Scientific Communications

Name: ____________________

Class: ____________________

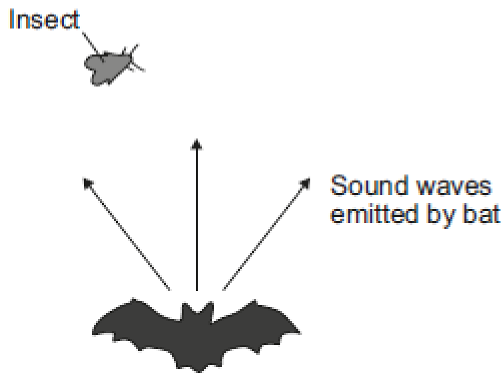
Date: ____________________

Time: **389 minutes**

Marks: **389 marks**

Comments:

1 Bats use the reflection of high pitched sound waves to determine the position of objects. The image below shows a bat and an insect flying in front of the bat.



(a) What determines the pitch of a sound wave?

Tick (✓) **one** box.

	Tick (✓)
amplitude	
frequency	
speed	

(1)

(b) State the name given to reflected sound waves.

....

(1)

(c) The bat emits a sound wave with a frequency of 25.0 kHz and a wavelength of 0.0136 metres.

Calculate the speed of this sound wave.

....

....

....

Speed = ... m/s

(2)

(d) Sound waves are longitudinal. Describe a longitudinal sound wave.

....

....

....

....

(2)
(Total 6 marks)

2 A small community of people live in an area in the mountains.
The houses are not connected to the National Grid.

The people plan to buy an electricity generating system that uses either the wind or the flowing water in a nearby river.

Figure 1 shows where these people live.

Figure 1

(a) It would not be economical to connect the houses to the National Grid.
Give **one** reason why.

....

....

....

....

(1)

(b) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Information about the two electricity generation systems is given in **Figure 2**.

Figure 2

The wind turbine costs £50 000 to buy and install.
The hydroelectric generator costs £20 000 to buy and install.
The average power output from the wind turbine is 10 kW.
The hydroelectric generator will produce a constant power output of 8 kW.

Compare the advantages and disadvantages of the two methods of generating electricity.

Use your knowledge of energy sources as well as information from **Figure 2**.

(6)
(Total 7 marks)

3 Infrared and microwaves are two types of electromagnetic radiation.

(a) State **one** example of the use of each type of radiation for communication.

Infrared: ....

Microwaves: ....

(2)

(b) Some of the properties of infrared and microwaves are the same.

State **two** of these properties.

1 ....

....

2 ....

....

(2)
(Total 4 marks)

4 All European Union countries are expected to generate 20% of their electricity using renewable energy sources by 2020.

The estimated cost of generating electricity in the year 2020 using different energy sources is shown in **Table 1**.

Table 1

Energy source	Estimated cost (in the year 2020) in pence per kWh
Nuclear	7.8
Solar	25.3
Tidal	18.8
Wind	10.0

France generated 542 billion kWh of electricity using nuclear power stations in 2011.
France used 478 billion kWh of electricity and sold the rest of the electricity to other countries in 2011.

(a) France may continue generating large amounts of electricity using nuclear power stations instead of using renewable energy resources.

Suggest **two** reasons why.

1. ....

....

2. ....

....

(2)

(b) Give **two** disadvantages of generating electricity using nuclear power stations.

1. ....

....

2. ....

....

(2)

(c) A panel of solar cells has an efficiency of 0.15.

The total power input to the panel of solar cells is 3.2 kW.

Calculate the useful power output of this panel of solar cells in kW.

....

....

....

....

Useful power output = ... kW

(2)

(d) **Table 2** shows the manufacturing cost and efficiency of different types of panels of solar cells.

Table 2

Type of Solar Panel	**Cost to manufacture a 1 m^2 solar panel in £**	**Efficiency in %**
A	40.00	20
B	22.50	15
C	5.00	10

Some scientists think that having a low manufacturing cost is more important than improving the efficiency of solar cells.

Use information from **Table 2** to suggest why.

....

....

....

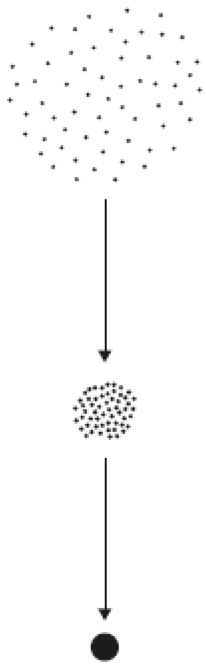
....

....

....

(2)
(Total 8 marks)

5 (a) The figure below shows how a star is formed.
Use **one** answer from each box to complete the sentences.



gas	**rock**	**water**

A star starts as a huge cloud of dust and ____________________ particles in space.

friction	**fusion**	**gravity**

The force of ____________________ pulls the particles in the cloud closer together.

protostar	**red giant**	**white dwarf**

The compressed mass of particles

forms a ____________________ .

(3)

(b) Elements heavier than iron are formed in a supernova.
What is a supernova?

Tick (✓) **one** box.

the explosion of a massive star ☐

a very bright, hot young star ☐

a very cool super giant star ☐

(1)

(c) Brown dwarf stars are small stars too cool to give out visible light. They were first discovered in 1995. Scientists think that there are millions of these stars spread throughout the Universe.

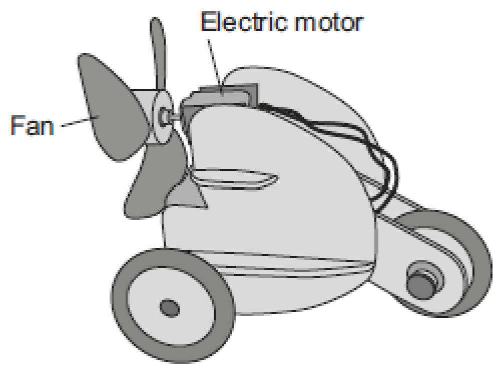
Which **one** of the following is the most likely reason why brown dwarf stars were not discovered before 1995?

Tick (✓) **one** box.

Brown dwarf stars did not exist before 1995.	☐
Scientists were looking in the wrong part of the Universe.	☐
The telescopes and measuring instruments were not sensitive enough.	☐

(1)
(Total 5 marks)

6 The diagram shows an air-driven toy.
When the electric motor is switched on the fan rotates.
The fan pushes air backwards making the toy move forwards.



(a) (i) The toy has a mass of 0.15 kg and moves forward with a velocity of 0.08 m/s.

How is the momentum of the toy calculated?

Tick (✓) **one** box.

$0.15 + 0.08 = 0.230$	☐
$0.15 \div 0.08 = 1.875$	☐
$0.15 \times 0.08 = 0.012$	☐

(1)

(ii) What is the unit of momentum?

Tick (✓) **one** box.

kg m/s ☐ m/s^2 ☐ kg/m/s ☐

(1)

(iii) Use the correct answer from the box to complete the sentence.

less than	**equal to**	**more than**

The momentum of the air backwards is .... the momentum of the toy forwards.

(1)

(b) The electric motor can rotate the fan at two different speeds.

Explain why the toy moves faster when the fan rotates at the higher of the two speeds.

....

....

....

....

(2)
(Total 5 marks)

7 (a) Uranium has two natural isotopes, uranium-235 and uranium-238.

Use the correct answer from the box to complete the sentence.

electrons	**neutrons**	**protons**

The nucleus of a uranium-238 atom has three more .... than the nucleus of a uranium-235 atom.

(1)

(b) Uranium-235 is used as a fuel inside a nuclear reactor.
Energy is released from nuclear fuels by the process of nuclear fission.

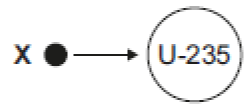
What is the energy released from nuclear fuels inside a nuclear reactor used for?

....

(1)

(c) **Figure 1** shows the nucleus of an atom of uranium-235 (U-235) about to undergo nuclear fission.

Figure 1



(i) Before nuclear fission can happen the nucleus of a uranium atom has to absorb the particle labelled **X**.

What is particle **X**?

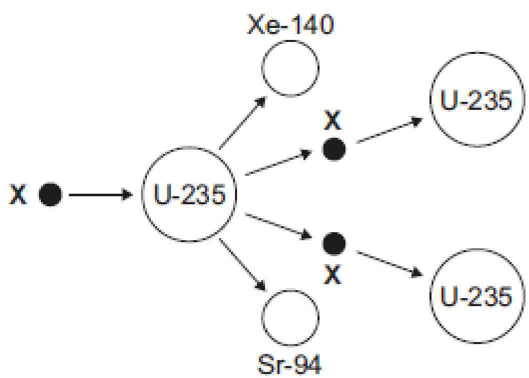
Tick (✓) **one** box.

an electron ☐ a neutron ☐ a proton ☐

(1)

(ii) The process of nuclear fission, shown in **Figure 2**, causes the nucleus of the uranium-235 (U-235) atom to split apart and release two of the particles X.

Figure 2



Complete **Figure 2** to show how the particles **X start** a chain reaction.

(2)
(Total 5 marks)

8 Alpha particles, beta particles and gamma rays are types of nuclear radiation.

(a) Describe the structure of an alpha particle.

....

....

(1)

(b) Nuclear radiation can change atoms into ions by the process of ionisation.

(i) Which type of nuclear radiation is the least ionising?

Tick (✓) **one** box.

alpha particles	☐
beta particles	☐
gamma rays	☐

(1)

(ii) What happens to the structure of an atom when the atom is ionised?

....

....

(1)

(c) People working with sources of nuclear radiation risk damaging their health.

State **one** precaution these people should take to reduce the risk to their health.

....

....

(1)

(d) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

The type of radiation emitted from a radioactive source can be identified by comparing the properties of the radiation to the properties of alpha, beta and gamma radiation.

Describe the properties of alpha, beta and gamma radiation in terms of their:

- penetration through materials
- range in air
- deflection in a magnetic field.

(6)
(Total 10 marks)

9 (a) Brown dwarf stars are thought to have been formed in the same way as other stars.
They are too small for nuclear fusion reactions to take place in them.
Brown dwarf stars emit infrared radiation but are not hot enough to emit visible light.

(i) Describe how a star is formed.

....

....

....

....

(2)

(ii) Describe the process of nuclear fusion.

....

....

....

(1)

(iii) Scientists predicted that brown dwarf stars existed before the first one was discovered in 1995.

Suggest **one** reason why scientists are now able to observe and identify brown dwarf stars.

....

....

....

(1)

(b) In the 18th century some scientists suggested a theory about how the planets formed in the Solar System. The theory was that after the Sun formed, there were cool discs of matter rotating around the Sun. These cool discs of matter formed the planets. The scientists thought this must have happened around other stars too.

(i) Thinking about this theory, what would the scientists have predicted to have been formed in other parts of the Universe?

....

....

(1)

(ii) Since the 1980s scientists studying young stars have shown the stars to be surrounded by cool discs of rotating matter.

What was the importance of these observations to the theory the scientists suggested in the 18th century?

....

....

(1)

(c) The Earth contains elements heavier than iron.

