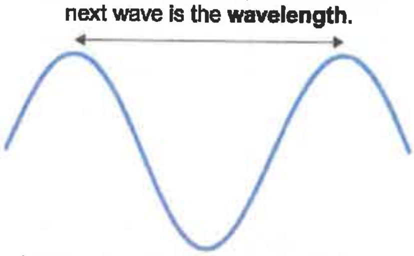
SP5d Electromagnetic waves

Specification reference: P5.7; P5.8; P5.12

Progression questions

- What are some examples of electromagnetic waves?
- What do all electromagnetic waves have in common?
- Which electromagnetic waves can our eyes detect?

A A marsh marigold flower seen in visible light (left) and ultraviolet light (right).



B Electromagnetic waves are transverse waves.

We see things when light travels from a source and is reflected by an object into our eyes. The light transfers energy from the source to our eyes. Light is a type of **electromagnetic wave**.

Our eyes can detect certain **frequencies** of light, and we refer to these frequencies as **visible light**. Different frequencies cause us to see different colours. Lower frequencies of visible light appear more red and higher frequencies appear more blue.

1 We see visible light as a range of colours from red to green to violet. Explain whether red or violet light has the higher frequency.

Some animals, such as birds, can also detect electromagnetic waves with frequencies that are higher than visible light. Electromagnetic waves with frequencies a little higher than visible light are called **ultraviolet (UV)**.

2 Look at the photos in A. Describe what a marsh marigold flower would look like to a bird.

All electromagnetic waves are **transverse** waves. This means that the electromagnetic vibrations are at right angles to the direction in which the energy is being transferred by the wave. All electromagnetic waves travel at the same speed (3×10^8 m/s) in a **vacuum**. Like all waves, electromagnetic waves transfer energy from a source to an observer.

3 **a** What types of waves are electromagnetic waves?

b State two ways in which electromagnetic waves differ from one another.

Electromagnetic waves with frequencies slightly lower than visible light are called **infrared (IR)**. All objects emit energy by infrared radiation. The hotter the object the more energy it emits. The photo on the opening page for this unit shows what penguins would look like if our eyes could detect infrared radiation. We can feel the effects of infrared radiation when energy is transferred from the Sun to our skin.

4 **Write down two similarities and two differences between infrared radiation and ultraviolet radiation.**

5 **Look at the opening page for this unit. Which parts of the penguins are the hottest?**

Discovering infrared

The first person to investigate infrared radiation was the British astronomer William Herschel (1738–1822). He put dark, coloured filters on his telescope to help him observe the Sun safely. He noticed that different coloured filters heated up his telescope to different extents and he wondered whether the different colours of light contained different 'amounts of heat'.

To test his idea he used a prism to split sunlight into a spectrum and then put a thermometer in each of the colours in turn. He also measured the temperature just beyond the red end of the spectrum, where there was no visible light.

6 Look at photo D.

a Which colour of visible light caused the greater temperature rise?

b Compare the energy transferred to the thermometer by infrared radiation and by visible light.

D A modern version of Herschel's experiment.

Exam-style question

State two characteristics that all electromagnetic waves have in common. *(2 marks)*

Did you know?

Some animals have special sense organs to detect infrared radiation. Many snakes, such as pit vipers, have these organs under their eyes, which help them to detect warm-blooded prey.

C

Checkpoint

How confidently can you answer the Progression questions?

Strengthen

S1 Describe how we can see a flower on a sunny day. Use the words 'energy' and 'transferred' in your answer.

S2 Explain why the image we see may not be the same as the image a bird sees.

Extend

E1 Compare and contrast infrared, visible light and ultraviolet radiation.

E2 Does photo D show that violet light transfers less energy than red light? Explain your answer.

SP5e The electromagnetic spectrum

Specification reference: P5.10; P5.11; H P5.13

Progression questions

- What are the main groupings of waves in the electromagnetic spectrum?
- What characteristics of electromagnetic waves are used to group them?
- H What are some of the differences in the behaviour of waves in different parts of the electromagnetic spectrum?

A A rainbow shows the colours of the visible spectrum.

Visible light is part of a family of waves called electromagnetic waves. Our eyes can detect different colours in visible light. Scientists describe seven colours in the visible spectrum:

red, orange, yellow, green, blue, indigo, violet.

You can remember the order of the colours using a phrase such as ROY G BIV.

Did you know?

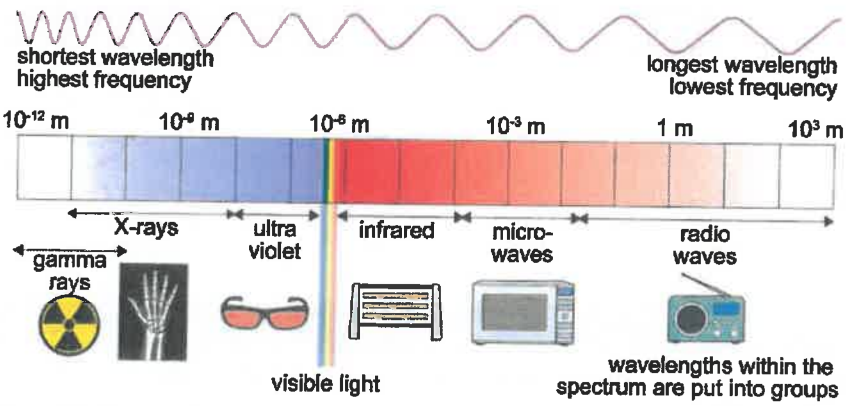
The colours in visible light were described by Sir Isaac Newton (1642–1727). He originally divided the spectrum into five colours, which were all that he could see. However, he thought there was a mystical connection between the colours, the days of the week and the number of known planets, so he ended up describing seven colours.

The colour of visible light depends on its frequency. If the frequency of an electromagnetic wave is lower than that of red light, human eyes cannot see it. Infrared, **microwaves** and **radio waves** have lower frequencies than red light.

1 Name three different types of electromagnetic waves.

Ultraviolet radiation has a higher frequency than visible light. Even higher frequencies and shorter wavelengths are present in **X-rays** and then **gamma rays**.

The full range of electromagnetic waves is called the **electromagnetic spectrum**. The spectrum is continuous, so all values of frequency are possible. Higher frequency waves have shorter wavelengths, and lower frequency waves have longer wavelengths. It is convenient to group the spectrum into seven wavelength groups, as shown in diagram B.



B the electromagnetic spectrum (not to scale)

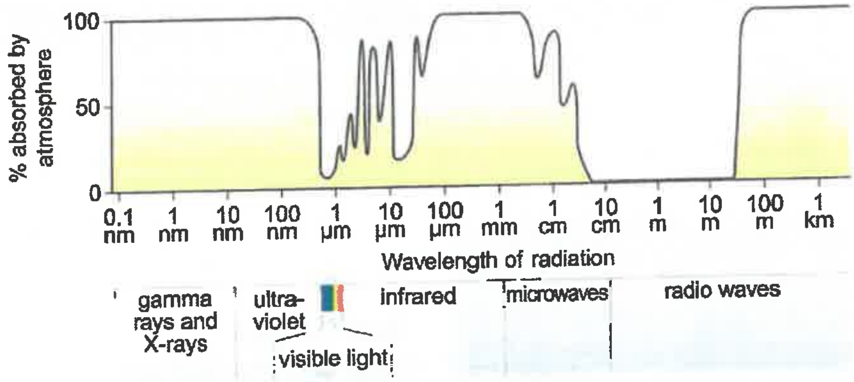
2 Which part of the electromagnetic spectrum has a higher frequency than X-rays?

3 What type of electromagnetic wave has a wavelength between those of visible light and X-rays?

4 How do we know that electromagnetic waves can travel through a vacuum, such as space?

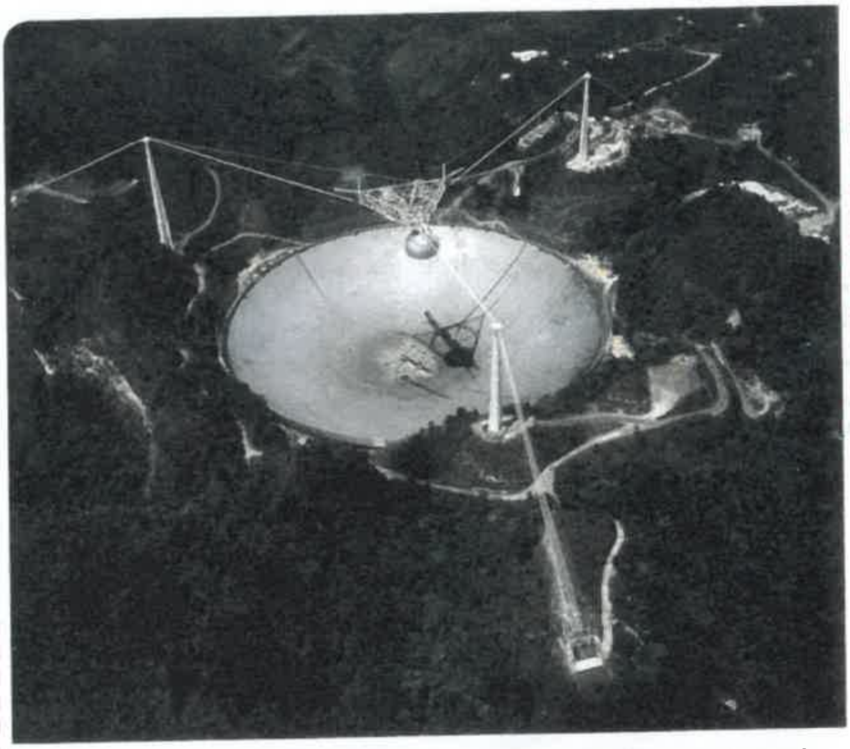
H

Stars and other space objects can emit energy at all wavelengths. Astronomers use telescopes to study this radiation but they need to use different kinds of telescope to study different wavelengths. This is because different materials affect electromagnetic waves depending on the wavelength. For example, diagram C shows which wavelengths pass through the atmosphere and which are absorbed.



C Absorption of electromagnetic radiation by the atmosphere. You do not need to recall the details of this diagram.

Most telescopes use curved mirrors to focus the electromagnetic radiation onto a central sensor. The type of material used for the mirror and the size of the telescope depend on the wavelength of the radiation being studied.



D The Arecibo telescope in Puerto Rico has a reflector dish that is over 300 m in diameter and contains nearly 40 000 aluminium panels.

5 Look at diagram C. Explain why telescopes that detect infrared radiation from objects in space are put into orbit around the Earth.

Exam-style question

State one way in which X-rays are similar to visible light, and one way in which they are different. *(2 marks)*

Checkpoint

How confidently can you answer the Progression questions?

Strengthen

S1 List the seven parts of the electromagnetic spectrum in order and describe how the wavelength and frequency change from one end of the spectrum to the other.

Extend

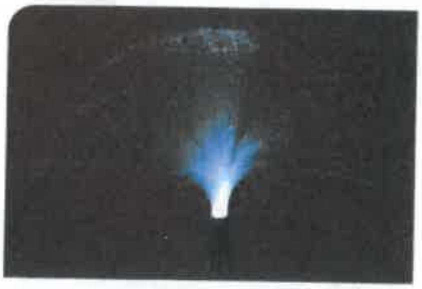
E1 H Explain how the locations and types of instruments astronomers use depend on the wavelength of the electromagnetic waves that they study.

SP5f Using the long wavelengths

Specification reference: H P5.13; H P5.14; P5.22; H P5.23

Progression questions

- What are some uses of radio waves, microwaves and infrared?
- H How are radio waves produced and detected?
- H How do different substances affect radio waves, microwaves and infrared?



A This sculpture is made from optical fibres which act as 'light pipes'. Visible light and infrared can both be sent along optical fibres.

Did you know?

Microwave cooking was invented by Percy Spencer (1894–1970). The heating effects of radio waves had been known for years, but Spencer applied the idea to cooking after he noticed that waves from a radar apparatus he was working with had melted a chocolate bar in his pocket.

The uses for the waves in different parts of the electromagnetic spectrum depend on their wavelengths.

Visible light

Visible light is the part of the electromagnetic spectrum that our eyes detect. Light bulbs are designed to emit visible light, while cameras detect it and record images.

Infrared

Infrared radiation can be used for communication at short ranges, such as between computers in the same room or from a TV to its remote control unit. The information sent along optical fibres is also sent using infrared radiation.

A grill or toaster transfers energy to food by infrared radiation. The food absorbs the radiation and heats up. Thermal images show the amount of infrared radiation given off by different objects.

Security systems often have sensors that can detect infrared radiation emitted by intruders. Some buildings are fitted with systems of infrared beams and detectors – someone walking through one of these beams breaks it and sets off the alarm.

Microwaves

Microwaves are used for communications and satellite transmissions, including mobile phone signals. In a microwave oven, microwaves transfer energy to the food, heating it up.

B Pilots communicate with each other and with ground controllers using radio waves.

Radio waves

Radio waves are used for transmitting radio broadcasts and TV programmes as well as other communications. Some radio communications are sent via satellites. Controllers on the ground communicate with spacecraft using radio waves.

1 Which parts of our body can detect:

5 **a** visible light

5 **b** infrared radiation?

2 List three parts of the electromagnetic spectrum used for communication.

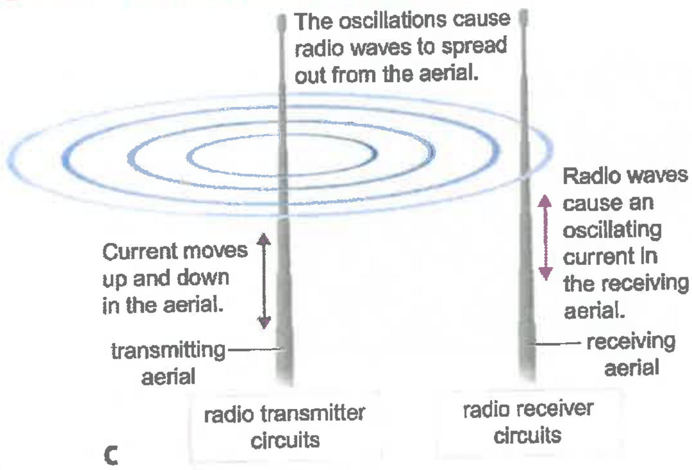
3 Describe how two different parts of the electromagnetic spectrum are used for cooking.