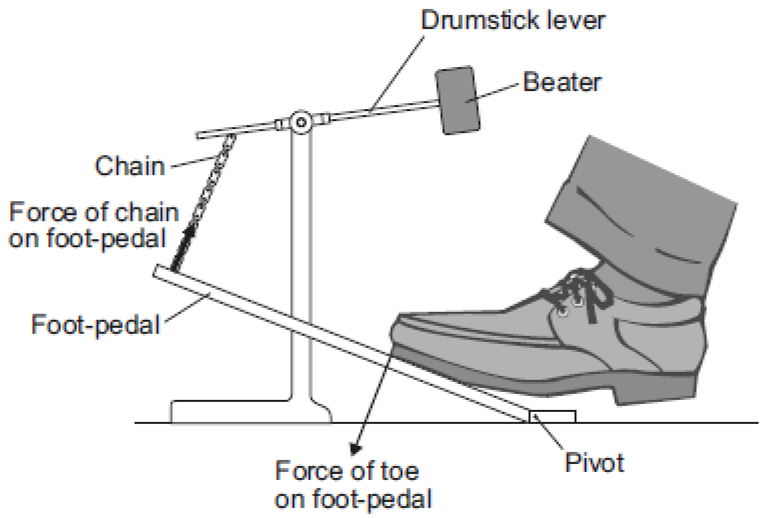
Why is the presence of elements heavier than iron in the Earth evidence that the Solar System was formed from material produced after a massive star exploded?

....

....

(1)
(Total 7 marks)

10 A drum is hit by a beater attached to a drumstick lever. The drumstick lever is attached to a foot-pedal by a chain, as shown below.



(a) State how the size of the force of the chain on the foot-pedal compares with the size of the force of the toe on the foot-pedal.

....

....

(1)

(b) The foot-pedal is pushed halfway down and held stationary.

The force of the toe and the force of the chain each create a moment which acts on the foot-pedal.

Compare the size and direction of the moments of the toe and the chain.

Tick (✓) **one** box.

Size	**Direction**	**Tick (✓)**
The moments are equal	same	
The moments are equal	opposite	
The moment of the force of the toe is greater	same	

(1)

(c) How can the drummer create a greater moment about the pivot without increasing the force he applies?

....

....

(1)
(Total 3 marks)

11 (a) Electromagnets are often used at recycling centres to separate some types of metals from other materials.

Give **one** reason why an electromagnet would be used rather than a permanent magnet.

....

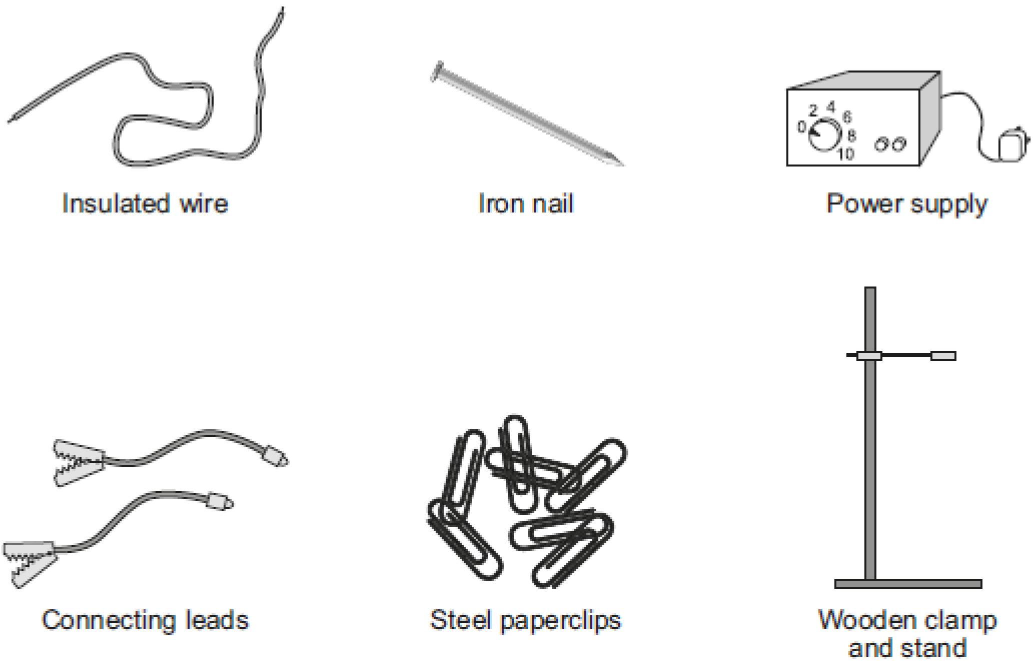
....

(1)

(b) **In this question you will gain marks for using good English, organising information clearly and using scientific words correctly.**

Some students want to build an electromagnet.

The students have the equipment shown below.

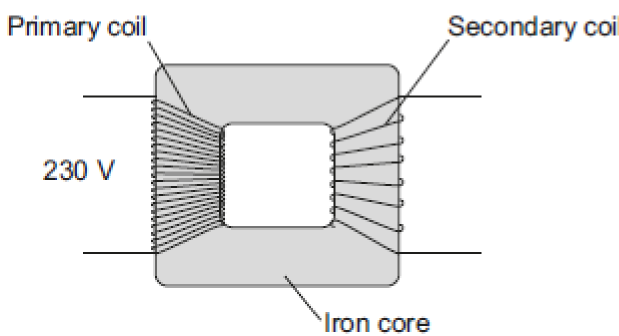


Describe how the students could build an electromagnet. Include in your answer how the students should vary and test the strength of their electromagnet.

(6)
(Total 7 marks)

12 **Figure 1** shows the structure of a traditional transformer.

Figure 1



(a) There is an alternating current in the primary coil of the transformer.

State what is produced in the iron core.

....

....

(2)

(b) A transformer has only **one** turn of wire on the secondary coil.
The potential difference across the secondary coil is 11.5 V
The potential difference across the primary coil is 230 V

Calculate the number of turns on the primary coil.

....

....

....

....

Number of turns on the primary coil = ...

(2)

(c) In most transformers, the power output is less than the power input.

State why.

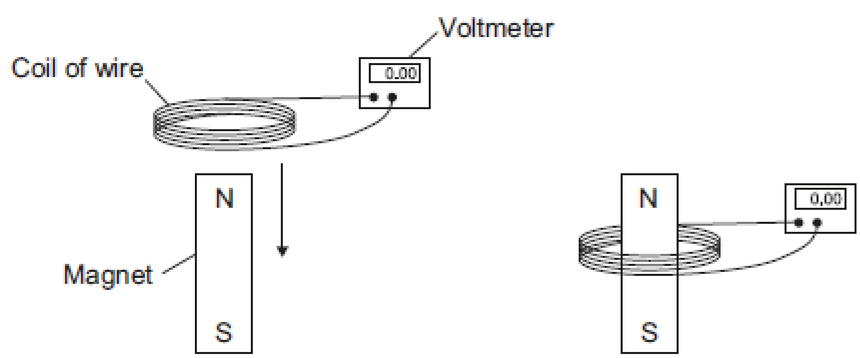
....

....

(1)

(d) Two students investigated how magnets can be used to produce a potential difference.
The students held a coil of wire above a magnet. The students quickly lowered the coil so that the magnet was inside the coil, as shown in **Figure 2**.

Figure 2



The students recorded the maximum potential difference for coils with different numbers of turns of wire. The results are shown in the table.

Number of turns of wire in the coil	Maximum potential difference in volts	
	Results from student 1	Results from student 2
5	0.09	0.08
10	0.20	0.15
15	0.31	0.25
20	0.39	0.33
25	0.51	0.39

(i) State the resolution of the voltmeter.

Give **one** reason why the resolution of the voltmeter is suitable for this investigation.

Resolution ....

Reason ....

....

(2)

(ii) The two students used exactly the same equipment to carry out their investigations. Both students recorded their results correctly.

Give the reason why student 2 got different results from student 1.

....

....

(1)

(iii) The students decided that even though the results were different, there was no need to repeat the investigation.

How do the results show that the investigation is reproducible?

....

....

(1)

(iv) State the name of the process which causes the potential difference to be produced in this investigation.

....

(1)

(e) A transformer has been developed that can be used with many different devices.

Suggest **one** advantage of having a transformer that can be used with many different devices.

....

....

(1)
(Total 11 marks)

13 X-rays and ultrasound can both be used for scanning internal organs.

(a) Ultrasound is used to scan unborn babies but X-rays are **not** used to scan unborn babies.

Explain why.

....

....

....

....

....

....

(3)

(b) The behaviour of ultrasound waves when they meet a boundary between two different materials is used to produce an image.

Describe how.

....

....

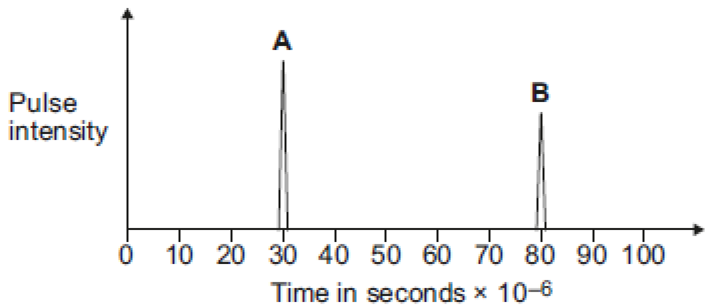
....

....

(2)

(c) **Figure 1** shows two pulses from a scan of an unborn baby. The emitted pulse is labelled **A**. The returning pulse picked up by the receiver is labelled **B**.

Figure 1



The closest distance between the unborn baby and the mother's skin is 4.0 cm.
Use information from **Figure 1** to calculate the average speed of the pulse.

....

....

....

....

....

....

Average speed = ... m/s

(3)

(d) **Figure 2** shows an X-ray of an arm with a broken bone.

Figure 2

© emmy-images/iStock

(i) Describe how X-rays are able to produce an image of bones.

....

....

....

....

....

....

(3)

(ii) Complete the following sentence.

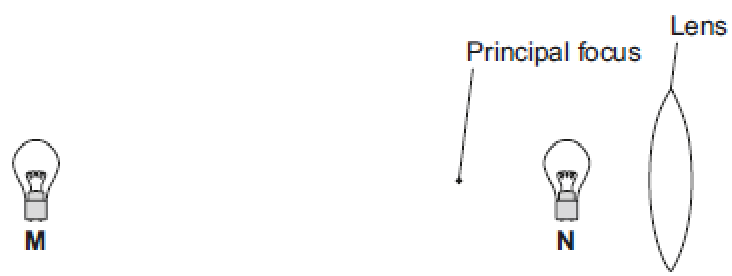
X-rays are able to produce detailed images because their wavelength

is very ....

(1)
(Total 12 marks)

14 (a) A light bulb is placed between a convex lens and the principle focus of this lens, at position **N** shown in **Figure 1**. The light bulb is then moved to position **M**, a large distance from the lens.

Figure 1



Describe how the nature of the image formed changes as the light bulb is moved from position **N** to position **M**.

....

....

....

....

....

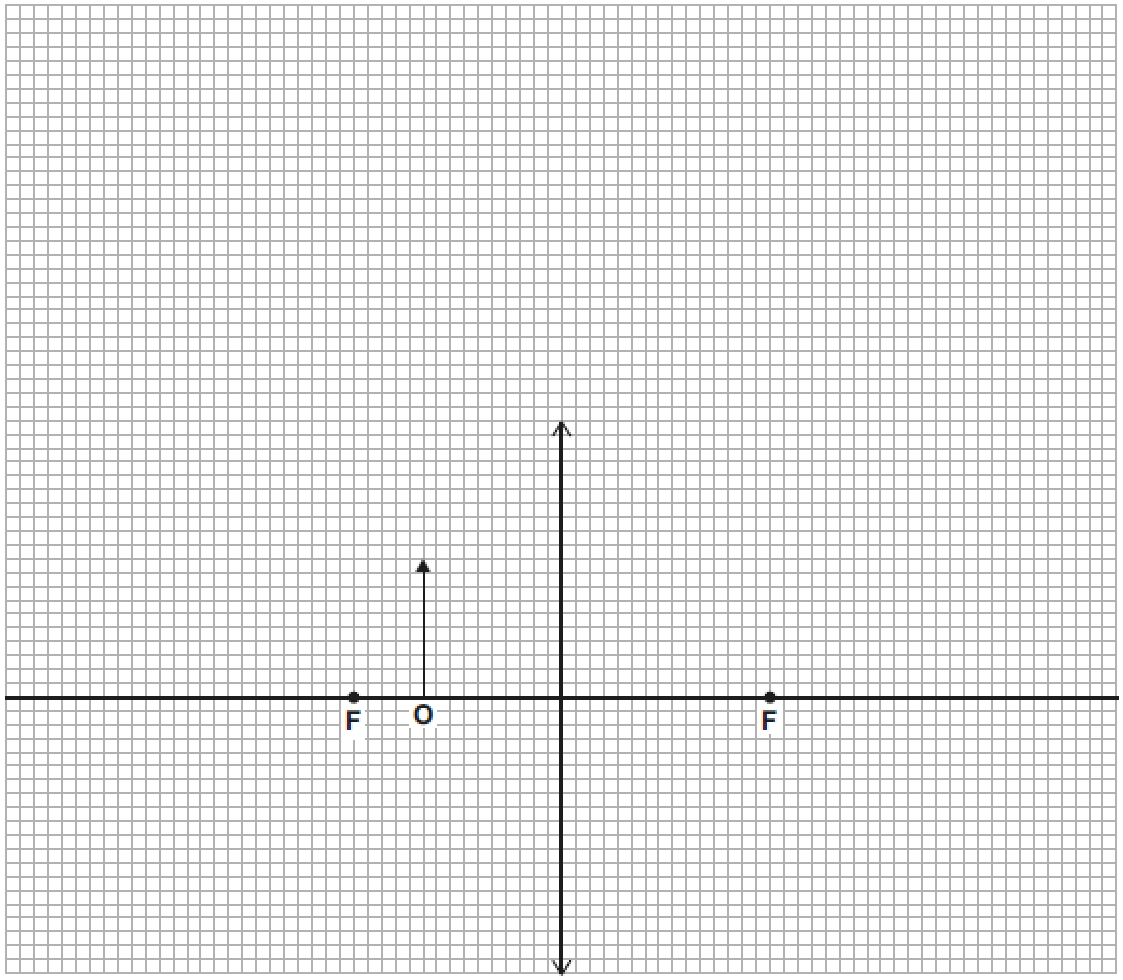
....

(3)

(b) An object, **O**, is very near to a convex lens, as shown in **Figure 2**.

Complete **Figure 2** to show how rays of light from the object form an image.

Figure 2

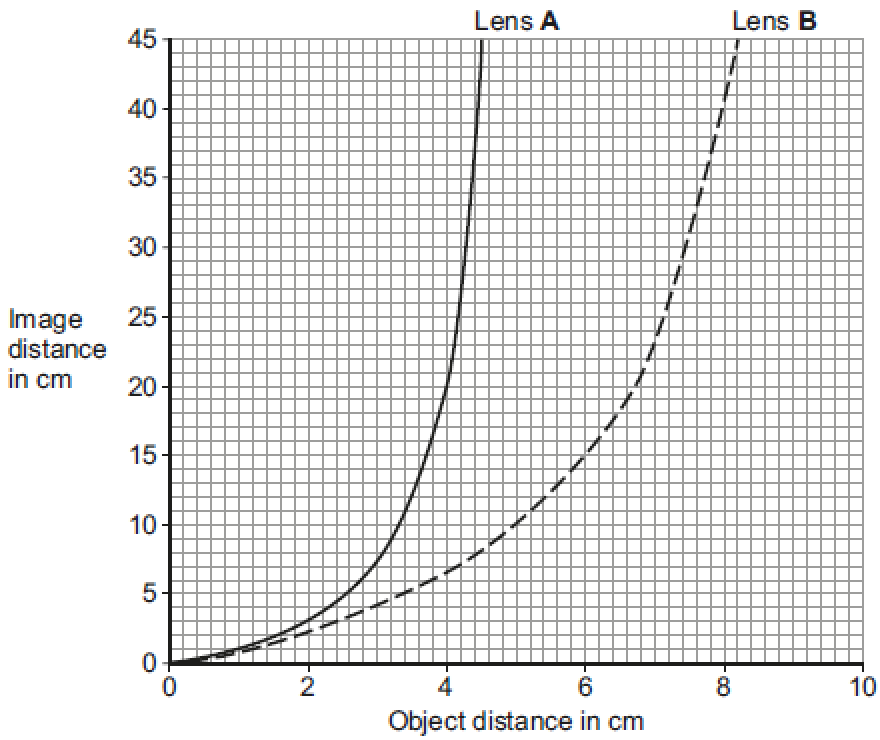


(3)

(c) The object distance is the distance from an object to the lens. The image distance is the distance from the lens to the image.

Figure 3 shows how the image distance changes with the object distance, for two identically shaped convex lenses, **A** and **B**. Each lens is made from a different type of glass.

Figure 3



(i) When the object distance is 4 cm, the image distance for lens **A** is longer than for lens **B**.

State why.

....

....

(1)

(ii) When the object is moved between lens **B** and the principal focus, the image size changes. The table shows the magnification produced by lens **B** for different object distances.

Object distance in cm	**Magnification**
0.0	1
5.0	2
6.7	3
7.5	4
8.0	5

Using information from **Figure 3** and the table, describe the relationship between the **image** distance and the magnification produced by lens **B**.

....

....

....

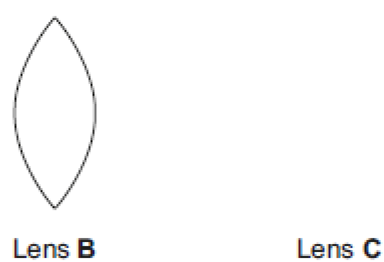
(2)

(iii) A third convex lens, lens **C**, is made from the same type of glass as lens **B**, but has a shorter focal length than lens **B**.

Lens **B** is shown in **Figure 4**.

Complete **Figure 4** to show how lens **C** is different from lens **B**.

Figure 4



(1)
(Total 10 marks)

15 (a) A car driver sees the traffic in front is not moving and brakes to stop his car.

The stopping distance of a car is the thinking distance plus the braking distance.

(i) What is meant by the 'braking distance'?

....

....

(1)

(ii) The braking distance of a car depends on the speed of the car and the braking force.

State **one** other factor that affects braking distance.

....

....

(1)

(iii) How does the braking force needed to stop a car in a particular distance depend on the speed of the car?

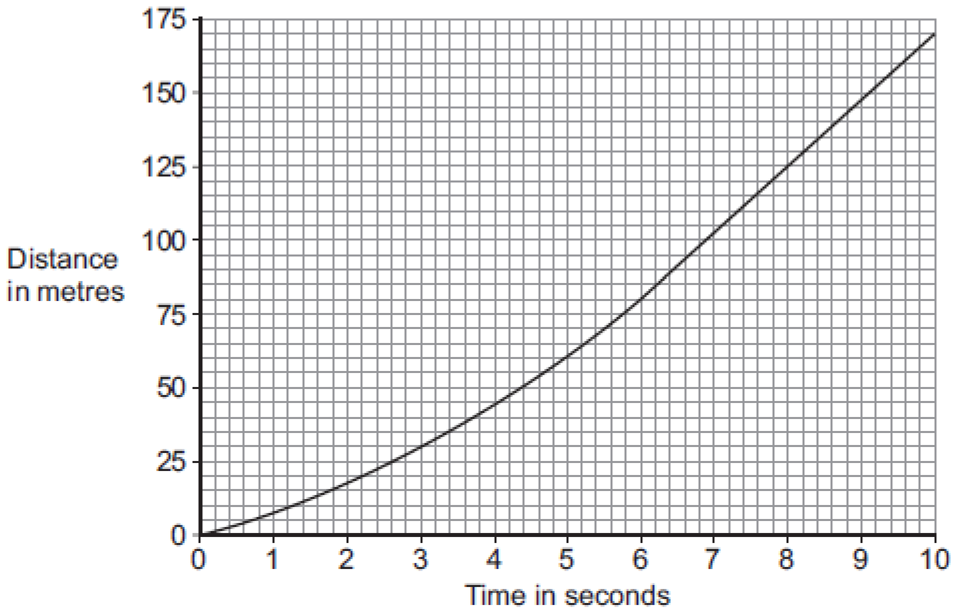
....

....

(1)

(b) **Figure 1** shows the distance−time graph for the car in the 10 seconds before the driver applied the brakes.

Figure 1



Use **Figure 1** to calculate the maximum speed the car was travelling at.
Show clearly how you work out your answer.

....

....

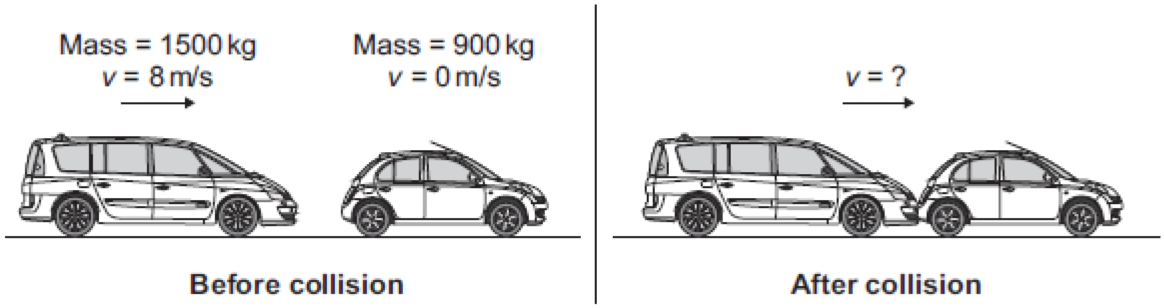
Maximum speed = ... m / s

(2)

(c) The car did not stop in time. It collided with the stationary car in front, joining the two cars together.

Figure 2 shows both cars, just before and just after the collision.

Figure 2



(i) The momentum of the two cars was conserved.

What is meant by the statement ‘momentum is conserved’?

....

....

(1)

(ii) Calculate the velocity of the two joined cars immediately after the collision.

....

....

....

....

....

Velocity = ... m / s

(3)

(d) Since 1965, all cars manufactured for use in the UK must have seat belts.

It is safer for a car driver to be wearing a seat belt, compared with not wearing a seat belt, if the car is involved in a collision.

Explain why.

....

....

....

....

....

....

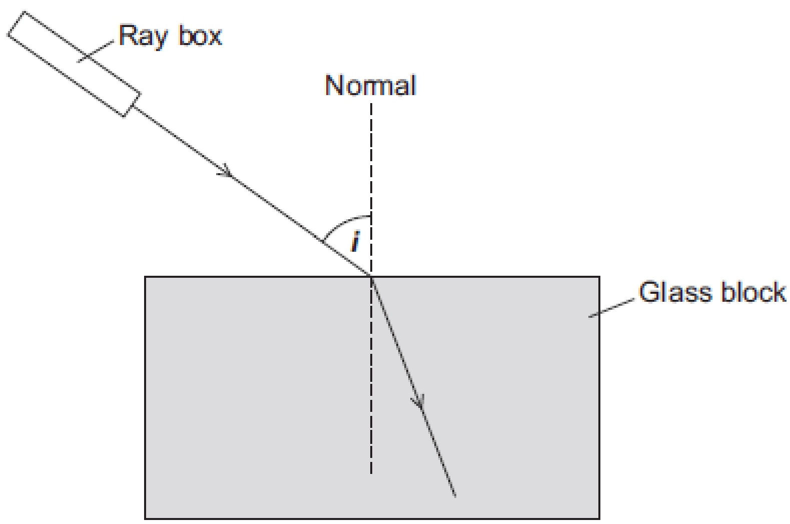
....