4 Suggest why security systems have sensors that detect infrared rather than other wavelengths of electromagnetic radiation.

H

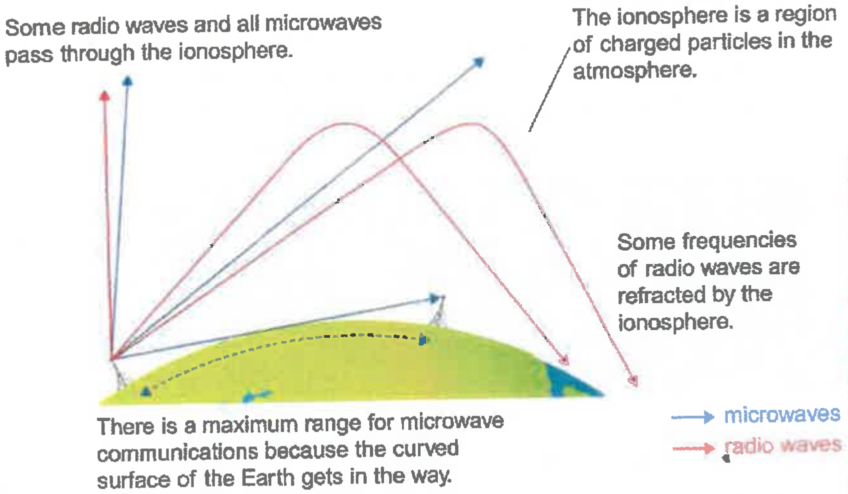
Radio waves are produced by **oscillations** (variations in current and voltage) in electrical circuits. A metal rod or wire can be used as an aerial to receive radio waves. The radio waves are absorbed by the metal and cause oscillations in electric circuits connected to the aerial.

Waves travel in straight lines unless they are reflected or refracted. Refraction is the bending of the path of a wave due to a change in velocity. Some frequencies of radio waves can be refracted by a layer in the atmosphere called the ionosphere. If radio waves reach the ionosphere at a suitable angle, they may be refracted enough to send them back towards the Earth. Microwaves are not refracted in the Earth's atmosphere.



C

5 Microwaves and radio waves are both used for communication between different places on the Earth. Explain why a satellite is needed to give microwaves a similar range to radio waves.



D The maximum distance (range) of radio communication is much greater than for microwave communication.

Exam-style question

Compare the ways in which infrared and microwaves are used in cooking.
(2 marks)

Checkpoint

How confidently can you answer the Progression questions?

Strengthen

S1 Draw a table or make a list of bullet points to show the uses for visible light, infrared, microwaves and radio waves.

Extend

E1 Compare the uses for visible light, infrared, microwaves and radio waves.

SP5g Radiation and temperature

Specification reference: P5.15P; H P5.16P; H P5.17P; H P5.18P

Progression questions

- How does the radiation emitted by a body depend on its temperature?
- H How does the temperature of a body depend on the amount of power it absorbs and radiates?
- H How is the temperature of the Earth affected by different factors?

A a lava flow in Hawaii

The intensity (amount) of radiation emitted by an object increases as its temperature increases. The wavelengths of the radiation emitted also change with temperature – the higher the temperature the shorter the wavelengths.

6th **1** Explain which emits more radiation, a cup of tea at 75 °C or a bowl of soup at 50 °C.

All of the lava in photo A is hot but only some of it is hot enough to emit radiation in visible wavelengths. The parts glowing yellow are hotter than the orange parts, which are hotter than the red parts.

7th **2** Explain why astronomers think that blue stars are hotter than yellow stars.

H

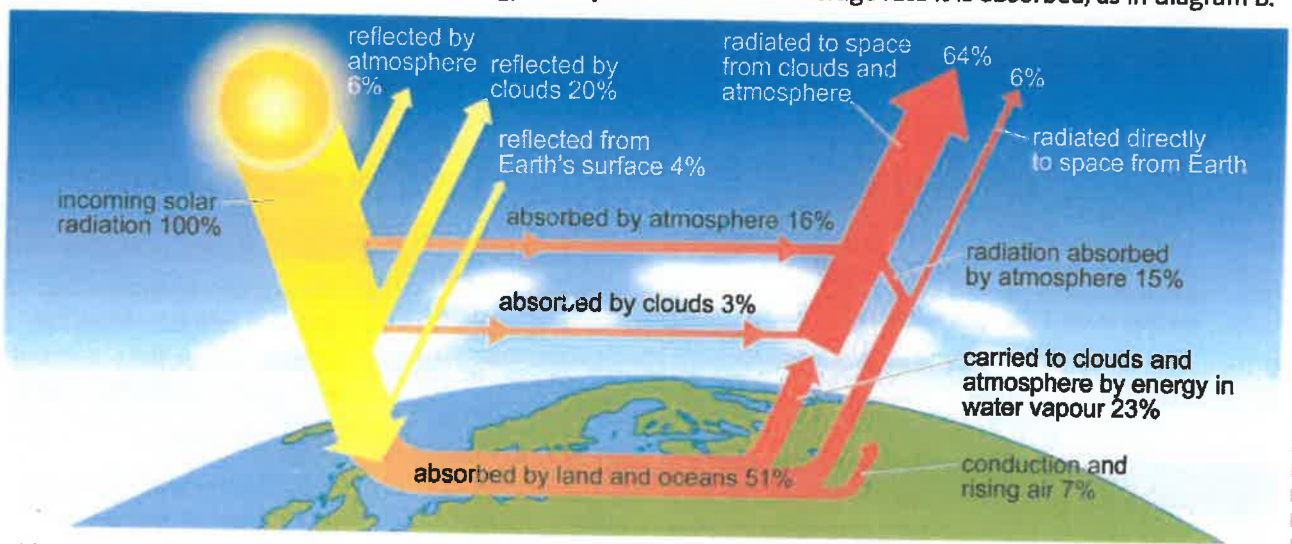
Constant temperatures

The amount of energy transferred in a certain time is the **power**. It is measured in **watts (W)** (1 W = 1 J/s). For a system to stay at a constant temperature it must absorb the same amount of power as it radiates.

6th **3** A butterfly house at 26 °C radiates 30 kW. What must happen for it to stay at 26 °C?

Earth's energy balance

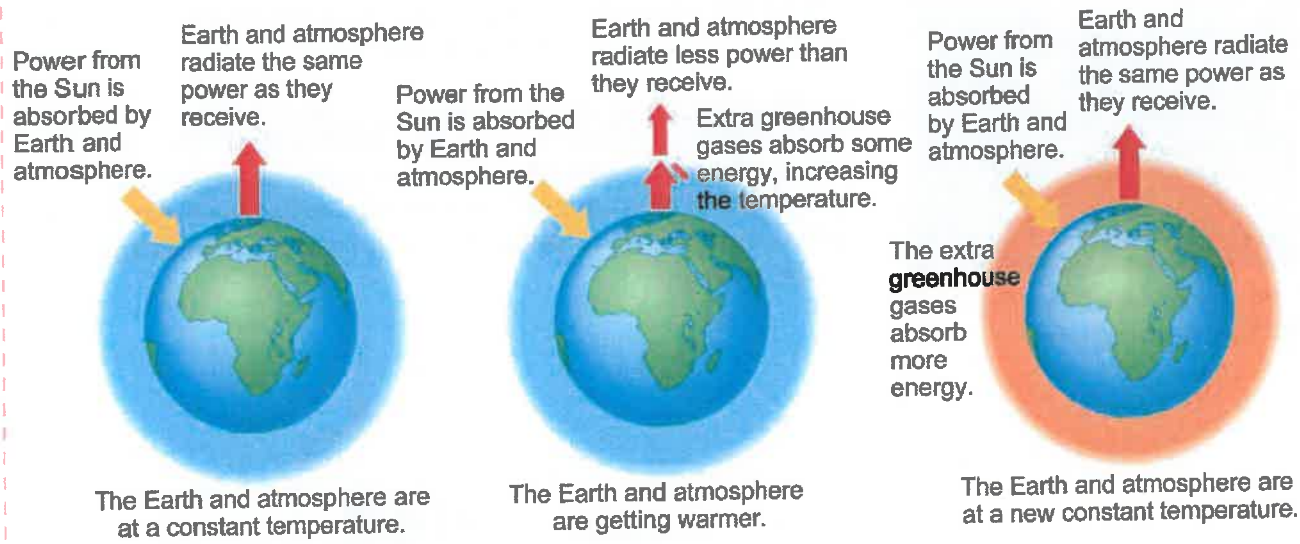
The Earth's surface absorbs about half of the radiation that reaches it from the Sun. It re-radiates this energy as infrared radiation, which can warm up the atmosphere. For the temperature of the Earth to stay the same, it must radiate energy into space at the same average rate it is absorbed, as in diagram B.



B The Earth's energy balance: the amount of energy leaving the atmosphere is the same as the amount coming in.

H

Some gases in our atmosphere (such as carbon dioxide) naturally absorb some energy, keeping the Earth at a higher temperature than if there were no atmosphere. This is the **greenhouse effect** and these gases are often called **greenhouse gases.** Many scientists think that humans have upset this natural balance and that the Earth is warming up because of an increase in greenhouse gases.



C how changes in the atmosphere can warm the Earth

If some greenhouse gases were removed from the atmosphere, the atmosphere would be able to hold less energy and its temperature would decrease.

4 Without the atmosphere, each square metre of the Earth's surface could receive an average of 343 W of solar power. Use diagram B to answer the following questions.

7th **a** What is the power absorbed by each square metre of Earth on average?

7th **b** Calculate the power being re-radiated from each square metre that goes directly into space.

6th **c** Describe what would happen if less than this amount went into space.

7th **5** If the Earth's average temperature rises to a new steady level, what can you say about the power absorbed and radiated by the Earth and atmosphere?

Did you know?

One idea to stop the Earth's temperature rising is to place a huge white screen, 2000 km by 2000 km, in space.

Exam-style question

Compare the radiation emitted by a stove at 100 °C and one at 150 °C.

(2 marks)

Checkpoint

How confidently can you answer the Progression questions?

Strengthen

S1 Blacksmiths heat iron before hammering it into a new shape. Explain how looking at the colour of the heated iron can tell them whether it is hot enough.

Extend

E1 Explain what effect giant white screens in space would have on the temperature of the Earth.

SP5g Core practical – Investigating radiation

Specification reference: P5.19P

Aim

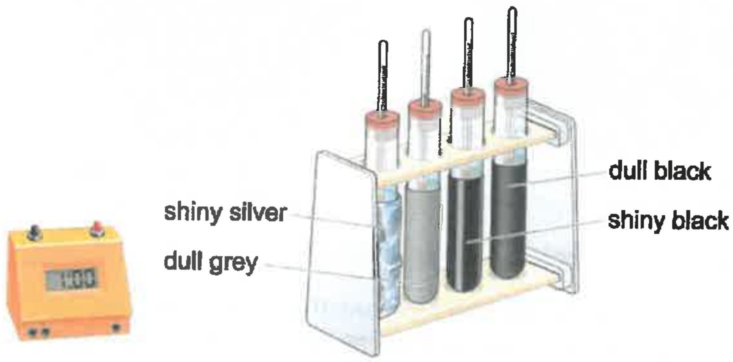
Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed.

A The radiator in this car helps to stop the engine becoming too warm.

The radiator on the car in photo A is designed to transfer energy to the outside air, to stop the engine overheating. Radiators to cool car engines were patented over 100 years ago, in 1879. Radiators are often painted to help them to transfer more energy by radiation.

Your task

Different types of surface affect how much energy is transferred by radiation from different objects. You will investigate the effect of different coloured surfaces on the amount of energy transferred by radiation from a tube of hot water.



B

Method

A Cover four or more boiling tubes in different coloured materials (as shown in diagram B).

B Pour the same volume of hot water from a kettle into each tube.

C Insert a bung with a thermometer into each tube. Measure the temperature of the water in each tube and start a stop clock.

D Record the temperature of the water in each tube every 2 minutes for 20 minutes.

Exam-style questions

1 Which part of the electromagnetic spectrum transfers energy by heating? *(1 mark)*

2 Some very hot objects emit visible light. Explain why the water in the boiling tubes does not emit visible light. *(2 marks)*

3 Explain one safety precaution that should be taken while carrying out this investigation. *(2 marks)*

4 The table shows a set of results from Ali's radiation investigation. Ali recorded the temperatures every five minutes.

a Draw a suitable chart or graph to show these results, with all four sets of results on the same axes. Draw a smooth line through each set of points. *(4 marks)*

Time (min)	Temperature of water (°C)			
	shiny silver	dull black	shiny black	dull grey
0	80	80	80	80
5	70	66	68	69
10	63	57	59	60
15	58	51	54	55
20	53	47	49	46

b Identify any points you think may be errors. *(1 mark)*

c Describe what your graph shows. *(4 marks)*

5 Use your graph to write a conclusion for the investigation. *(2 marks)*

6 Explain what is the best colour for a car radiator. *(2 marks)*

7 a Calculate the overall temperature change for the water in each tube, using the results as given in the table. *(4 marks)*

b What is the advantage of plotting a graph to help you to draw a conclusion for this experiment? *(2 marks)*

8 Ellie says 'Silver surfaces emit less radiation than grey ones'. Explain why this is not necessarily a valid conclusion from Ali's investigation. *(3 marks)*

9 The investigation described above was looking at whether the colour of a surface affects the amount of radiation it emits. Describe an experiment to investigate whether the colour of a surface affects how much radiation it absorbs. Your description should include the apparatus needed, the method to be followed and how you will make sure your test is fair. *(5 marks)*

10 The world is getting warmer, which is causing many glaciers to melt faster than they used to. However, scientists have also discovered that deposits of soot and dust on the surface of ice in Greenland are causing the icecap there to melt even more quickly.

a Explain what this report suggests about the difference in the amount of infrared radiation absorbed by light and dark surfaces. *(2 marks)*

b Use your ideas about the way different coloured surfaces reflect visible light to suggest how the colour of a surface affects the amount of infrared radiation it absorbs. *(3 marks)*

C Investigating ice melting in on a glacier

SP5h Using the short wavelengths

Specification reference: H P5.13; P5.22

Progression questions

- What are some uses of ultraviolet waves?
- What are some uses of X-rays and gamma rays?
- H How do different substances affect ultraviolet, X-rays and gamma rays?

Did you know?

Obtaining clean drinking water is a problem in many parts of the world. Microorganisms in water can be killed by putting the water in clear plastic bottles and leaving them in sunshine for several hours. Infrared energy from the sun heats up the water and the high temperature and the ultraviolet radiation both help to kill microorganisms.

A

Ultraviolet

Ultraviolet radiation transfers more energy than visible light. It is absorbed by most of the same materials that absorb visible light, including our skin. The energy transferred can be used to disinfect water by killing microorganisms in it.

7th **1** **Why would there be UV lamps at a sewage works?**

B Forged banknotes can be detected using UV light because they do not have markings that glow. These are real notes.

Some materials absorb ultraviolet radiation and re-emit it as visible light. This is called **fluorescence**. Fluorescent materials are often used in security markings – they are only visible when ultraviolet light shines on them.

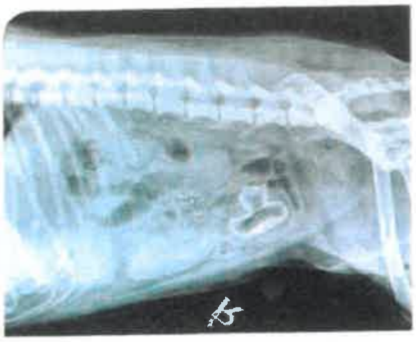
Many low energy light bulbs are fluorescent lamps. A gas inside these lamps produces ultraviolet radiation when an electric current passes through it. A coating on the inside of the glass absorbs the ultraviolet and emits visible light.

7th **2** **Why might someone write their postcode on a TV or computer using a pen with fluorescent ink that is not visible in normal light?**

X-rays

X-rays can pass through many materials that visible light cannot. For example, they can pass through muscles and fat easily but bone absorbs some X-rays. This means X-rays can be used in medicine to make images of the inside of the body. X-rays can also be used to examine the insides of metal objects and to inspect luggage in airport security scanners.

3 Suggest two reasons why security staff at airports use X-ray scanners to check luggage instead of looking inside the luggage.

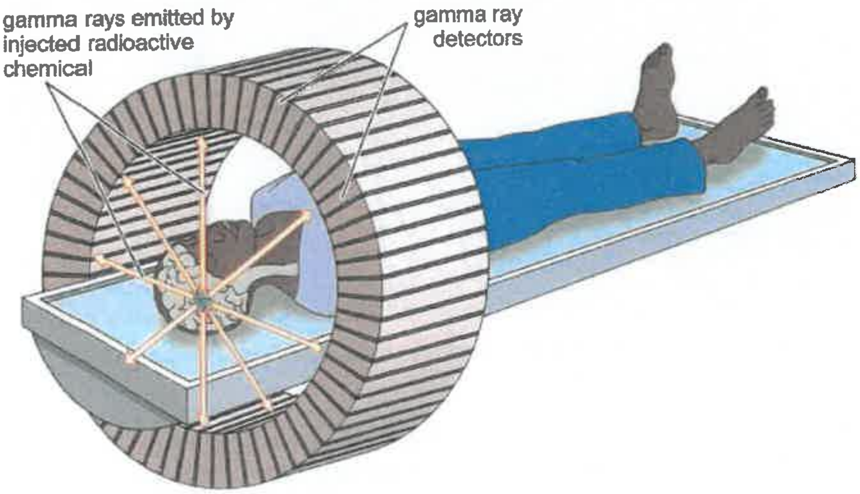


C This X-ray image shows that the dog has swallowed a toy duck.

Gamma rays

Gamma rays transfer a lot of energy, and can kill cells. For this reason, they are used to sterilise food and surgical instruments by killing potentially harmful microorganisms.

Gamma rays are used to kill cancer cells in **radiotherapy**. They can also be used to detect cancer. A chemical that emits gamma rays is injected into the blood. The chemical is designed to collect inside cancer cells. A scanner outside the body then locates the cancer by finding the source of the gamma rays. Gamma rays can pass through all the materials in the body.



D a gamma ray medical scanner

4 Describe two ways in which gamma rays can be used for medical purposes.

5 H Describe the differences in the way muscle, fat and bone absorb or transmit X-rays and gamma rays.

Exam-style question

Describe three different ways in which electromagnetic radiation with frequencies greater than that of visible light can be used in medicine.

(3 marks)

Did you know?

Lenses, such as spectacle lenses, work because light travels more slowly in glass than in air and changes direction as it changes speed. The change of speed when X-rays enter different materials is very small, so X-rays can only be focused using several metal lenses together.

Checkpoint

How confidently can you answer the Progression questions?

Strengthen

S1 Describe three uses for:

- **a** ultraviolet radiation
- **b** X-rays
- **c** gamma rays.

Extend

E1 State two similarities and two differences between:

- **a** gamma rays and ultraviolet radiation
- **b** gamma rays and X-rays.

SP5i EM radiation dangers

Specification reference: P5.20; P5.21; P5.24

Progression questions

- What are the dangers of electromagnetic radiation?
- How is the danger associated with an electromagnetic wave linked to its frequency?
- How is electromagnetic radiation linked to changes in atoms and their nuclei?

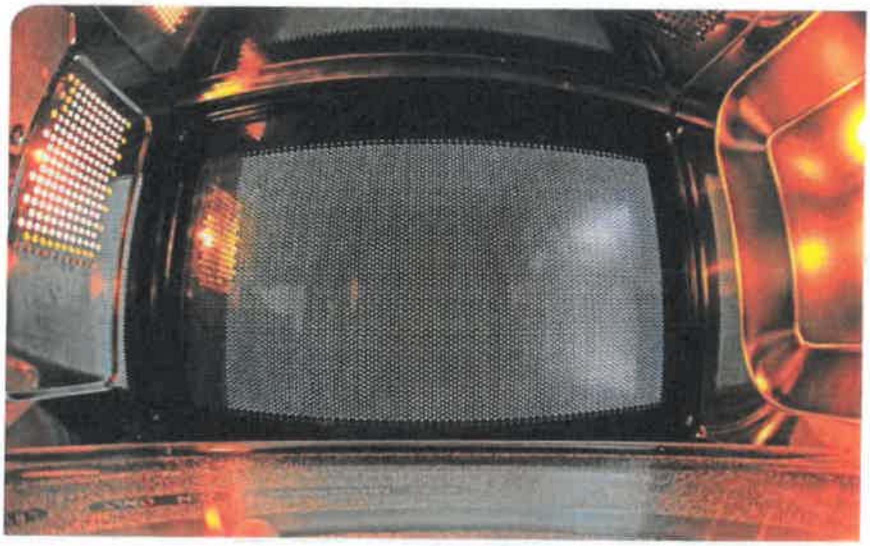
A Mobile phone transmitters use different frequencies of microwaves compared with microwave ovens.

1 Why should you be careful not to stand too close to a bonfire?

2 Why do microwave ovens have shields in them to stop the waves escaping?

C Sunburn is caused by too much ultraviolet radiation being absorbed by the skin.

All waves transfer energy. A certain microwave frequency can heat water and this frequency is used in microwave ovens. This heating could be dangerous to people because our bodies are mostly water and so the microwaves could heat cells from the inside. Mobile phones use different microwave frequencies. Current scientific evidence tells us that, in normal use, mobile phone signals are not a health risk.



B The metal grid in the door of the microwave oven reflects microwaves but the holes allow visible light through.

Infrared radiation is used in grills and toasters to cook food. Our skin absorbs infrared, which we feel as heat. Too much infrared radiation can damage or destroy cells, causing burns to the skin.

Higher-frequency waves transfer more energy than low-frequency waves and so are potentially more dangerous. Sunlight contains high frequency ultraviolet radiation, which carries more energy than visible radiation. The energy transferred by ultraviolet radiation to our cells can cause sunburn and damage **DNA**. Too much exposure to ultraviolet radiation can lead to **skin cancer**. We can help to protect our skin by staying out of the strongest sunshine, covering up with clothing and hats, and using sun cream with a high SPF (sun protection factor).

The ultraviolet radiation in sunlight can also damage our eyes. Skiers and mountaineers can suffer temporary 'snow blindness' because so much ultraviolet radiation is reflected from snow. We can protect our eyes using sunglasses.

D This photo was taken using ultraviolet light. The dark spots show parts of the skin that may have been damaged by exposure to lots of ultraviolet light from the Sun. Some of this damage could eventually turn into skin cancer.

7th 3 State three ways to protect your body against damage by UV radiation when in bright sunlight.

X-rays and gamma rays are higher frequency than ultraviolet radiation and so transfer more energy. They also can penetrate the body. Excessive exposure to X-rays or gamma rays may cause **mutations** in DNA that can kill cells or cause cancer.

7th 4 Why do people have hospital X-ray photographs taken if X-rays are so dangerous?

8th 5 Two different electromagnetic waves have frequencies of 10 000 Hz and 100 000 Hz. Explain which wave is likely to cause the most harm if absorbed by your body.

Radiation and atoms

Electromagnetic radiation is produced by changes in the electrons or the nuclei in atoms. For example, when materials are heated, changes in the way the electrons are arranged can produce infrared radiation or visible light. Changes in the nuclei of atoms can produce gamma radiation.

Radiation can also cause changes in atoms, such as causing atoms to lose electrons to become ions. You will learn more about this in Unit *SP6 Radioactivity*.

7th 6 Explain why gamma radiation produces positive ions.

Exam-style question

Look back at diagram C on *SP5e The electromagnetic spectrum*. Explain why changes in the composition of the atmosphere could cause an increase in skin cancer. *(2 marks)*

Did you know?

The world's oldest snow goggles are around 2000 years old and were made from leather, bone or wood. They protected the wearer from snow blindness by having only narrow slits to see through.

E

Checkpoint

How confidently can you answer the Progression questions?

Strengthen

S1 State one danger to your body of:

a microwaves
b infrared radiation
c ultraviolet radiation
d X-rays and gamma rays.

Extend

E1 Draw a table with a row for each part of the electromagnetic spectrum mentioned on these pages, with frequency increasing down the table. In the second column list any hazards that you know of for each part of the spectrum. Use your table to explain how the frequency relates to the potential danger.

Electromagnetic waves

Infrared and ultraviolet waves have different frequencies. Both types of wave can have harmful effects on humans. Compare and contrast the harmful effects of infrared and ultraviolet waves. **(6 marks)**

Student answer

Infrared waves and ultraviolet waves can both damage our skin [1]. *Infrared waves can cause skin burns, for example when we have been sunbathing* [2]. *Ultraviolet waves can damage our eyes and damage the cells in our skin which can lead to skin cancer* [3]. *Ultraviolet waves have higher frequencies than infrared waves, which is why they cause more harm* [4].

[1] This is a similarity between the harm caused by the two types of radiation. This question asks you to 'compare and contrast', so you need to include both similarities and differences.

[2] The student has mentioned a harmful effect of infrared.

[3] This mentions harmful effects of ultraviolet, and so is contrasting the harm with the harm caused by infrared.

[4] This last part explains why ultraviolet causes more harm by linking its frequency with the danger.

Verdict

This is a strong answer. It mentions the different types of harm that can be caused by each type of wave, and mentions similarities between the waves. The answer also links ideas together by pointing out that the higher frequency waves are more harmful.

Exam tip

Once you have written your answer, read the question again to make sure you have answered all parts of the question. In this case, don't forget to relate the harm caused by the different types of wave to their frequency.

Unit 7 BTEC Transition work

Task 1

Read the article 'Will electric cars break the National Grid'.

Research and find out how many electric cars there are currently on the roads in the UK. How does this compare to the number of petrol and diesel vehicles? Is the number of electric cars expected to increase in the future?

Task 2

Read the textbook excerpt 'The impact of new developments' and then write a short report explaining the economic, environmental, ethical and social impacts of the development of electric cars. You may need to do some more research to help you answer this task – if you do, don't forget to write down the website/article/book you have used.

Some questions that you might want to think about to get started..

Economic

- How much are electric cars to buy? Is this different to petrol or diesel cars?
- How much money is spent on the development of electric cars?
- Will there be an impact on car manufacturers if they don't successfully develop an electric model? What about their employees?

Environmental

- How is the electricity used to charge an electric car generated?
- Are there any environmental issues associated with the batteries in electric cars?
- What would the benefit be if everyone drove an electric car?