....

(4)
(Total 13 marks)

16 (a) **Figure 1** shows a ray of light entering a glass block.

Figure 1



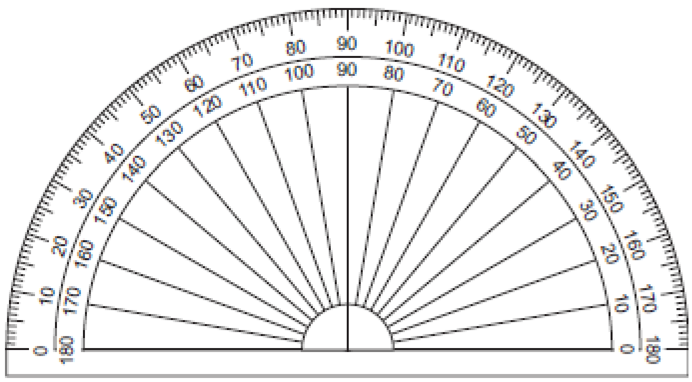
(i) The angle of incidence in **Figure 1** is labelled with the letter ***i***.

On **Figure 1**, use the letter ***r*** to label the angle of refraction.

(1)

(ii) **Figure 2** shows the protractor used to measure angles ***i*** and ***r***.

Figure 2



What is the resolution of the protractor?

Tick (✓) **one** box.

1 degree	☐	5 degrees	☐	10 degrees	☐

(1)

(iii) The table shows calculated values for angle ***i*** and angle ***r*** from an investigation.

Calculated values
sin ***i*** = 0.80
sin ***r*** = 0.50

Use the values from the table to calculate the refractive index of the glass.

....

....

....

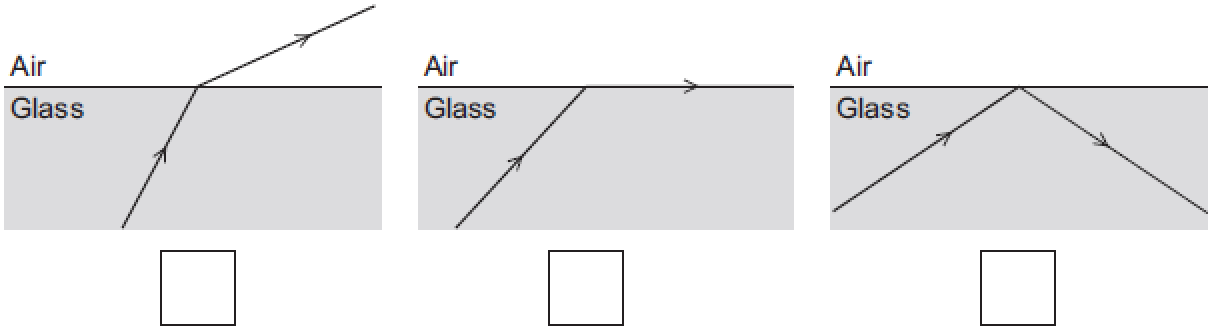
Refractive index = ...

(2)

(b) The diagrams below show a ray of light moving through glass.

Which diagram correctly shows what happens when the ray of light strikes the surface of the glass at the critical angle?

Tick (✓) **one** box.

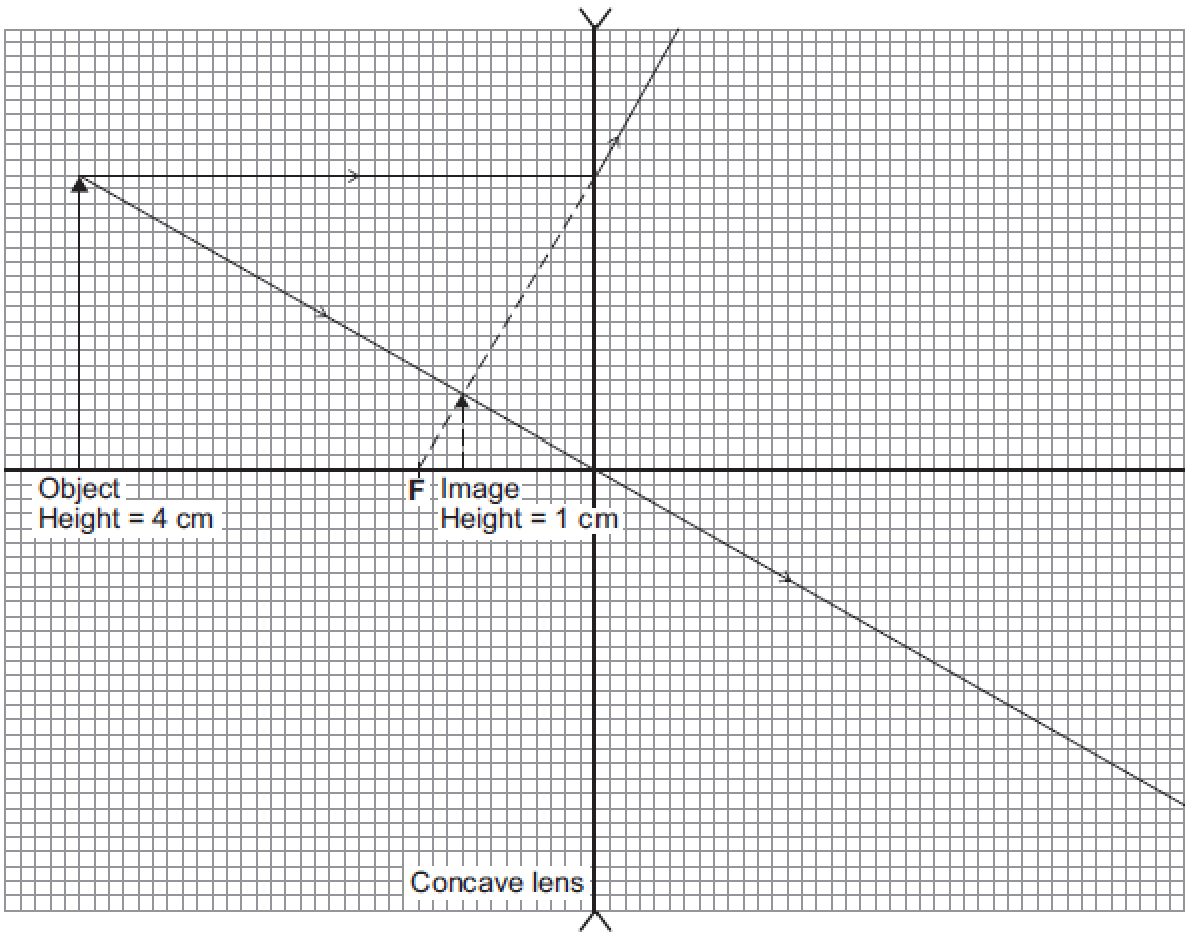


(1)

(c) A concave (diverging) lens is fitted into a door to make a security spyhole.

Figure 3 shows how this lens produces an image.

Figure 3



(i) State **one** word to describe the nature of the image in **Figure 3**.

....

(1)

(ii) Use data from **Figure 3** to calculate the magnification of the image.

....

....

....

Magnification = ...

(2)

(iii) What is another use for a concave lens?

Tick (✓) **one** box.

A magnifying glass	☐
Correcting short sight	☐
To focus an image in a camera	☐

(1)
(Total 9 marks)

17 Light changes direction as it passes from one medium to another.

(a) Use the correct answer from the box to complete the sentence.

diffraction	**reflection**	**refraction**

The change of direction when light passes from one medium to another is

called ....

(1)

(b) Draw a ring around the correct answer to complete the sentence.

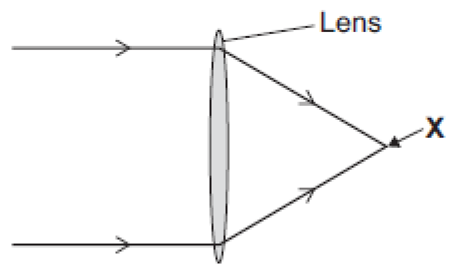
When light passes from air into a glass block, it changes

direction	away from the normal. towards the normal. to always travel along the normal.

(1)

(c) **Diagram 1** shows light rays entering and passing through a lens.

Diagram 1



(i) Which type of lens is shown in **Diagram 1**?

Draw a ring around the correct answer.

concave **convex** **diverging**

(1)

(ii) In **Diagram 1**, what is the point **X** called?

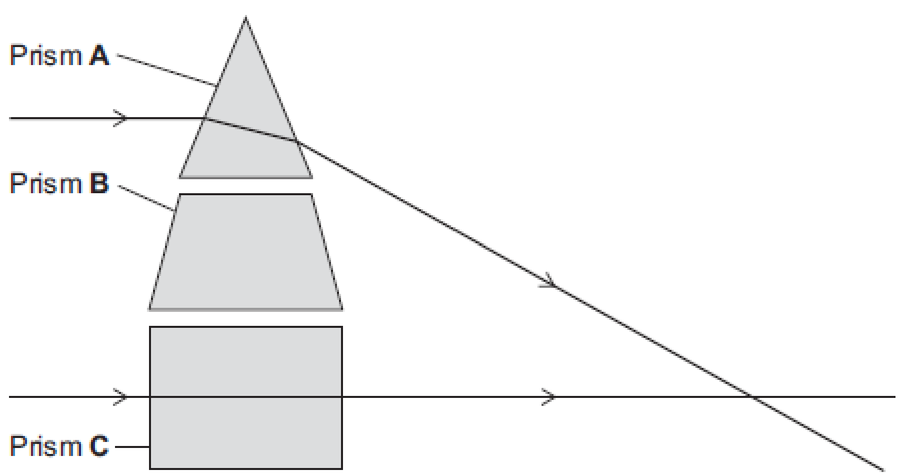
....

(1)

(d) A lens acts like a number of prisms.

Diagram 2 shows two parallel rays of light entering and passing through prism **A** and prism **C**.

Diagram 2



Draw a third parallel ray entering and passing through prism **B**.

(4)

(e) What **two** factors determine the focal length of a lens?

1 ....

2 ....

(2)
(Total 10 marks)

18 Solid, liquid and gas are three different states of matter.

(a) Describe the difference between the solid and gas states, in terms of the arrangement and movement of their particles.

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(4)

(b) What is meant by 'specific latent heat of vaporisation'?

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(2)

(c) While a kettle boils, 0.018 kg of water changes to steam.

Calculate the amount of energy required for this change.

Specific latent heat of vaporisation of water = 2.3×10^6 J / kg.

....

....