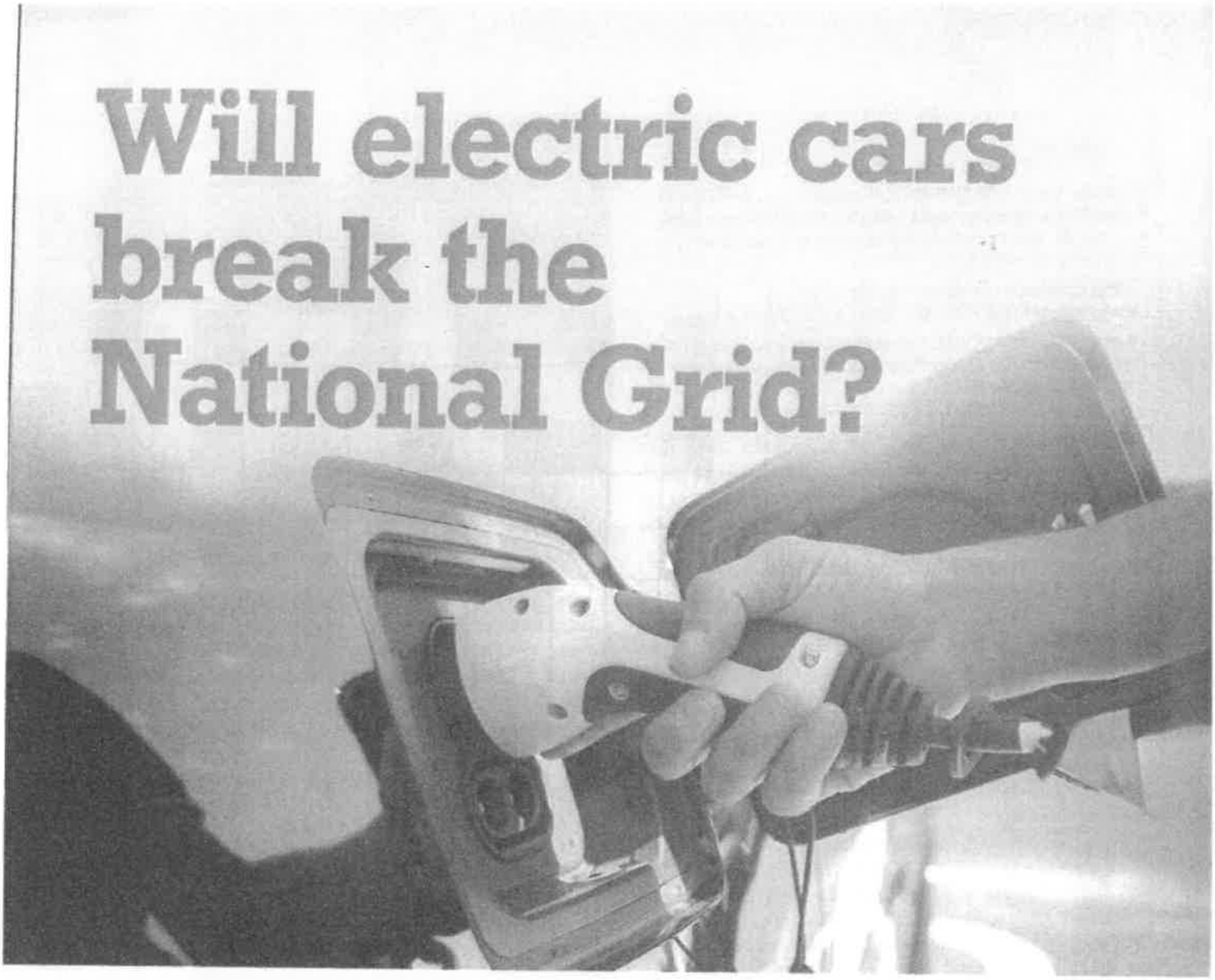
Ethical

- Will electric cars encourage people to drive more? Should we be encouraging the use of public transport?
- Will everyone be able to afford an electric car? If everyone has to have them will there be enough for those who can't afford to buy new?

Social impacts

- Will electric cars affect road safety as they are quiet?

Will electric cars break the National Grid?



Barry Smith

Will the UK's National Grid be able to cope as more people switch to electric vehicles? Barry Smith considers the challenges and some solutions currently being researched

Exam links

The terms in bold link to topics in the AQA, Edexcel, OCR, WJEC and CCEA A-level specifications, as well as the IB, Pre-U and SQA exam specifications.

When discussing our likely **energy** demands, key ideas include **power** and the **conservation of energy**, and the **units** in which power and energy are measured.

Every time you plug in your smartphone, tablet or laptop its lithium-ion battery is doing something it really does not want to do — store energy. During charging, the positive lithium ions are pushed to one side of the battery. This requires energy because, according to Coulomb's law, like electrical charges repel each other. The energy used to charge the battery is stored by reversible chemical reactions.

When the device is in use, the reactions reverse as the battery discharges. Unfortunately, during charge and discharge some energy is dissipated to the surroundings as heat, so the useful energy you get out is always less than the energy you put in. The efficiency is always less than 100%. To make matters worse these batteries degrade over time, so portable devices are not able to store very much energy.

There is significant interest in using batteries to help store electricity for our homes and vehicles. By applying an understanding of energy, power and electricity we can consider whether lithium-ion batteries are up to the task.

Keeping the lights on

The National Grid Control Centre is responsible for keeping the lights on each second of every day. To prevent power cuts, they instruct power stations on how to vary the amount of electricity generated so that the amount supplied matches demand.

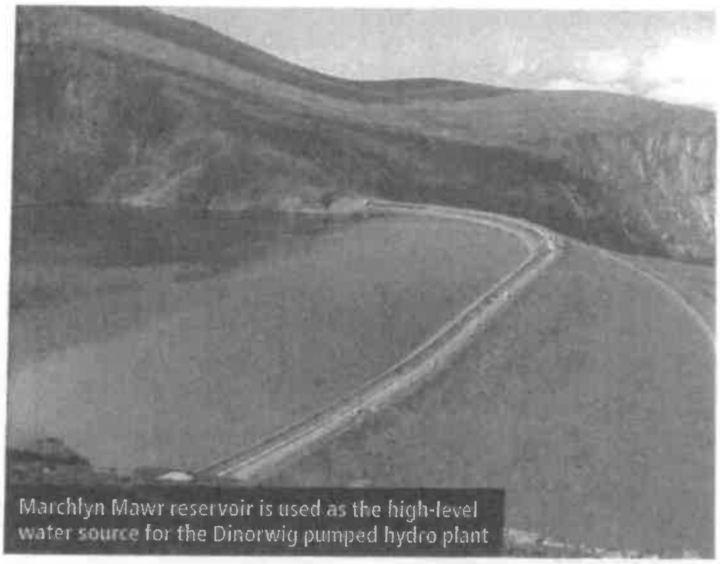
Box 1 Energy units

We usually measure electrical energy in kilowatt-hours (kWh). 1 kWh is equivalent to the energy used by a 1 kilowatt (kW) device running for 1 hour (h). We can work out how much this is in joules if we convert to watts and seconds:

energy transferred (J) = power (W) × time (s)

energy transferred (J) = $1000\,W \times 3600\,s = 3.6 \times 10^6\,J = 3.6\,MJ$

In exams a common mistake is confusing energy and power. The kilowatt-hour is a unit of energy because it is the product of multiplying power and time.



Marchlyn Mawr reservoir is used as the high-level water source for the Dinorwig pumped hydro plant

Boiling 1 litre of water in a kettle requires more than 300000 joules (J) of energy. This would mean that the digits on an electricity meter measuring in joules would be changing too fast to see. Instead, we usually measure electricity in kilowatt-hours (kWh — Box 1). Boiling a kettle only requires around 0.1 kWh.

The amount of electricity that we use varies during the course of each day. Figure 1 shows the electrical power supply for Great Britain. Not much electricity is used in the early hours of the morning, when most people are in bed. Demand increases when people get up and go to schools and jobs, and then it usually peaks in the evening when most people are at home, cooking their evening meal. The minimum demand usually occurs in the summer and the maximum in the winter, when it is colder and darker, and most people are indoors. The total power can exceed 50 gigawatts (GW), equivalent to around 14000 kWh of energy each second.

On top of daily and seasonal variations, the UK National Grid also has to cope with TV pickups. These are when demand spikes due to the curious British urge for a hot drink at the end of television programmes, as households across the country switch on their kettles at the same time. (The record TV pickup was 2.8 GW, when England lost on penalties in the 1990 World Cup semi-final.) Due to changing viewing habits TV pickups are becoming less severe, although in future the charging of electric vehicles and switching from gas to electricity for heating have the potential to cause even larger demand spikes.

Pumped hydro energy storage

To accommodate such large fluctuations, at present the UK relies on pumped hydro energy storage. This type of power station has two reservoirs of water at different heights, connected by a network of pipes. In periods of low demand, when electricity is cheaper (usually in the early hours of the morning), the water is pumped from the lower reservoir to the storage reservoir uphill. When demand increases rapidly the water is released from the top reservoir and flows through turbines, which spin generators to produce electricity (Box 2).

The largest of the UK's four pumped hydro plants is Dinorwig, in Wales. It is among the quickest-responding power stations in the world, able to generate 1.7 GW of power less than 16 seconds after being called into service. At full power it can provide electricity for 5 hours, selling electricity at a higher price when demand is high. What is more, so as not to spoil the landscape in Snowdonia National Park, most of the power station is hidden inside a mountain. To fit all the equipment, engineers had to hollow out a cavern bigger than St Paul's Cathedral.

While pumped hydro plants are very useful, they are very expensive to build. Also, the UK does not have the space required for more similar energy storage schemes. This is a problem because demand for electricity is increasing.

The increasing demand for electricity

To avoid the worst consequences of climate change, by the middle of the century the burning of fossil fuels will have to be

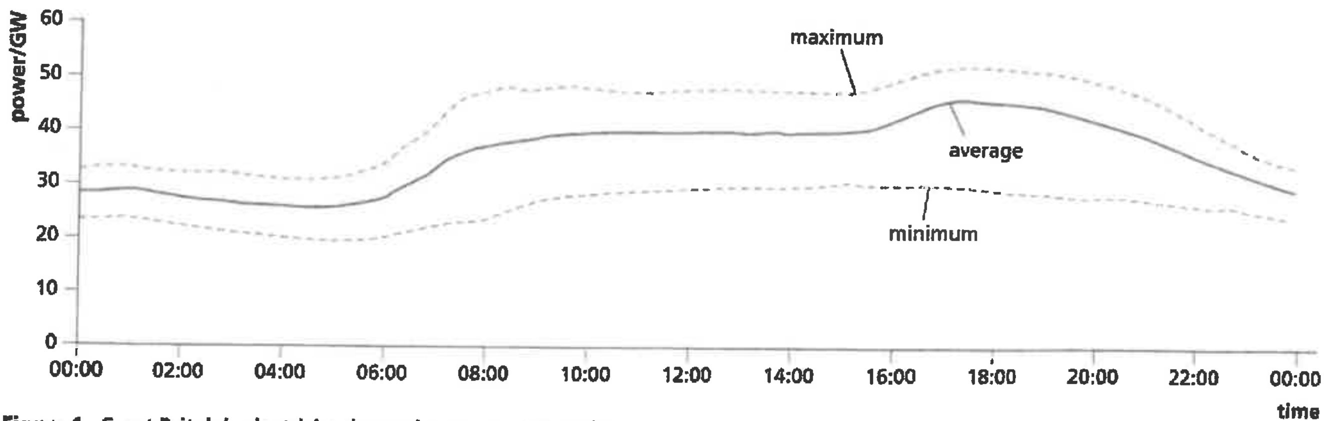
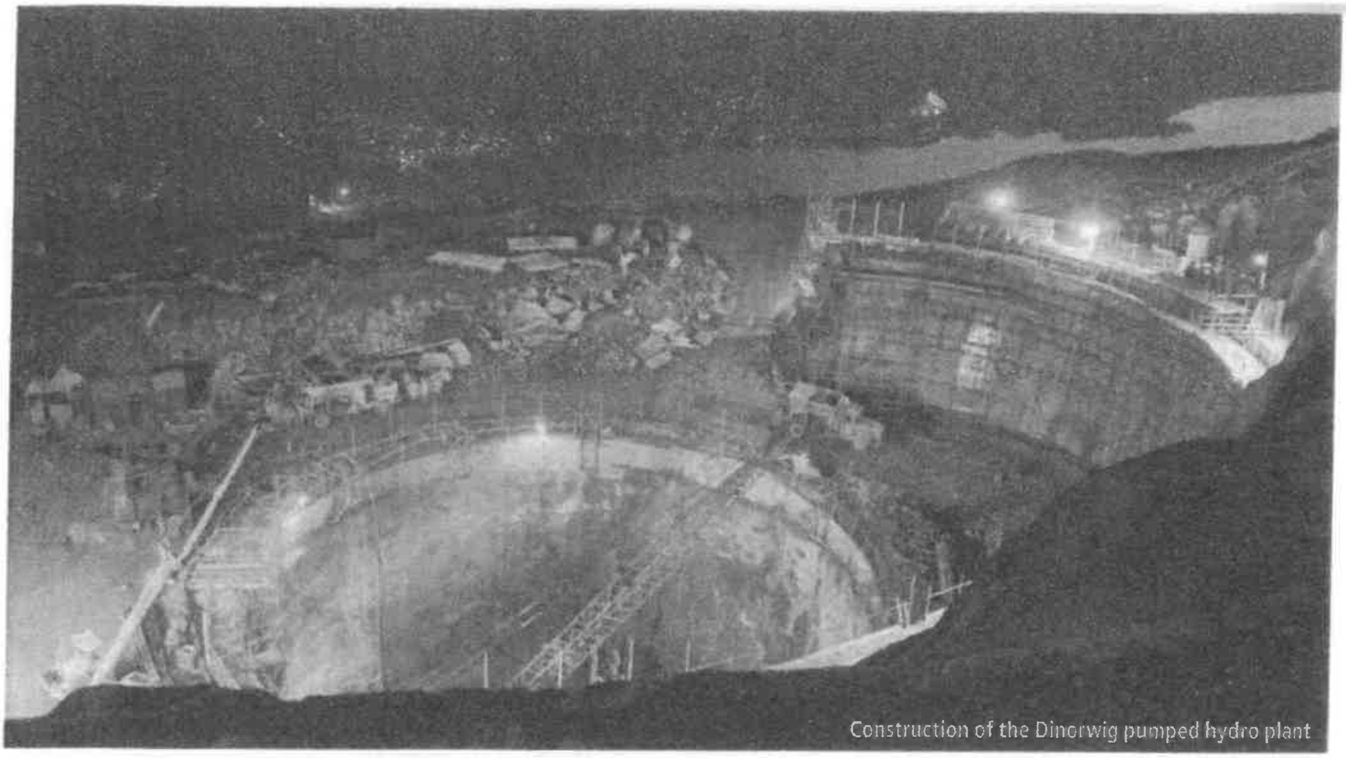


Figure 1 Great Britain's electricity demand over an average day


Construction of the Dinorwig pumped hydro plant

dramatically reduced. We are therefore becoming more reliant on renewable energy technologies, such as wind and solar, which are variable, unlike the predictable output of coal, gas and nuclear power stations.

As part of the United Nations agreement on limiting climate change, by 2050 the UK aims to have reduced its carbon dioxide emissions to only one-fifth of the amount released in 1990. To reduce pollution from transport, governments around the world are also phasing out petrol and diesel vehicles; the UK plan is to ban the sale of these vehicles by 2040.

Electric vehicles

Rather than burning petrol or diesel in an internal combustion engine, we can power vehicles using batteries to turn electric motors. If the electricity is produced using renewable energy or nuclear power stations, this can also help reduce harmful emissions, such as carbon dioxide, nitrogen oxides and particulates.

Already, barely a week goes by without an established car manufacturer announcing plans to build a new electric car. They seem to be taking seriously the threat of the automotive and energy company, Tesla, to sell us its Powerwall home battery systems, with which to charge their expanding range of vehicles.

What would happen if all our petrol and diesel cars were replaced with electric ones? Running an electric car may double the 3000–4000 kWh of electricity used each year by a typical household. If everyone gets home from work and plugs their car in to charge at the same time, the people at the National

Box 2 The physics of pumped hydro

The upper lake at Dinorwig has around 6.7 million cubic metres of water.

Each cubic metre of water has a mass of 1000 kg. To lift water uphill, work is done against the Earth's gravitational field. The increase in gravitational potential energy of 1 m^3 of water when it is lifted 500 m between the lakes at Dinorwig can be found using the equation:

$$\text{change in gravitational potential energy} = \text{mass} \times \text{gravitational field strength} \times \text{change in height}$$

$$\Delta E_p = mg\Delta h \qquad (2.1)$$

So, in this case:

$$\Delta E_p = 1000\,\text{kg} \times 9.8\,\text{m s}^{-2} \times 500\,\text{m}$$
$$= 4.9 \times 10^6\,\text{J}$$
$$= 4.9\,\text{MJ}$$

When electricity is needed the stored water is released, flowing downhill through six turbines. These spin the generators, so that energy is transferred by electrical working from the generators to the National Grid and distributed.

Using the principle of conservation of energy, we can work out how fast the water is flowing when it reaches the turbines:

kinetic energy = ½ × mass × velocity²

$$E_k = \tfrac{1}{2}mv^2 \qquad (2.2)$$

gain in kinetic energy = decrease in gravitational potential energy

$$\tfrac{1}{2}mv^2 = mg\Delta h \qquad (2.3)$$

If we rearrange Equation 2.3 to make v^2 the subject, the mass m cancels:

$$v^2 = 2g\Delta h \qquad (2.4)$$

In this case:

$$v^2 = 2 \times 9.8\,\text{m s}^{-2} \times 500\,\text{m}$$
$$= 9800\,\text{m}^2\,\text{s}^{-2}$$

So:

$$v = 99\,\text{m s}^{-1}$$

Unfortunately, some energy is dissipated by heating the pipes and the bearings of the turbine and generator due to friction. In fact, the overall efficiency of the pumped storage is only around 75%. Even so, pumped storage still works out cheaper than trying to rapidly vary the output of other power stations.

References and further reading

Further information about our energy uses, and a discussion of related challenges:

Mackay D. J. C. (2009) *Sustainable Energy — Without the Hot Air*, UIT Cambridge.

An updated version of the book can be downloaded free of charge from: **www.withouthotair.com/download.html**

For more information about the Dinorwig pumped hydro storage system: **www.electricmountain.co.uk**

Grid Control Centre would not be happy, because the surge in demand could cause power cuts. If we do not plan for this eventuality, the lights will go out. The transition to electric vehicles must be managed effectively, to ensure this does not happen. Thankfully, electric vehicles may be part of the solution.

Rather than build many large, fast-responding power stations, we may be able to make use of the batteries in electric cars. When the car is parked and plugged in the battery can be used to supply energy to the National Grid instead of the vehicle. Sending power from the vehicle to the grid is being trialled. The car owners specify the times they do not need the battery to be charged and are prepared to sell electricity to the grid. Then, at times when demand is high, the car's battery can send power to support the grid. When demand drops the vehicle's battery can be charged steadily, using cheaper electricity overnight. However, there are some hurdles still to be overcome.

The road to better batteries

One concern about switching to electric vehicles is known as range anxiety — how far can you drive before the battery runs out? This problem can be illustrated by comparing how much energy petrol stores with energy stored by a lithium-ion battery. The chemical energy stored in 1 kilogram of petrol is around 70 times the amount stored by a 1 kilogram lithium-ion battery. This means that you need a very heavy battery (and


Charging points are becoming more widespread


Electric car lithium battery pack and power connections

regenerative braking to charge the battery when the car slows down) to provide an acceptable driving range. For example, the 40 kWh battery pack in a Nissan LEAF electric car can provide a range of around 160 miles — less than half that of a comparable petrol car.

Another issue is that batteries lose capacity (known as capacity fade). After fully charging and discharging a battery a few thousand times it cannot store as much energy. This is a problem for an electric vehicle because after a few years it may not be able to reach the distant destinations that it used to manage without stopping at a fast-charging point, which are not always easy to find.

Scientists and engineers are researching ways to make batteries more powerful and energy dense. Perhaps the next generation of electric vehicles will be fitted with solid-state batteries, lithium-air batteries or one of the other types of battery in development, all of which promise a significant increase in performance.

Car manufacturers are also carrying out trials to see if old electric vehicle batteries could be used to provide energy stores connected to the grid. These so-called second-life batteries could continue to be used even after their performance is no longer good enough to meet the high-power demands of vehicles.

The future of storage

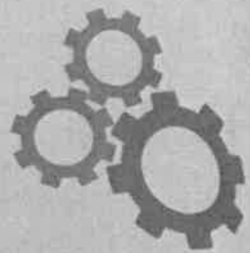
The problem of storing energy has led to a variety of ingenious engineering solutions that apply a range of physics ideas. While large batteries are now being connected to provide storage on the national grid, they are still dwarfed by the 30 GWh capacity of the UK's pumped hydro stations. However, batteries are only one possibility. Other options that are being actively researched include flywheels, producing hydrogen, compressing or liquifying air, ultracapacitors and superconducting magnetic energy storage.

The growth in energy storage in tandem with electric vehicles will be defining technologies in the years ahead. Perhaps some of you reading this will choose careers in which you will be helping to keep the lights on.

Barry Smith is a former physics teacher, who has returned to university to undertake research on energy storage and its applications.

Getting started

The concepts and ideas involved in scientific research are wide ranging and also complex in terms of the science which helps to explain them. As the development in 'cutting-edge' science continues, the number of applications to which it is put increases. This, in theory at least, also helps people all over the world. Working with a partner, produce a questionnaire to be used on learners and staff at your school or college to help you appreciate the general level of scientific understanding in a small sample of the population. Your questionnaire should be a maximum of 20 questions designed to show if people understand a contemporary science issue, e.g. the difference between non-renewable and renewable energy sources or between embryonic and adult stem cells, or the value of space exploration.



A Contemporary scientific issues

This section outlines a number of the fundamental scientific issues which are linked to areas of scientific development. Study of this section will focus on: energy sources, medical treatments, pharmaceuticals and chemicals, food technology and nanotechnology. In each topic you will be provided with an outline of the contemporary scientific issues involved and the impact of some of the technological developments associated with the science.

Understand the scientific issues in terms of ethical, social, economic and environmental impact

Science is moving forward fast. There are developments in areas ranging from the nature of the universe to new ways of treating both inherited and infectious diseases. Much contemporary science – especially the new developments which result from our expanding scientific knowledge – has an impact on human life and well-being. Whenever you look at a contemporary scientific issue you need to consider what ethical, social, economic and environmental impact it may have – if any. What do these terms mean?

- **Economic impacts:** Scientific discoveries and technological developments often affect the financial situation of individuals, companies or countries in unexpected ways. For example, a genetically modified crop which has a much higher yield can have a positive economic benefit on farmers and indeed a whole country. A new medical treatment may make a lot of money for the company which produces it but make a health service or individuals who want it much poorer.

Often the economic impacts of a scientific issue are complicated and work at very different levels.

- **Environmental impacts:** Both global and local environments are fragile. A new scientific development may harm the environment – for example, when CFCs were developed as refrigerants, no-one could have imagined they would cause a hole in the ozone layer. However, scientific developments can also protect the environment – for example solar lamps used in Africa both reduce harmful gases being released into the atmosphere and improve human health.
- **Ethical impacts:** When people try to decide the ethical impact of new science it will depend on many things. For example, many people think that treatments which help infertile couples have children are a very good thing, but some people think it is unethical either because of their religious beliefs or because they think the human population is too big already.
- **Social impacts:** Every time a scientific or technological development changes how people live, it has a social impact. For example, antibiotics have had a big impact on life expectancy and family size in many countries by preventing deaths from bacterial diseases. GM crops containing high levels of nutrients or vaccines could have a similar impact in areas such as sub-Saharan Africa. Driverless cars could greatly reduce road deaths and enable old people to remain independent longer.

Energy sources

Energy transfers are used to power our cars, boats and planes and for lighting, heating and cooking in our homes and industries. Most of the energy we use comes from fossil fuels such as coal, oil and natural gas. Even the

Triple BTEC Science Tasks

Chemistry

Organic Chemistry Keywords

You need to learn these, again flashcards to help are available on my website

Addition polymerisation - A long chain formed of repeating units, eg alkenes

Alkane - a hydrocarbon that only has single bonds in it.

General Formula - the simplest algebraic formula for a compound

Empirical Formula - a formula showing the lowest whole number ratios of elements in a compound.

Structural Formula - The minimal amount of detail needed to determine the special arrangement od elements in a compound

Unsaturated - a compounds that has double or triple bonds

Hydrocarbon - a compounds that is made from hydrogen and carbon only

Alkene - a compound that has at least one double bond

Alkyl group - a side chain that has been forms from an alkane by removing a hydrogen

Functional group - the part of an organic compound that is responsible for the properties

Saturated - a compound that only has single bonds

Aromatic - a compound that contains a benzene ring

Alkynes - A compound that has a least one triple bond

Radical - an element or compound that has an unpaired electron

Homologous Series - a set of organic compounds with the same functional group

Displayed formula - This shows that position of all atoms and the bonding between them

Naming Organic Compounds - The Rules

The prefix of the name indicates the number of carbon atoms present in the molecule.

The functional group, and hence the homologous series to which the compound belongs is usually indicated by the suffix of the name.

1. Find the longest carbon - carbon chain (not always straight).
2. Identify the side branches.
3. Circle all the functional groups and identify them.
4. Number the chain so that the branch with the highest priority functional group has the lowest number possible.
5. Di-, tri etc used for more than one branch of same kind.
6. Branches in alphabetical order.
7. Comma's between numbers eg 2,2 or 2,3.
8. Hyphens separate numbers from letters eg 2,2-dimethyl and no gaps between names eg methylpropane

Balancing Equations 1

These are best done by trial and error

Video links; https://youtu.be/HxKOiqOcJD8

1. $Mg + HIO_3 \rightarrow Mg(IO_3) + H_2$
2. $BaCl_2 + Na_2SO_4 \rightarrow NaCl + BaSO_4$
3. $NaI + HOCl \rightarrow NaIO_3 + HCl$
4. $Al + MnO_2 \rightarrow Al_2O_3 + Mn$
5. $Ba(OH)_2 + H_2SO_4 \rightarrow BaSO_4 + H_2O$
6. $K_2CO_3 + AgNO_3 \rightarrow KNO_3 + Ag_2CO_3$
7. $Sr(ClO_4)_2 + K_2SO_4 \rightarrow SrSO_4 + KClO_4$
8. $Al + H_2SO_4 \rightarrow Al_2(SO_4)_3 + H_2$
9. $HNO_3 + H_2S \rightarrow NO + S + H_2O$
10. $Pb(NO_3)_2 + KCl \rightarrow PbCl_2 + KNO_3$
11. $MgCO_3 + HNO_3 \rightarrow Mg(NO_3)_2 + H_2O + CO_2$
12. $H_2SO_4 + NaOH \rightarrow Na_2SO_4 + H_2O$
13. $SO_2 + HNO_2 \rightarrow H_2SO_4 + NO$
14. $HI + H_2SO_4 \rightarrow H_2O + H_2S + I_2$
15. $HCl + Al(OH)_3 \rightarrow H_2O + AlCl_3$
16. $NaOH + CuSO_4 \rightarrow Na_2SO_4 + Cu(OH)_2$
17. $HF + Ba(NO_3)_2 \rightarrow HNO_3 + BaF_2$
18. $NO_2 + H_2 \rightarrow NH_3 + H_2O$
19. $NH_3 + O_2 \rightarrow NO + H_2O$
20. $HCl + FeCl_2 + H_2O_2 \rightarrow FeCl_3 + H_2O$

Balancing Equations 2

These are best done using the oxidation numbers method

Video links; Balancing Equations Using Oxidation States - Atoms, Electrons, Structure and Bonding #18 https://youtu.be/xQ9th5CpKgo