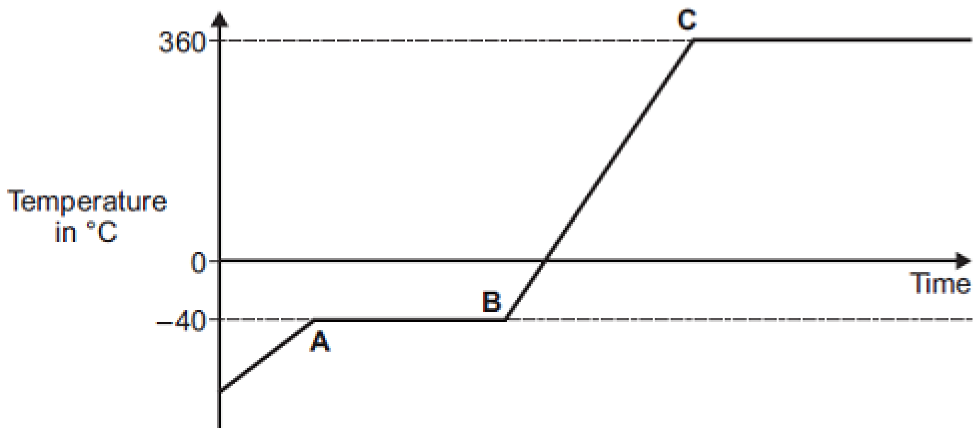
....

Energy required = ... J

(2)

(d) The graph shows how temperature varies with time for a substance as it is heated.

The graph is **not** drawn to scale.



Explain what is happening to the substance in sections **AB** and **BC** of the graph.

Section **AB** ....

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Section **BC** ....

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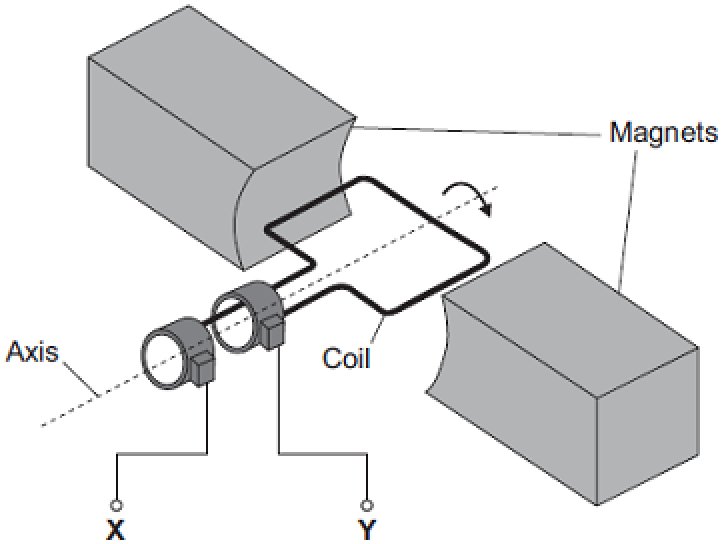
(4)
(Total 12 marks)

19 The diagram shows an a.c. generator.

The coil rotates about the axis shown and cuts through the magnetic field produced by the magnets.



(a) (i) A potential difference is induced between **X** and **Y**.

Use the correct answer from the box to complete the sentence.

electric	**generator**	**motor**	**transformer**

This effect is called the .... effect.

(1)

(ii) What do the letters a.c. stand for?

....

(1)

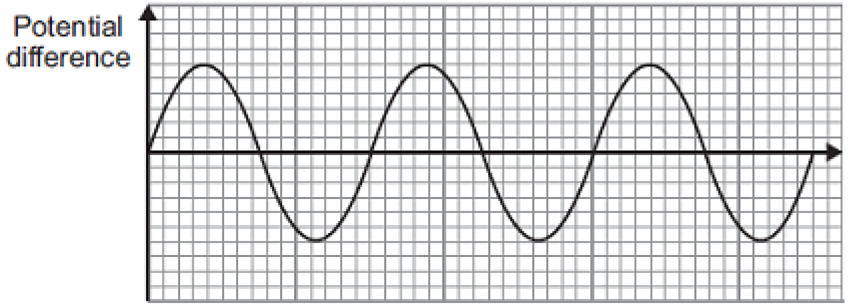
(iii) Name an instrument that could be used to measure the potential difference between **X** and **Y**.

....

(1)

(b) **Graph 1** shows the output from the a.c. generator.

Graph 1



(i) One of the axes on **Graph 1** has been labelled 'Potential difference'.

What should the other axis be labelled?

....

(1)

(ii) The direction of the magnetic field is reversed.

On **Graph 1**, draw the output from the a.c. generator if everything else remains the same.

(2)

(c) The number of turns of wire on the coil is increased. This increases the maximum induced potential difference.

State **two** other ways in which the maximum induced potential difference could be increased.

1 ....

....

2 ....

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(2)
(Total 8 marks)

20 Different parts of the electromagnetic spectrum have different uses.

(a) The diagram shows the electromagnetic spectrum.

Radio waves	Microwaves	Infrared	Visible light	Ultraviolet	X-rays	Gamma rays

(i) Use the correct answers from the box to complete the sentence.

amplitude	**frequency**	**speed**	**wavelength**

The arrow in the diagram is in the direction of increasing ....

and decreasing ....

(2)

(ii) Draw a ring around the correct answer to complete the sentence.

The range of wavelengths for waves in the electromagnetic

spectrum is approximately

10^{-15} to 10^{4}
10^{-4} to 10^{4}
10^{4} to 10^{15}

metres.

(1)

(b) The wavelength of a radio wave is 1500 m.
The speed of radio waves is 3.0×10^{8} m / s.

Calculate the frequency of the radio wave.

Give the unit.

....

....

....

Frequency = ...

(3)

(c) (i) State **one** hazard of exposure to infrared radiation.

....

(1)

(ii) State **one** hazard of exposure to ultraviolet radiation.

....

(1)

(d) X-rays are used in hospitals for computed tomography (CT) scans.

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

....

....

(1)

(ii) State a property of X-rays that makes them suitable for your answer in part **(d)(i)**.

....

....

(1)

(iii) The scientific unit of measurement used to measure the dose received from radiations, such as X-rays or background radiation, is the millisievert (mSv).

The table shows the X-ray dose resulting from CT scans of various parts of the body.

The table also shows the time it would take to get the same dose from background radiation.

Part of the body	**X-ray dose in mSv**	**Time it would take to get the same dose from background radiation**
Abdomen	9.0	3 years
Sinuses	0.5	2 months
Spine	4.0	16 months

A student suggests that the X-ray dose and the time it would take to get the same dose from background radiation are directly proportional.

Use calculations to test this suggestion and state your conclusion.

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(3)
(Total 13 marks)

21 On 14 October 2012, a skydiver set a world record for the highest free fall from an aircraft.

After falling from the aircraft, he reached a maximum steady velocity of 373 m / s after 632 seconds.

(a) Draw a ring around the correct answer to complete the sentence.

This maximum steady velocity is called the [frictional / initial / terminal] velocity.

(1)

(b) The skydiver wore a chest pack containing monitoring and tracking equipment. The weight of the chest pack was 54 N.

The gravitational field strength is 10 N / kg.

Calculate the mass of the chest pack.

....

....

Mass of chest pack = ... kg

(2)

(c) During his fall, the skydiver's acceleration was not uniform.

Immediately after leaving the aircraft, the skydiver's acceleration was 10 m / s ^{2}.

(i) Without any calculation, estimate his acceleration a few seconds after leaving the aircraft.

Explain your value of acceleration in terms of forces.

Estimate ....

Explanation ....

....

....

....

....

....

(3)

(ii) Without any calculation, estimate his acceleration 632 seconds after leaving the aircraft.

Explain your value of acceleration in terms of forces.

Estimate ....

Explanation ....

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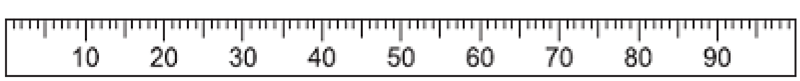
(3)
(Total 9 marks)

22 A student carries out an investigation using a metre rule as a pendulum.

(a) **Diagram 1** shows a metre rule.

Diagram 1



(i) Draw, on **Diagram 1**, an **X** to show the position of the centre of mass of the rule.

(1)

(ii) State what is meant by the 'centre of mass of an object'.

....

....

(1)

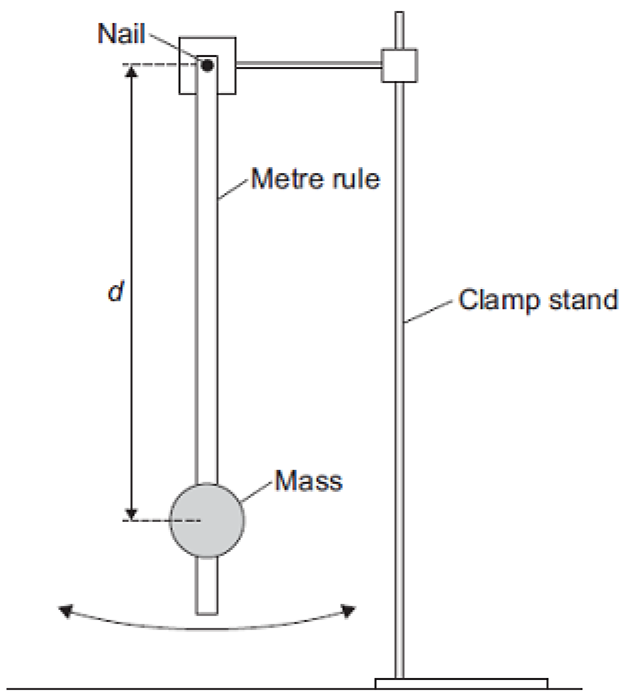
(b) The student taped a 100 g mass to a metre rule.

She set up the apparatus as shown in **Diagram 2**.

She suspended the metre rule from a nail through a hole close to one end, so she could use the metre rule as a pendulum.

The distance d is the distance between the nail and the 100 g mass.

Diagram 2



(i) Draw, on **Diagram 2**, a **Y** to show a possible position of the centre of mass of the pendulum.

(1)

(ii) The student carried out an investigation to find out how the time period of the pendulum varies with *d*.

Some of her results are shown in the table.

	Time for 10 swings in seconds				
***d* in cm**	**First test**	**Second test**	**Third test**	**Mean value**	**Mean time for 1 swing in seconds**
10.0	15.3	15.4	15.5	15.4	1.54
30.0	14.7	14.6	14.7	14.7	1.47
50.0	15.3	15.6	15.4	15.4	1.54
70.0	16.5	16.6	16.5		

Complete the table.

You may use the space below to show your working.

....

....

(3)

(iii) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

Describe how the student would carry out the investigation to get the results in the table in part (ii).

You should include:

- any other apparatus required
- how she should use the apparatus
- how she could make it a fair test
- a risk assessment
- how she could make her results as accurate as possible.