1. $KBr + H_2SO_4 \rightarrow KHSO_4 + Br_2 + SO_2 + H_2O$
2. $KCl + MnO_2 + H_2SO_4 \rightarrow K_2SO_4 + MnSO_4 + Cl_2 + H_2O$
3. $NaI + H_2SO_4 \rightarrow Na_2SO_4 + I_2 + H_2S + H_2O$
4. $Zn + NO_3^- + H^+ \rightarrow Zn^{2+} + NH_4^+ + H_2O$
5. $HNO_3 + H_3AsO_3 \rightarrow NO + H_3AsO_4 + H_2O$
6. $PbS + H_2O_2 \rightarrow PbSO_4 + H_2O$
7. $Cu + HNO_3 \rightarrow Cu(NO_3)_2 + NO + H_2O$
8. $KIO_3 + KI + H_2SO_4 \rightarrow K_2SO_4 + H_2O + I_2$
9. $Cu + HNO_3 \rightarrow Cu(NO_3)_2 + NO + H_2O$
10. $HNO_3 + I_2 \rightarrow HIO_3 + NO_2 + H_2O$
11. $H_2SO_3 + KMnO_4 \rightarrow K_2SO_4 + MnSO_4 + H_2SO_4 + H_2O$
12. $FeSO_4 + K_2Cr_2O_7 + H_2SO_4 \rightarrow Cr_2(SO_4)_3 + K_2SO_4 + Fe_2(SO_4)_3 + H_2O$
13. $MnSO_4 + NaBiO_3 + H_2SO_4 \rightarrow NaMnO_4 + Bi_2(SO_4)_3 + H_2O + Na_2SO_4$
14. $FeSO_4 + KMnO_4 + H_2SO_4 \rightarrow K_2SO_4 + MnSO_4 + Fe_2(SO_4)_3 + H_2O$
15. $H_2C_2O_4 + KMnO_4 + H_2SO_4 \rightarrow CO_2 + K_2SO_4 + MnSO_4 + H_2O$
16. $MoO_3 + Zn + H_2SO_4 \rightarrow Mo_2O_3 + ZnSO_4 + H_2O$
17. $KMnO_4 + KCl + H_2SO_4 \rightarrow MnSO_4 + K_2SO_4 + H_2O + Cl_2$
18. $KNO_2 + KMnO_4 + H_2SO_4 \rightarrow MnSO_4 + H_2O + KNO_3 + K_2SO_4$
19. $K_2CrO_4 + Na_2SO_3 + HCl \rightarrow KCl + Na_2SO_4 + CrCl_3 + H_2O$
20. $NaOH + Br_2 \rightarrow NaBr + NaBrO_3 + H_2O$

Turning experiments in to balanced symbol equations

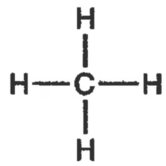
For each of the following experiments give the balanced symbol equation

Video links; Writing Balanced Equations from Word Descriptions. https://youtu.be/WtkxGYAuZqU

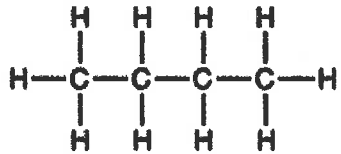
1. Aluminium and iron (III) oxide are reacted together.
2. Nitrogen and chlorine gas react together.
3. Carbon and chlorine gas react together.
4. Calcium chloride is reacted potassium hydroxide.
5. Tetraphosphorus reacts with chlorine.
6. Ethene completely combusts.
7. Magnesium reacts with carbon dioxide.
8. Hydrogen peroxide decomposes.
9. Ethane completely combusts.
10. Iron (III) oxide can carbon react.
11. Titanium (IV) chloride reacts with magnesium.
12. Phosphine (PH_3) is reacted with oxygen.
13. Phosphane (PH_5) is reacted with oxygen.
14. Copper (II) chloride is reacted with sodium hydroxide.
15. Potassium iodide reacts with lead (II) nitrate.
16. Phosphorus trichloride reacts with water.
17. Propane burns completely.
18. Lead (II) nitrate decomposes.
19. Glucose reacts with oxygen.
20. Ammonia reacts with oxygen.

Naming alkanes

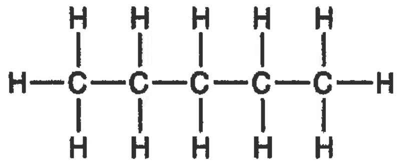
Video link; Naming Alkanes Using IUPAC Systematic Nomenclature - Organic Chemistry #1
https://youtu.be/uv7pJsSiq5w

1.


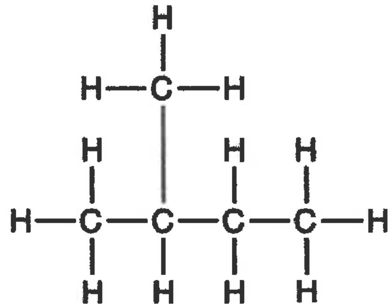
a. methane
b. ethane
c. propane
d. butane

2.


a. butane
b. propane
c. pentane
d. ethane

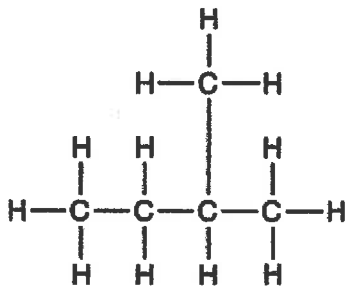
3.


a. 2-ethylpropane
b. 1-methylbutane
c. pentane
d. 2-methylpentane

4.


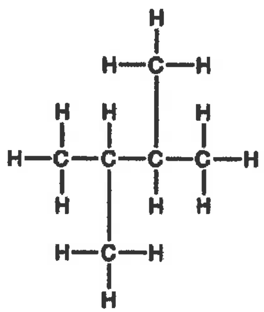
a. pentane
b. 2-methylbutane
c. 1-methylbutane
d. 3-methylbutane

5.



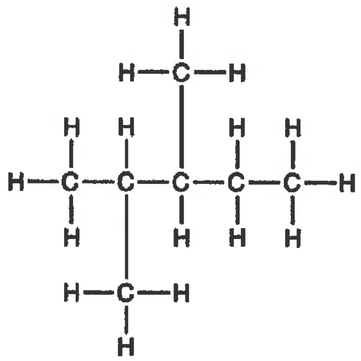
a. pentane
b. 2-methylbutane
c. 1-methylbutane
d. 3-methylbutane

6.



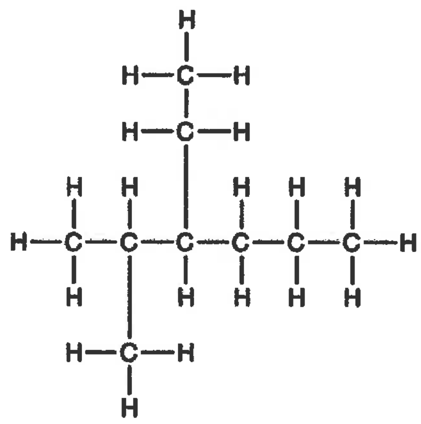
a. 2,3-methylbutane
b. 2,2-dimethylbutane
c. 2,3-dimethylpentane
d. 2,3-dimethylbutane

7.



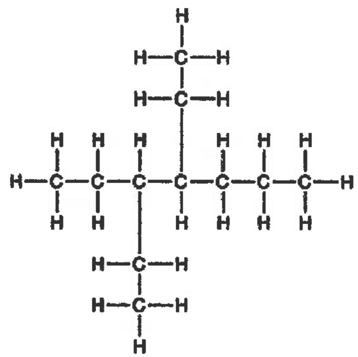
a. 3-ethyl-2-methylbutane
b. 2-ethyl-2-methylbutane
c. 2,3-dimethylpentane
d. 2,3-dimethylbutane

8.



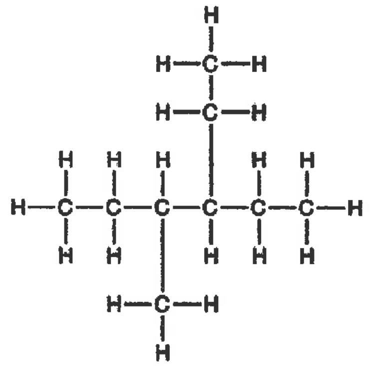
a. 3-methyl-2-ethylhexane
b. 3-ethyl-2-methylhexane
c. 2-ethyl-3-methylhexane
d. 2-methyl-3-ethylhexane

9.

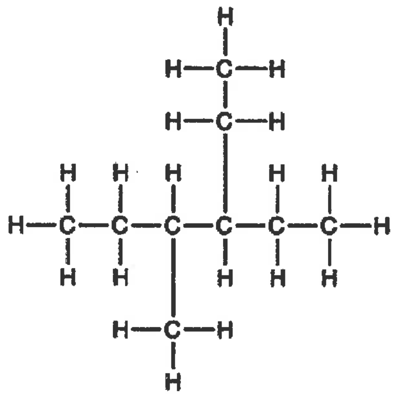


a. 3-ethyl-4-propylhaxane
b. 3-propyl-4-ethylhexane
c. 4-ethyl-3-propylhaxane
d. 3,4-diethlyheptane

10.

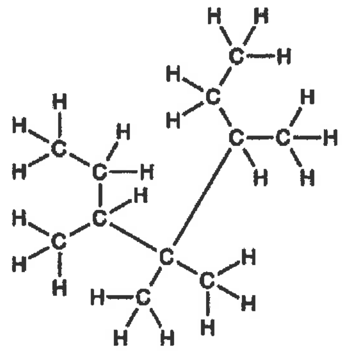


a. 3-ethyl-4-methylhexane
b. 3,4-diethylpentane
c. 2,3-diethylpentane
d. 2-ethyl-4-methylhexane



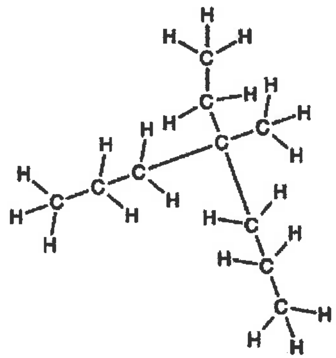
11.

a. 3,4-dimethylhexane
b. 3,4-diethylhexane
c. 4-ethyl-3-methylhexane
d. 4-ethyl-3-methylheptane



12.

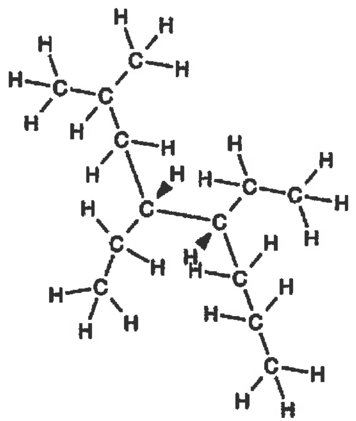
a. 3-methylheptane
b. 3,4,4,5-methylheptane
c. 3,4,5-tetramethylheptane
d. 3,4,4,5-tetramethylheptane



13.

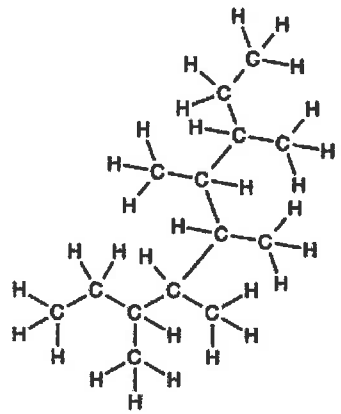
a. 4-ethyl-4methylheptane
b. 4-methyl-4ethylheptane
c. 4-methyl-4-propylhexane
d. 3-methyl-3-propylhexane

14.



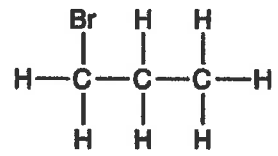
a. 3,4-dipropylpentane
b. 2,3-dipropylpentane
c. 4,5-diethyl-2-methyloctane
d. 4,5-diethyl-7-methyloctane

15.



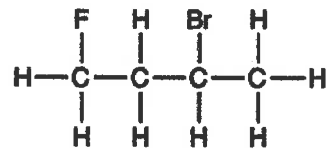
a. 7,6,5,4-methylnonane
b. 1,2,3,4,5,6,7-heptamethylheptane
c. 1,2,3,4,5,6,7-methylheptane
d. 3,4,5,6,7-pentamethylnonane

16.



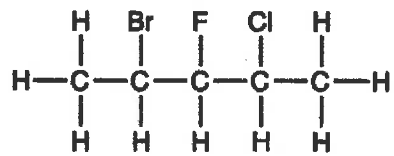
a. 3- bromopropane
b. bromopropane
c. 1-bromopropane
d. 2- bromopropane

17.



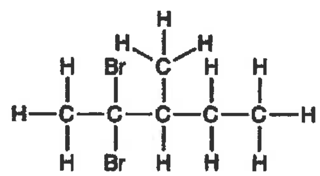
a. 3-bromo-1-flourobutane
b. 1-flouro-3-bromorbutane
c. 2-bromo-4-flurobutnae
d. 4-fluor-2-bromobutane

18.



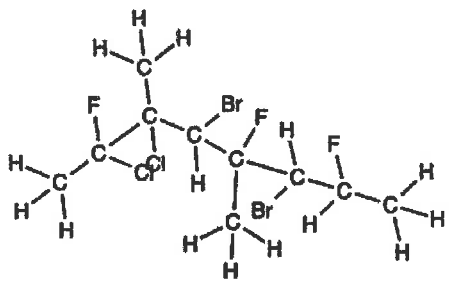
a.2-bromo-4-chloro-3-fluropentane
b. 2-bromo-3-fluropentane
c. 4-chloro-3-fluropentane
d. 2-bromo-4-chloropentane

19.



a. 2-bromo-3-methylpentane
b. 2,2-dibromo-3-methylpentane
c. 3-methyl 2,2-dibromopentane
d. 4,4-dibromo-3-methylpentane

20.

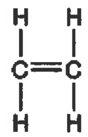


a. 2,4,7-triflouro-6,7-dichloro-4,6-diethyl-3,5-dibromoctane
b. 2,5,7-triflouro-2,3-dichloro-3,5-diethyl-4,6-dibromooctane
c. 3,5-dibromo-6,7-dichloro-4,6-diethyl-2,4,7-triflourooctane
d. 4,6-dibromo-2,3-dichloro-3,5-diethyl-2,5,7-triflourooctane

Naming Alkenes

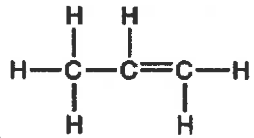
Video link: Naming Alkenes Using IUPAC Systematic Nomenclature - Organic Chemistry #2
https://youtu.be/C-Rt17aLXWQ

1.



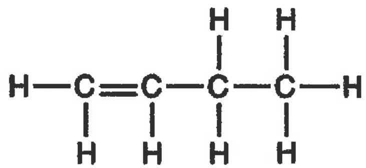
a. methene
b. ethene
c. methane
d. ethane

2.



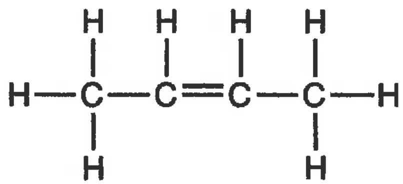
a. prop-1-ene
b. prop-2-ene
c. propane
d. prop-3-ene

3.

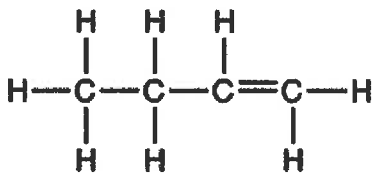


a. but-4-ene
b. but-3-ene
c. but-2-ene
d. but-1-ene

4.

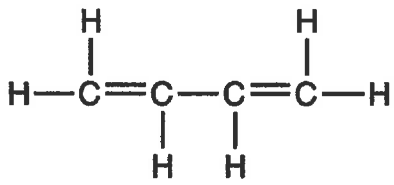


a. but-4-ene
b. but-3-ene
c. but-2-ene
d. but-1-ene



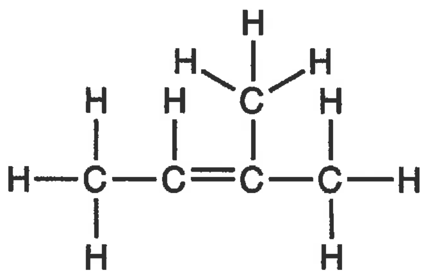
5.

a. but-4-ene
b. but-3-ene
c. but-2-ene
d. but-1-ene



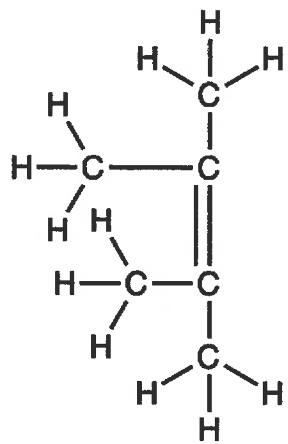
6.

a. but-1,3-diene
b. but-1-ene
c. but-2-ene
d. but-3-ene



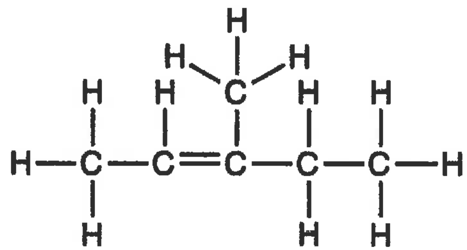
7.

a. 3-methylbut-2-ene
b. 2-methylbut-2-ene
c. pent-2-ene
d. 2-methylpent-2-ene



8.

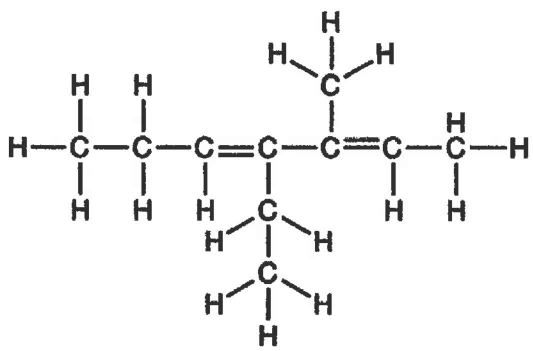
a. 3,2-methylbut-2-ene
b. 2,3-dimethylbut-2-ene
c. pent-2-ene
d. 2,3-methylpent-2-ene



9.

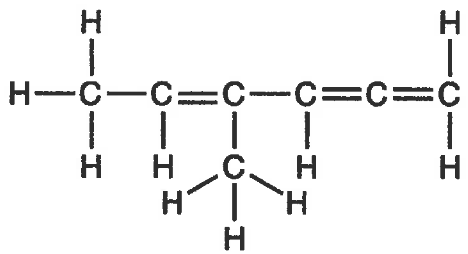
a. 3-methylpent-2-ene
b. 1,2-dimethylbut-1-ene
c. 3,4-dimethylbut-3-ene
d. 3-methylpent-3-ene

10.



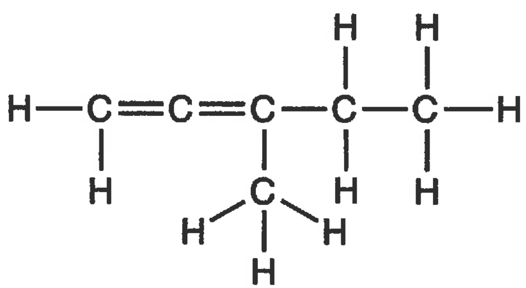
a. 4-ethyl-5-methylhept-3,5-diene
b. 4,5-diethylhex-3,5-diene
c. 4-ethyl-3-methylhex-2,4-diene
d. 4-ethyl-3-methylhept-2,4-diene

11.



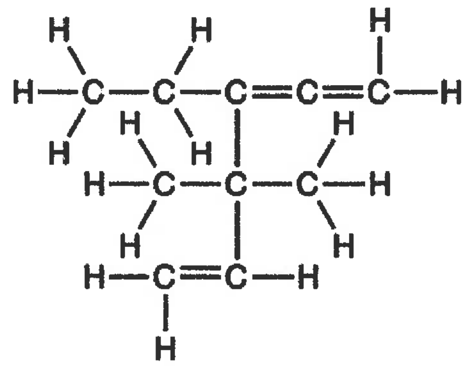
a. 3-methylhex-2,4,5-triene
b. 4-methylhex-1,2,4-triene
c. 1-ethyl-1-methylbut-2,3-diene
d. 4-ethyl-4-methyl-but-1,4-diene

12.



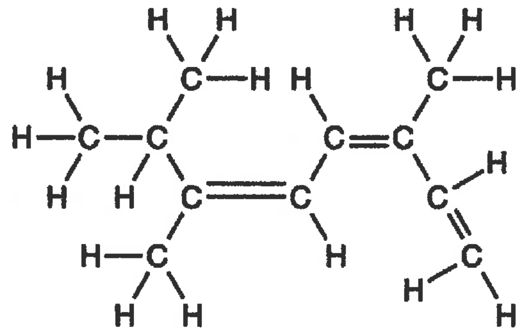
a. 2-ethylbutene
b. 3-methylpent-3,4-diene
c. 3-ethylbut-1,2-diene
d. 3-methylpent-1,2-diene

13.



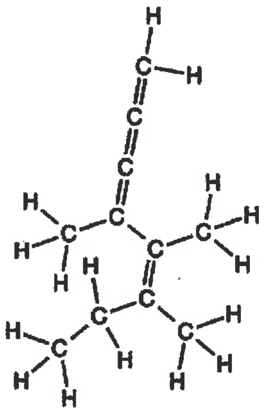
a. 4-ethyl-3,3-dimethylhex-1,4,5-triene
b. 4,4-diethyl-3-methylhex-1,4,5-triene
c. 4,4-diethyl-3-methylhex-1,2,4-triene
d. 4,4-diethyl-3,3-dimethylhex-1,2,5-triene

14.



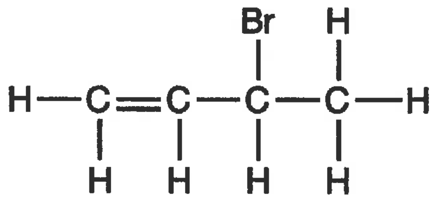
a. 3,5,7-trimethylhept-3,5-diene
b. 3,6,7-trimethyloct-1,3,5-triene
c. 2,3,6-trimethylhept-3,5,7-diene
d. 2,3,6-trimethylhept-3,5-diene

15.



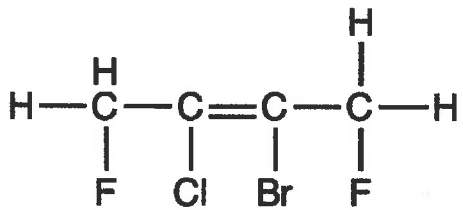
a. 6-ethyl-3,4-dimethylhept-2,4,5,6-tetraene
b. 2-ethyl-4,5-dimethylhept-1,2,3,5-tetraene
c. 3,5,6-trimethyloct-2,4,5,6-tetraene
d. 4,5,6-trimethyloct-1,2,3,5-tetraene

16.



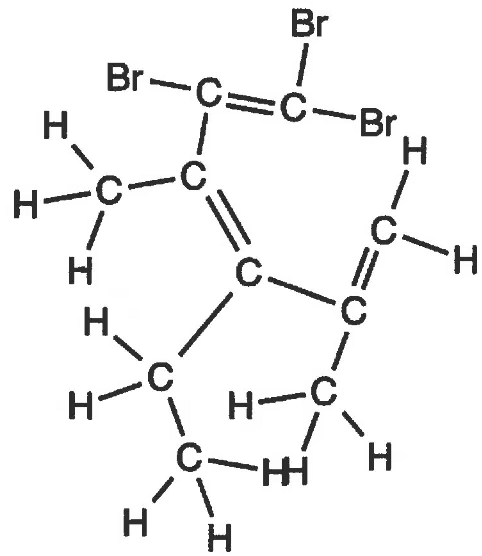
a. 3-bromobut-1-ene
b. 2-bromobut-3-ene
c. 2-bromobut-2-ene
d. 3-bromobut-2-ene

17.



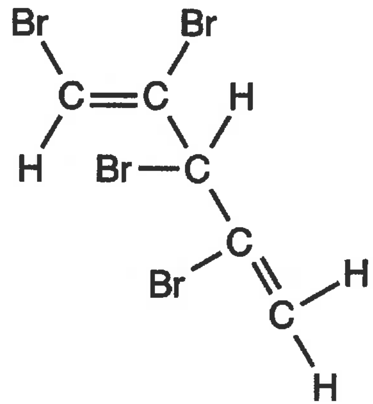
a. 1-flouro-2-bromo-3-chloro-4-flourobut-2-ene
b. 2-bromo-3-chloro-diflouorbut-2-ene
c. 3-bromo-2-chloro-1,4-diflouorbut-2-ene
d. 2-bromo-3-chloro-1,4-diflouorbutene

18.



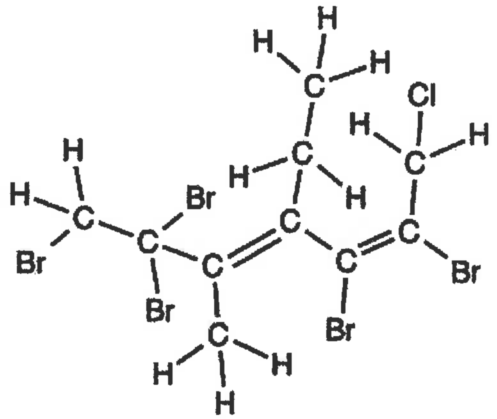
a. 1,1,2-tribomo-4-ethyl-3,5-dimethylhex-1,3,5-triene
b. 1-tribomo-4-ethyl-3-dimethylhex-1-triene
c. 1,1,2-tribomo-4-methyl-3,5-dimethylhex-1,3,5-triene
d. 1,1,2-tribomo-4-methyl-3,5-dimethylhept-1,3,5-triene

19.



a. 1,2,3,4-tetrabromopent-1,4-diene
b. tetrabromopent-1,4-diene
c. 1,2,3,4,5-tetrabromopent-1,4-diene
d. 1,2,3,4-tetrabromopent-1,4-diene

20.



a. 1,2,2,5,6-pentabromo-7-chloro-4-ethyl-3-methylhept-3,5-diene
b. 2,3,6,6,7-pentabromo-1-chloro-4-ethyl-5-methylhept-2,4-diene
c. pentabromochloroethylmethylhept-3,5-diene
d. 2,3,6,7-pentabromo-1-chloro-4-ethylhept-2,4-diene

Skeletal formula

Video link: Skeletal Formula - Organic Chemistry #6 https://youtu.be/yiuhhkO2QzY

1.

a. methane
b. ethene
c. ethane
d. propane

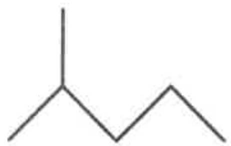
2.

a. propane
b. methane
c. ethane
d. ethene

3.

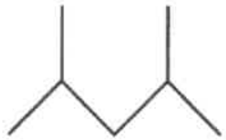
a. butane
b. propane
c. hexane
d. pentane

4.



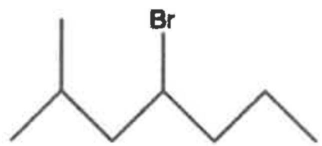
a. 4-methylpentane
b. methylbutane
c. 2-methylpentane
d. 2-methylbutane

5.

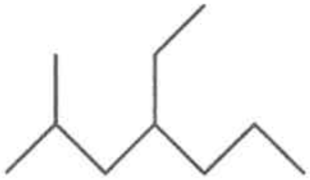


a. pentane
b. 2,4-dimethylbutane
c. 2,4-dimethylpentane
d. 2,4-dimethylhaxane

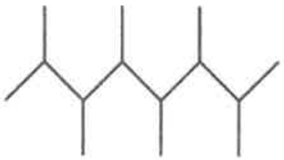
6.



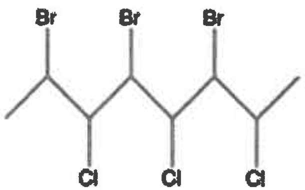
a. 4-bromo-2-methylheptane
b. 4-bromomethyl-2-methylheptane
c. 4-bromomethyl-2-methylpentane
d. 4-bromomethyl-2-methylhexane

7. 

a. 4-ethyl-6-methylheptane
b. 4-ethyl-2-methylheptane
c. 4-ethyl-2-methylhexane
d. -ethyl-6-methylhexane

8. 

a. 1,2,3,4,5,6,7,8-hexamethyloctane
b. Tetradecane
c. 2,3,4,5,6,7-hexamethyloctane
d. 2,3,4,5,6,7-methyloctane

9. 