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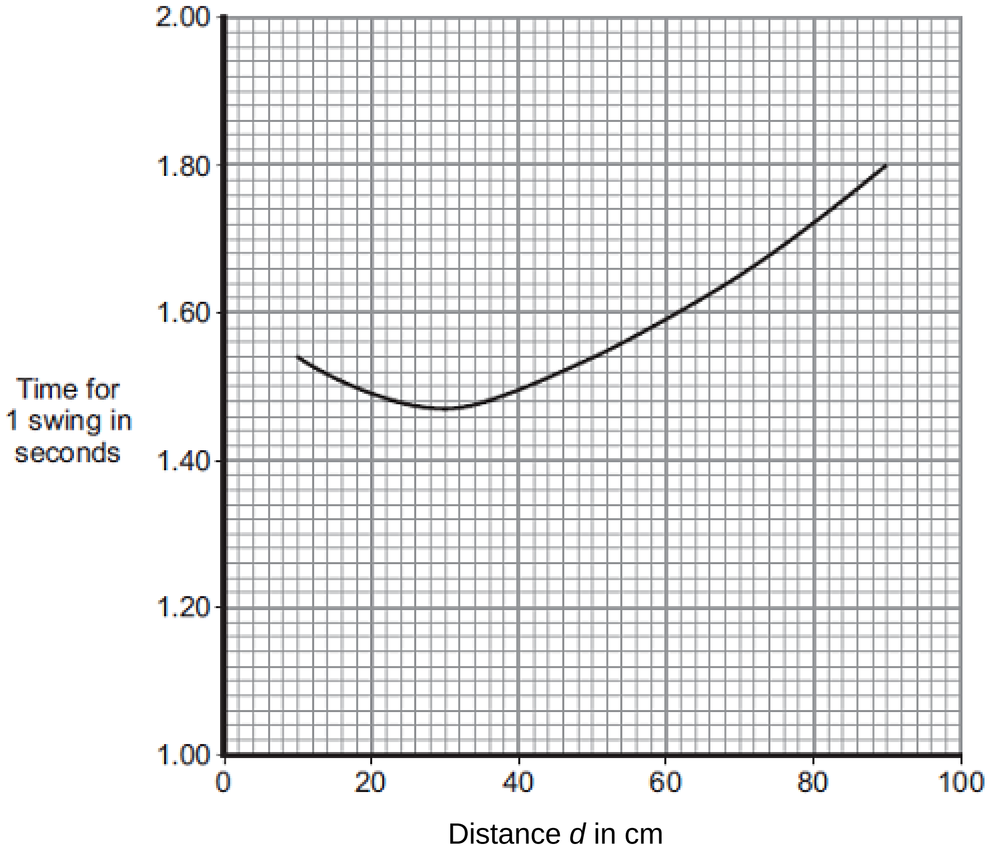
(6)

(c) A graph of the student's results is shown below.



(i) Describe the pattern shown by the graph.

....

....

....

....

(2)

(ii) The student thinks that the measurements of time for d = 10 cm might be anomalous, so she takes a fourth measurement.

Her four measurements are shown below.

15.3 s **15.4 s** **15.5 s** **15.3 s**

State whether you consider any of these measurements to be anomalous.

Justify your answer.

....

....

....

....

(2)
(Total 16 marks)

23 Astronomers claim that there are about 300 billion stars in the Milky Way.

(a) Describe how stars are formed.

....

....

....

....

....

....

(3)

(b) Use the correct answer from the box to complete the sentence.

decay	**fission**	**fusion**

Energy is released in stars by the process of nuclear ....

(1)

(c) State why a star is stable during the 'main sequence' period of its life cycle.

....

....

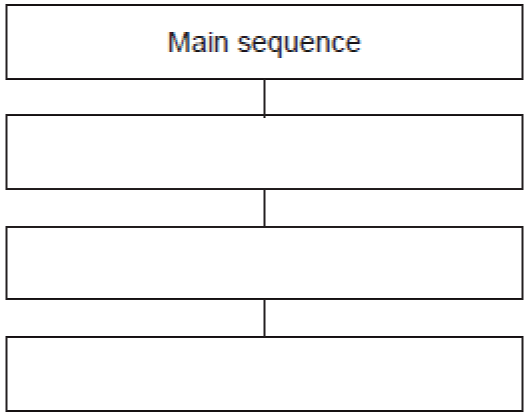
(1)

(d) The life cycle of a star after the ‘main sequence’ period depends on the size of the star.

A particular star is the same size as the Sun.

What are the stages, after the main sequence, in the life cycle of this star?

State them in order by writing in the boxes.



(3)
(Total 8 marks)

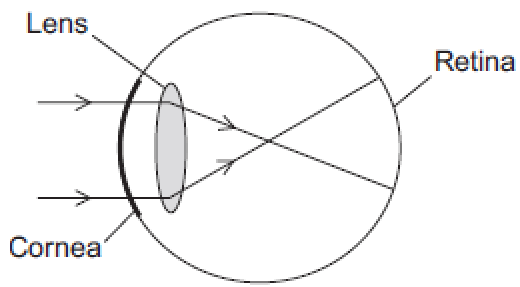
24 Lenses can be used to correct visual defects.

Figure 1 shows a child wearing glasses.
Wearing glasses allows a lens to correct a visual defect.

Figure 1

(a) **Figure 2** shows rays of light entering a child's eye and being focused at a point. This point is not on the retina so the child sees a blurred image.

Figure 2



(i) What is the visual defect of this eye?

....

....

(1)

(ii) Use the correct answer from the box to complete the sentence.

converging	**convex**	**diverging**

The type of lens used to correct this visual defect is a .... lens.

(1)

(b) Visual defects may be corrected with eye surgery. A laser may be used in eye surgery.

Use the correct answer from the box to complete the sentence.

light	**sound**	**X-rays**

A laser is a concentrated source of ....

(1)

(c) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Lasers can be used to correct a visual defect by changing the shape of the cornea.

A knife is used to cut a flap in the cornea. The laser vaporises a portion of the cornea and permanently changes its shape. The flap is then replaced.

Most patients are back at work within a week. Driving may be unsafe for one to two weeks. Tinted glasses with ultraviolet protection are needed when out in the sun for the first three months.

Many people in their mid-40s need reading glasses. This is because the eye lens becomes less flexible with age. Laser surgery cannot cure this.

Laser surgery for both eyes costs £1000. A pair of glasses costs £250.

Describe the advantages and disadvantages of:

- having laser surgery to correct visual defects
- wearing glasses to correct visual defects.

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Extra space ....

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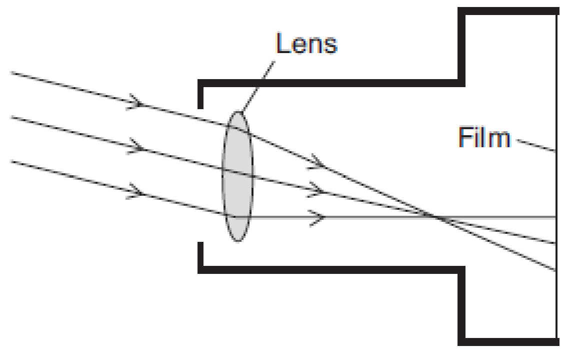
(6)

(d) **Figure 3** shows parallel rays of light, from a point on a distant object, entering a camera.

Figure 3



Describe the adjustment that has to be made to focus the image on the film.

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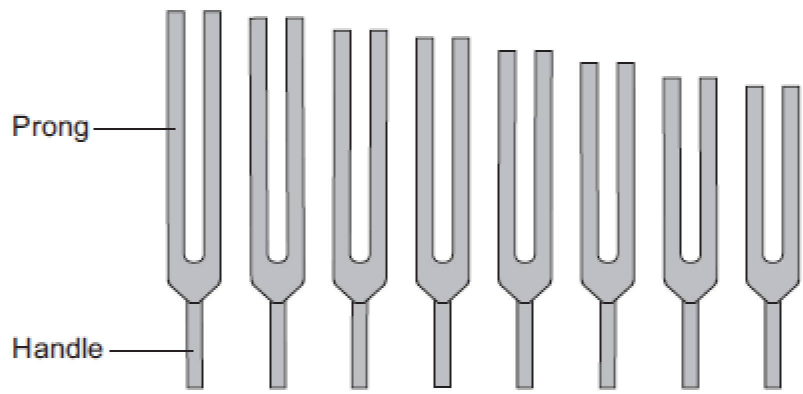
(2)
(Total 11 marks)

25 **Figure 1** shows a set of tuning forks.

Figure 1



A tuning fork has a handle and two prongs. It is made from metal.

When the prongs are struck on a hard object, the tuning fork makes a sound wave with a single frequency. The frequency depends on the length of the prongs.

(a) Use the correct answer from the box to complete each sentence.

direction	**loudness**	**pitch**	**speed**

The frequency of a sound wave determines its ....

The amplitude of a sound wave determines its ....

(2)

(b) Each tuning fork has its frequency engraved on it. A student measured the length of the prongs for each tuning fork.

Some of her data is shown in the table.

Frequency in hertz	**Length of prongs in cm**
320	9.5
384	8.7
480	7.8
512	7.5

(i) Describe the pattern shown in the table.

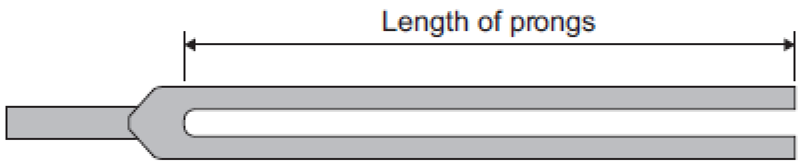
....

....

(1)

(ii) **Figure 2** shows a full-size drawing of a tuning fork.

Figure 2



Measure and record the length of the prongs.

Length of prongs = ... cm

(1)

Use the data in the table above to estimate the frequency of the tuning fork in **Figure 2**.

Explain your answer.

....

....

....

....

....

Estimated frequency = ... Hz

(3)

(c) Ultrasound waves are used in hospitals.

(i) Use the correct answer from the box to complete the sentence.

electronic	**hydraulic**	**radioactive**

Ultrasound waves can be produced by .... systems.

(1)

(ii) The frequency of an ultrasound wave used in a hospital is 2×10^6 Hz.

It is **not** possible to produce ultrasound waves of this frequency using a tuning fork.

Explain why.

....

....

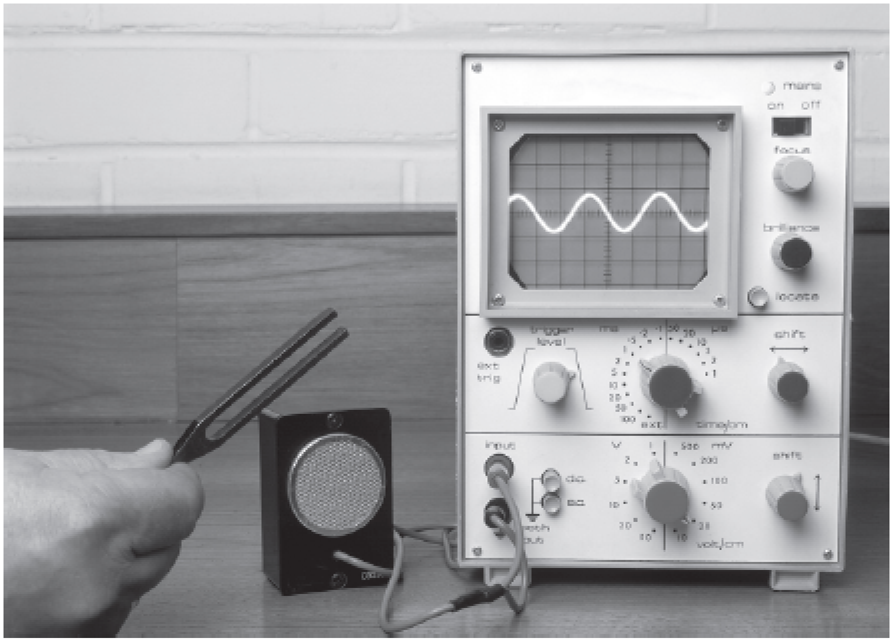
....

....

(2)

(d) **Figure 3** shows a tuning fork and a microphone. The microphone is connected to an oscilloscope.

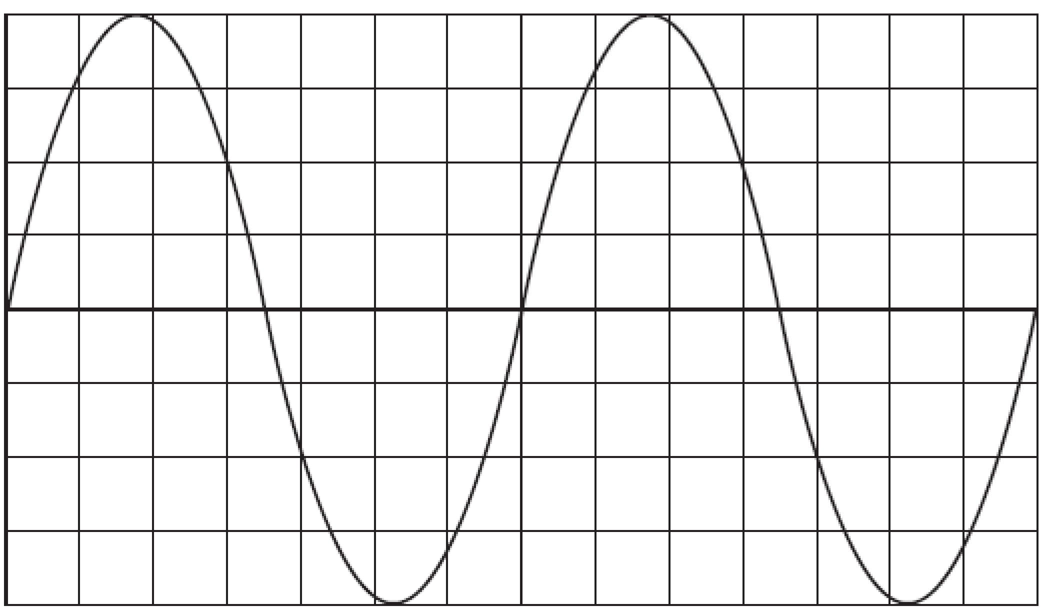
Figure 3



When the tuning fork is struck and then placed in front of the microphone, a trace appears on the oscilloscope screen.

Figure 4 shows part of the trace on the screen.

Figure 4



Each horizontal division in **Figure 4** represents a time of 0.0005 s.

What is the frequency of the tuning fork?

....

....

....

Frequency = ... Hz

(3)
(Total 13 marks)

26 Different radioactive isotopes have different values of half-life.

(a) What is meant by the 'half-life' of a radioactive isotope?

....

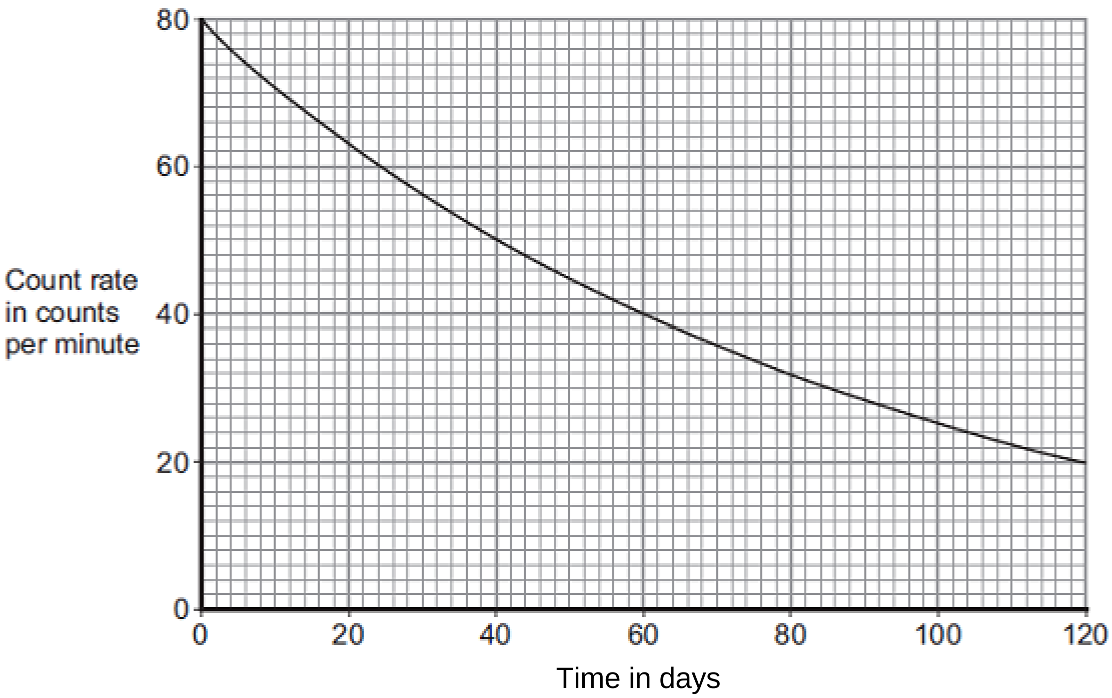
....

....

(1)

(b) **Figure 1** shows how the count rate from a sample of a radioactive isotope varies with time.

Figure 1



Use information from **Figure 1** to calculate the half-life of the radioactive isotope.

Show clearly on **Figure 1** how you obtain your answer.

Half-life = ... days

(2)

(c) The table below shows data for some radioactive isotopes that are used in schools.

Radioactive isotope	**Type of radiation emitted**	**Half-life in years**
Americium-241	Alpha and gamma	460
Cobalt-60	Gamma	5
Radium-226	Alpha, beta and gamma	1600
Strontium-90	Beta	28
Thorium-232	Alpha and beta	1.4×10^{10}

(i) State which radioactive isotope in the table above emits only radiation that is **not** deflected by a magnetic field.

Give a reason for your choice.

....

....

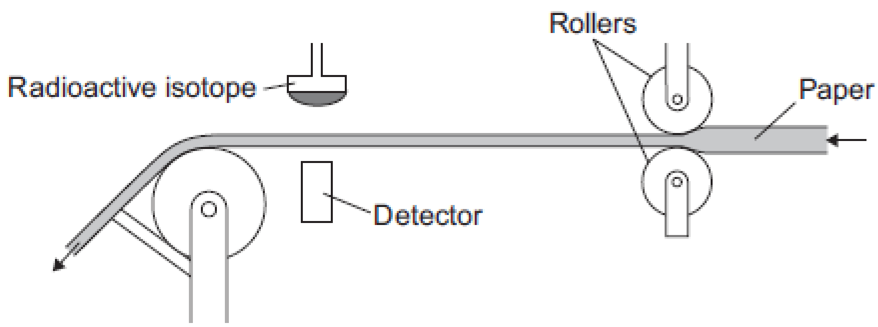
....

....

(2)

(ii) **Figure 2** shows a radioactive isotope being used to monitor the thickness of paper during production.

Figure 2



State which radioactive isotope in the table should be used to monitor the thickness of the paper.

Explain your choice.

....

....

....

....

....

(3)

All the radioactive isotopes in the table have practical uses.

State which source in the table would need replacing most often.

Explain your choice.

....

....

....

....

....

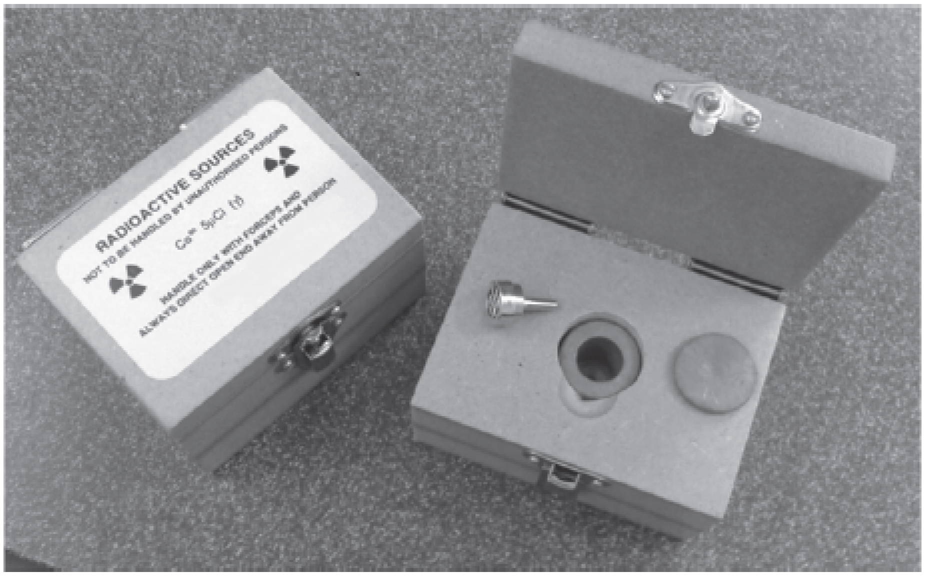
(3)

(iii) When the radioactive isotopes are not in use, they are stored in lead-lined wooden boxes.

The boxes reduce the level of radiation that reaches the surroundings.

Figure 3 shows two of these boxes.

Figure 3



State **one** source from the table which emits radiation that could penetrate the box.

Explain your answer.

....

....

....

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....

....

(3)
(Total 14 marks)

27 (a) A company is developing a system which can heat up and melt ice on roads in the winter. This system is called ‘energy storage’.

During the summer, the black surface of the road will heat up in the sunshine.

This energy will be stored in a large amount of soil deep under the road surface. Pipes will run through the soil. In winter, cold water entering the pipes will be warmed and brought to the surface to melt ice.

The system could work well because the road surface is black.

Suggest why.

....

....

(1)

(b) (i) What is meant by specific latent heat of fusion?

....

....

....

....

(2)

(ii) Calculate the amount of energy required to melt 15 kg of ice at 0 °C.

Specific latent heat of fusion of ice = 3.4×10^5 J/kg.

....

....

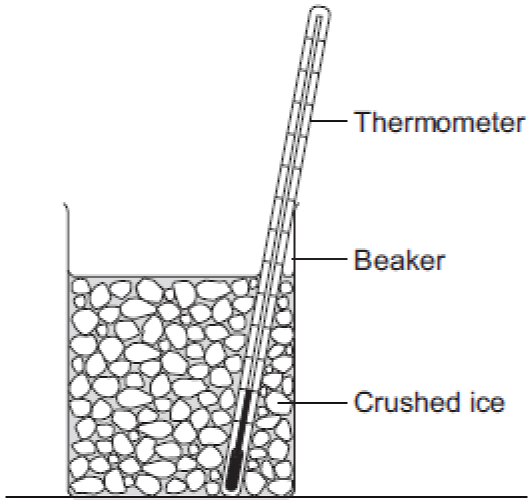
Energy = ... J

(2)

(c) Another way to keep roads clear of ice is to spread salt on them.
When salt is added to ice, the melting point of the ice changes.

A student investigated how the melting point of ice varies with the mass of salt added.

The figure below shows the equipment that she used.



The student added salt to crushed ice and measured the temperature at which the ice melted.

(i) State **one** variable that the student should have controlled.

....

....

(1)

(ii) During the investigation the student stirred the crushed ice.

Suggest **two** reasons why.

Tick (✓) **two** boxes.

	Tick (✓)
To raise the melting point of the ice	
To lower the melting point of the ice	
To distribute the salt throughout the ice	
To keep all the ice at the same temperature	
To reduce energy transfer from the surroundings to the ice	

(2)

(iii) The table below shows the data that the student obtained.

Mass of salt added in grams	0	10	20
Melting point of ice in °C	0	-6	-16

Describe the pattern shown in the table.

....

....

(1)

(d) Undersoil electrical heating systems are used in greenhouses. This system could also be used under a road.

A cable just below the ground carries an electric current. One greenhouse system has a power output of 0.50 kW.

Calculate the energy transferred in 2 minutes.

....

....

....

Energy transferred = ... J

(3)

(e) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

A local council wants to keep a particular section of a road clear of ice in the winter.