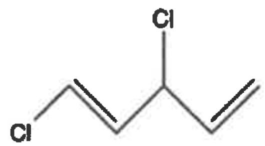
a. 2,4,6-tribromo-3,5,7-trichlorooctane
b. 2,3,4,5,6,7-tribromotrichlorooctane
c. 2,4,6-tribromo-3,5,7-trichlorohexane
d. 2,4,6,8-tribromo-1,3,5,7-trichlorohexane

10. 

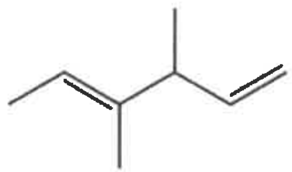
a. pentane
b. pent-3-ene
c. pent-2-ene
d. pent-1-ene

11. 

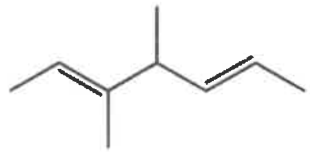
a. hexene
b. hex-1,4-diene
c. hex-2,5-diene
d. pent-1,4-diene

12. 

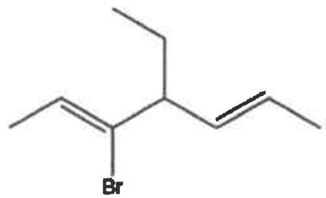
a. 1,3-dicholohex-2,5-diene
b. 3,6-dicholohex-1,4-diene
c. 1,3-dicholopent-1,4-diene
d. 3,5-dicholopent-1,4-diene

13. 

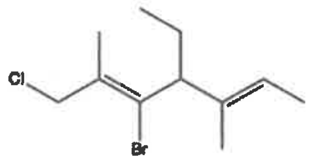
a. 3,4-dimethylhex-2,5-diene
b. 4-methylhex-1,4-diene
c. 3,4-diethylhex-2,5-diene
d. 3,4-dimethylhex-1,4-diene

14. 

a. 2,3-dimethylhex-1,4-diene
b. 4,5-diemthylhept-2,5-diene
c. 3,4-dimethylhex-1,4-diene
d. 3,4-diemthylhept-2,5-diene

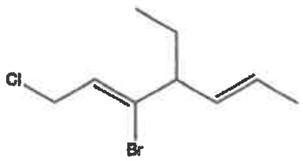
15. 

a. 5-bromo-4-ethylhept-2,5-diene
b. 3-bromo-4-ethylhept-2,5-diene
c. 3-bromo-4-methylhept-2,5-diene
d. 3-bromomethyl-4-ethylhept-2,5-diene

16. 

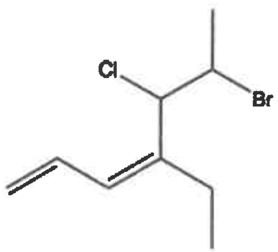
a. 3-bromo-1-chloro-4-ethyl-2,5-dimethylhept-2,5-diene
b. 1-chloro-3-bromo-4-ethyl-2,5-dimethylhept-2,5-diene
c. 5-bromo-7-chloro-4-ethyl-3,6-dimethylhept-2,5-diene
d. 5-bromo-8-chloro-4-ethyl-3,6-dimethyloct-2,5-diene

17.



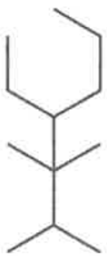
a. 4-bromo-1-chloro-5-ethlyoct-3,7-diene
b. 5-bromo-7-chloro-4-ethlyhept-2,5-diene
c. 3-bromo-1-chloro-4-ethlyhept-2,5-diene
d. 3-bromo-1-chloro-4-ethlyhex-2,5-diene

18.



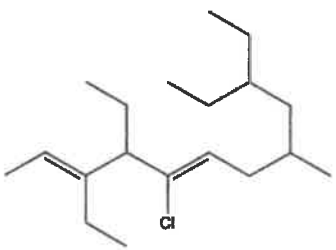
a. 2-bromo-3-chloro-4-ethylhept-4,6-diene
b. 6-bromo-5-chloro-4-ethylhept-1,3-diene
c. 6-bromo-5-chloro-4-ethylhex-1,3-diene
d. 2-bromo-3-chloro-4-ethylhex-4,6-diene

19.



a. 4-ethyl-2,3,3-trimethlyheptane
b. Bob
c. 4-propyl-2,3,3-trimethlyhexane
d. 4-ethyl-2,3,3methlyheptane

20.



a. 8-chloro-3,9,10-triethyl-5-methyldodec-7,10-diene
b. 5-chloro-3,4,10-triethyl-8-methyldodec-2,5-diene
c. 5-chloro-3,4,10-ethyl-8-methyldec-2,5-ene
d. 8-chloro-3,9,10-triethyl-5-methyldec-7,10-diene

Answers

Atomic structure

1. b
2. a
3. a
4. a
5. b
6. b
7. c
8. a
9. c
10. b
11. b
12. a
13. d
14. c
15. a
16. c
17. a
18. b
19. b
20. D

Properties of ionic compounds

1. b
2. c
3. c
4. c
5. d
6. d
7. c
8. b

9. d
10. c
11. c
12. c
13. b
14. c
15. d

Covalent bonding

1. c
2. b
3. a
4. b
5. b
6. d
7. d
8. a
9. b
10. c
11. c
12. a
13. B and d
14. b
15. a
16. a
17. b
18. a
19. a
20. C

Formula of Ionic Compounds

1. AgI
2. MgI_2

3. LiI
4. PbI_2
5. CuI_2
6. $FeBr_3$
7. $FeBr_2$
8. $BaBr_2$
9. $SrBr_2$
10. $SrCl_2$
11. $CuCl_2$
12. $FeCl_2$
13. $CaCl_2$
14. $LiCl_2$
15. $BaCl_2$
16. Na_2O
17. K_2O
18. ZnO
19. Al_2O_3
20. SrO
21. Cu_2O
22. CuO
23. Fe_2O_3
24. FeO
25. Cr_2O_3
26. $FeCO_3$
27. $(NH_4)_2CO_3$
28. $CuCO_3$
29. $PbCO_3$
30. Na_2CO_3
31. $MgCO_3$
32. $FeCO_3$
33. $BaCO_3$
34. $KHCO_3$
35. $Sr(HCO_3)_2$
36. $LiHCO_3$
37. NH_4HCO_3
38. $NaHCO_3$
39. $Mg(HCO_3)_2$
40. $(NH_4)_2S$

41. FeS
42. Al_2S_3
43. $Fe_2(SO_4)_3$
44. $FeSO_4$
45. $PbSO_4$
46. $Al_2(SO_4)_3$
47. $ZnSO_4$
48. $BaSO_4$
49. $(NH_4)_2SO_4$
50. $MgSO_4$
51. Li_2SO_4
52. $Mg(OH)_2$
53. $Al(OH)_3$
54. KOH
55. NH_4OH
56. $Ba(OH)_2$
57. $LiOH$
58. $Ca(OH)_2$
59. $Sr(OH)_2$
60. $Al(NO_3)_3$
61. NH_4NO_3
62. $Pb(NO_3)_2$
63. $NaNO_2$
64. Li_3N
65. Mg_3N_2

Oxidation numbers

1. a
2. b
3. a
4. a
5. c
6. c
7. c
8. c
9. d
10. d

11. c
12. d
13. b
14. a
15. a
16. c
17. b
18. c
19. d
20. A

Balancing Equations 1

These are best done by trial and error

1. $2Mg + 2HIO_3 \rightarrow 2Mg(IO_3) + H_2$
2. $BaCl_2 + Na_2SO_4 \rightarrow 2NaCl + BaSO_4$
3. $NaI + 3HOCl \rightarrow NaIO_3 + 3HCl$
4. $4Al + 3MnO_2 \rightarrow 2Al_2O_3 + 3Mn$
5. $Ba(OH)_2 + H_2SO_4 \rightarrow BaSO_4 + 2H_2O$
6. $K_2CO_3 + 2AgNO_3 \rightarrow 2KNO_3 + Ag_2CO_3$
7. $Sr(ClO_4)_2 + K_2SO_4 \rightarrow SrSO_4 + 2KClO_4$
8. $2Al + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2$
9. $2HNO_3 + 3H_2S \rightarrow 2NO + 3S + 4H_2O$
10. $Pb(NO_3)_2 + 2KCl \rightarrow PbCl_2 + 2KNO_3$
11. $MgCO_3 + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2O + CO_2$
12. $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$
13. $SO_2 + 2HNO_2 \rightarrow H_2SO_4 + 2NO$
14. $8HI + H_2SO_4 \rightarrow 4H_2O + H_2S + 4I_2$
15. $3HCl + Al(OH)_3 \rightarrow 3H_2O + AlCl_3$
16. $2NaOH + CuSO_4 \rightarrow Na_2SO_4 + Cu(OH)_2$
17. $2HF + Ba(NO_3)_2 \rightarrow 2HNO_3 + BaF_2$
18. $2NO_2 + 7H_2 \rightarrow 2NH_3 + 4H_2O$
19. $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$
20. $2HCl + 2FeCl_2 + H_2O_2 \rightarrow 2FeCl_3 + 2H_2O$

Balancing Equations 2

These are best done using the oxidation numbers method

1. $2KBr + 3H_2SO_4 \rightarrow 2KHSO_4 + Br_2 + SO_2 + 2H_2O$
2. $2KCl + MnO_2 + 2H_2SO_4 \rightarrow K_2SO_4 + MnSO_4 + Cl_2 + 2H_2O$
3. $8NaI + 5H_2SO_4 \rightarrow 4Na_2SO_4 + 4I_2 + H_2S + 4H_2O$
4. $4Zn + NO_3^- + 10H^+ \rightarrow 4Zn^{2+} + NH_4^+ + 3H_2O$
5. $2HNO_3 + 3H_3AsO_3 \rightarrow 2NO + 3H_3AsO_4 + H_2O$
6. $PbS + 4H_2O_2 \rightarrow PbSO_4 + 4H_2O$
7. $3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$
8. $KIO_3 + 5KI + 3H_2SO_4 \rightarrow 3K_2SO_4 + 3H_2O + 3I_2$
9. $3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$
10. $10HNO_3 + I_2 \rightarrow 2HIO_3 + 10NO_2 + 4H_2O$
11. $5H_2SO_3 + 2KMnO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 2H_2SO_4 + 3H_2O$
12. $6FeSO_4 + K_2Cr_2O_7 + 7H_2SO_4 \rightarrow Cr_2(SO_4)_3 + K_2SO_4 + 3Fe_2(SO_4)_3 + 7H_2O$
13. $4MnSO_4 + 10NaBiO_3 + 14H_2SO_4 \rightarrow 4NaMnO_4 + 5Bi_2(SO_4)_3 + 14H_2O + 3Na_2SO_4$
14. $10FeSO_4 + 2KMnO_4 + 8H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 8H_2O$
15. $5H_2C_2O_4 + 2KMnO_4 + 3H_2SO_4 \rightarrow 10CO_2 + K_2SO_4 + 2MnSO_4 + 8H_2O$
16. $2MoO_3 + 3Zn + 3H_2SO_4 \rightarrow Mo_2O_3 + 3ZnSO_4 + 3H_2O$
17. $2KMnO_4 + 10KCl + 8H_2SO_4 \rightarrow 2MnSO_4 + 6K_2SO_4 + 8H_2O + 5Cl_2$
18. $5KNO_2 + 2KMnO_4 + 3H_2SO_4 \rightarrow 2MnSO_4 + 3H_2O + 5KNO_3 + K_2SO_4$
19. $2K_2CrO_4 + 3Na_2SO_3 + 10HCl \rightarrow 4KCl + 3Na_2SO_4 + 2CrCl_3 + 5H_2O$
20. $6NaOH + 3Br_2 \rightarrow 5NaBr + NaBrO_3 + 3H_2O$

Turning experiments in to balanced symbol equations

1. $Fe_2O_3 + 2Al \rightarrow 2Fe + Al_2O_3$
2. $N_2 + 3Cl_2 \rightarrow 2NCl_3$
3. $C + 2Cl_2 \rightarrow CCl_4$
4. $CaCl_2 + 2KOH \rightarrow Ca(OH)_2 + 2KCl$
5. $P_4 + 6Cl_2 \rightarrow 4PCl_3$
6. $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

7. $2Mg + CO_2 \rightarrow 2MgO + C$
8. $2H_2O_2 \rightarrow 2H_2O + O_2$
9. $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$
10. $Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$
11. $TiCl_4 + 2Mg \rightarrow 2MgCl_2 + Ti$
12. $2PH_3 + 3O_2 \rightarrow P_2O_3 + 3H_2O$
13. $2PH_5 + 5O_2 \rightarrow P_2O_5 + 5H_2O$
14. $CuCl_2 + 2NaOH \rightarrow Cu(OH)_2 + 2NaCl$
15. $2KI + Pb(NO_3)_2 \rightarrow 2KNO_3 + PbI_2$
16. $PCl_3 + 3H_2O \rightarrow P(OH)_3 + 3HCl$
17. $C_3H_8 + 5O_2 \rightarrow 5CO_2 + 4H_2O$
18. $2Pb(NO_3)_2 \rightarrow 2PbO + 4NO_2 + O_2$
19. $C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2$
20. $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

Naming alkanes

1. a
2. a
3. c
4. b
5. b
6. d
7. c
8. b
9. d
10. a
11. c
12. d
13. a
14. c
15. d
16. c
17. a
18. a
19. b

20. D

Naming alkenes

Answer key

1. b
2. a
3. d
4. c
5. d
6. a
7. b
8. b
9. a
10. d
11. b
12. d
13. a
14. b
15. d
16. a
17. c
18. a
19. d
20. B

Skeletal formula

1. c
2. a
3. d
4. c
5. c
6. a
7. b
8. c
9. a

10. c
11. b
12. c
13. d
14. d
15. b
16. a
17. c
18. b
19. a
20. B