Describe the advantages and disadvantages of keeping the road clear of ice using:

- energy storage
- salt
- undersoil electrical heating.

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Extra space ....

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(6)
(Total 18 marks)

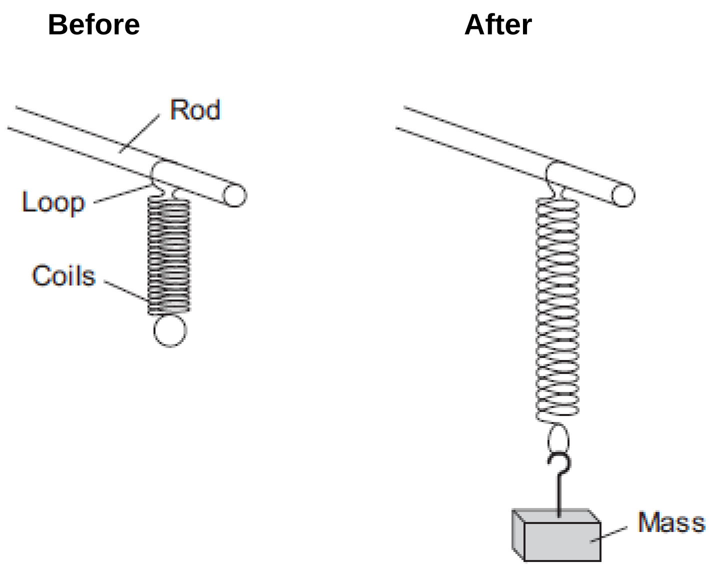
28 A student investigated the behaviour of springs. She had a box of identical springs.

(a) When a force acts on a spring, the shape of the spring changes.

The student suspended a spring from a rod by one of its loops. A force was applied to the spring by suspending a mass from it.

Figure 1 shows a spring before and after a mass had been suspended from it.

Figure 1



(i) State **two** ways in which the shape of the spring has changed.

1 ....

2 ....

(2)

(ii) No other masses were provided.

Explain how the student could test if the spring was behaving elastically.

....

....

....

....

(2)

(b) In a second investigation, a student took a set of measurements of force and extension.

Her results are shown in **Table 1** .

Table 1

Force in newtons	0.0	1.0	2.0	3.0	4.0	5.0	6.0
Extension in cm	0.0	4.0		12.0	16.0	22.0	31.0

(i) Add the missing value to **Table 1**.

Explain why you chose this value.

....

....

....

....

(3)

(ii) During this investigation the spring exceeded its limit of proportionality.

Suggest a value of force at which this happened.

Give a reason for your answer.

Force = ... N

Reason ....

....

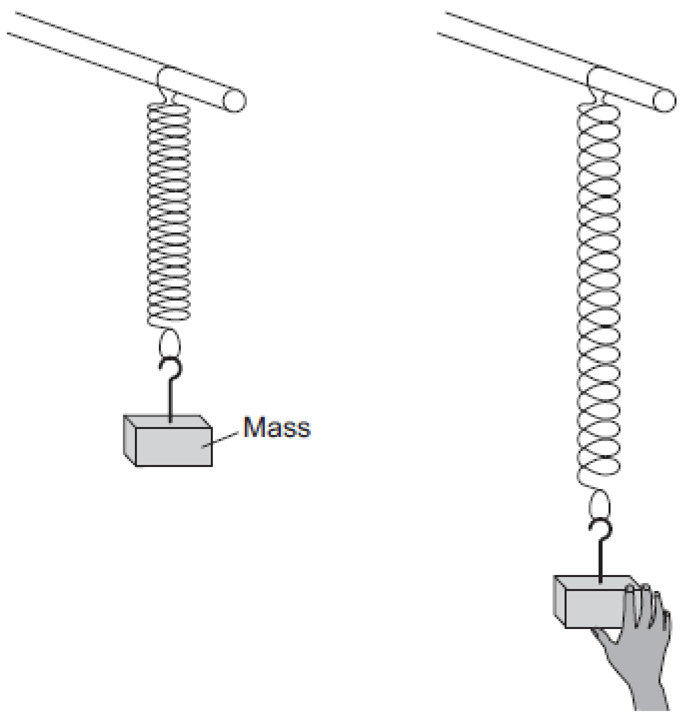
....

(2)

(c) In a third investigation the student:

- suspended a 100 g mass from a spring
- pulled the mass down as shown in **Figure 2**
- released the mass so that it oscillated up and down
- measured the time for 10 complete oscillations of the mass
- repeated for masses of 200 g, 300 g and 400 g.

Figure 2



Her results are shown in **Table 2**.

Table 2

	Time for 10 complete oscillations in seconds			
Mass in g	**Test 1**	**Test 2**	**Test 3**	**Mean**
100	4.34	5.20	4.32	4.6
200	5.93	5.99	5.86	5.9
300	7.01	7.12	7.08	7.1
400	8.23	8.22	8.25	8.2

(i) Before the mass is released, the spring stores energy.

What type of energy does the spring store?

Tick (✓) **one** box.

	Tick (✓)
Elastic potential energy	
Gravitational potential energy	
Kinetic energy	

(1)

(ii) The value of time for the 100 g mass in **Test 2** is anomalous.

Suggest **two** likely causes of this anomalous result.

Tick (✓) **two** boxes.

	Tick (✓)
Misread stopwatch	
Pulled the mass down too far	
Timed half oscillations, not complete oscillations	
Timed too few complete oscillations	
Timed too many complete oscillations	

(2)

(iii) Calculate the correct mean value of time for the 100 g mass in **Table 2**.

....

....

Mean value = ... s

(1)

(iv) Although the raw data in **Table 2** is given to 3 significant figures, the mean values are correctly given to 2 significant figures.

Suggest why.

....

....

....

....

(2)

(v) The student wanted to plot her results on a graph. She thought that four sets of results were not enough.

What extra equipment would she need to get more results?

....

....

....

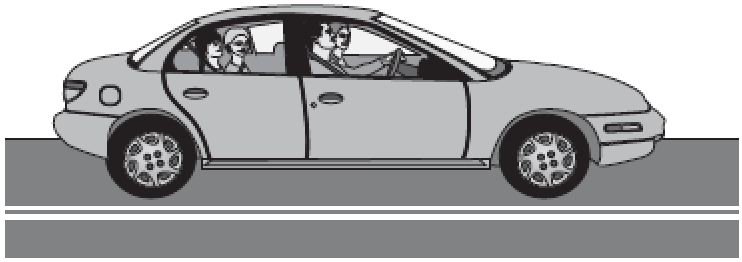
....

(2)

(Total 17 marks)

29 The figure below shows a car with an electric motor.

The car is moving along a flat road.



(a) (i) Use the correct answers from the box to complete each sentence.

light	**electrical**	**kinetic**	**potential**	**sound**

The car's motor transfers .... energy

into useful .... energy as the car moves.

Some energy is wasted as .... energy.

(3)

(ii) What happens to the wasted energy?

....

....

(1)

(b) The electric motor has an input energy of 50 000 joules each second.

The motor transfers 35 000 joules of useful energy each second.

Calculate the efficiency of the electric motor.

....

....

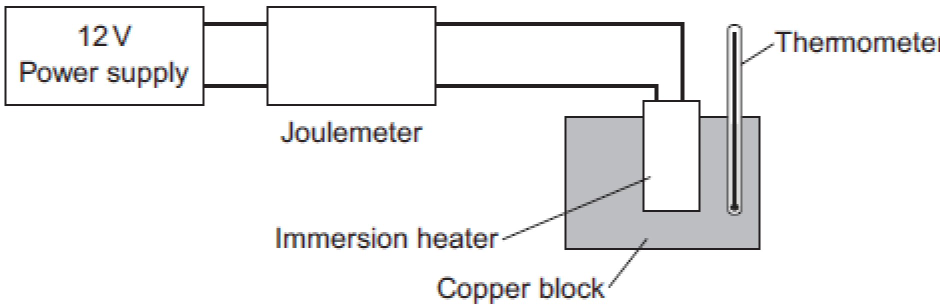
....

Efficiency = ...

(2)
(Total 6 marks)

30 A student used the apparatus in **Figure 1** to obtain the data needed to calculate the specific heat capacity of copper.

Figure 1



The initial temperature of the copper block was measured.

The power supply was switched on.

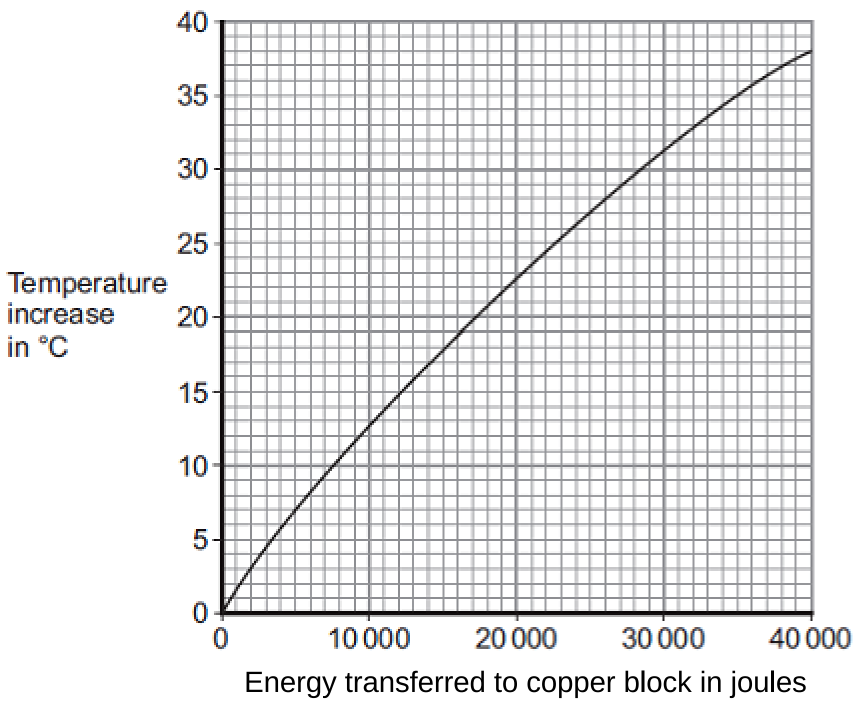
The energy transferred by the heater to the block was measured using the joulemeter.

The temperature of the block was recorded every minute.

The temperature increase was calculated.

Figure 2 shows the student's results.

Figure 2



(a) Energy is transferred through the copper block.

What is the name of the process by which the energy is transferred?

Tick (✓) **one** box.

Conduction ☐

Convection ☐

Radiation ☐

(1)

(b) Use **Figure 2** to determine how much energy was needed to increase the temperature of the copper block by 35 °C.

.... joules

(1)

(c) The copper block has a mass of 2 kg.

Use your answer to part (b) to calculate the value given by this experiment for the specific heat capacity of copper. Give the unit.

....

....

....

....

Specific heat capacity = ...

(3)

(d) This experiment does **not** give the correct value for the specific heat of copper.

Suggest **one** reason why.

....

....

(1)
(Total 6 marks)

31 **Table 1** shows information about different light bulbs.

The bulbs all have the same brightness.

Table 1

Type of bulb	**Input power in watts**	**Efficiency**
Halogen	40	0.15
Compact fluorescent (CFL)	14	0.42
LED	7	0.85

(a) (i) Calculate the useful power output of the CFL bulb.

....

....

....

Useful power output = ... watts

(2)

(ii) Use your answer to part **(i)** to calculate the waste energy produced each second by a CFL bulb.

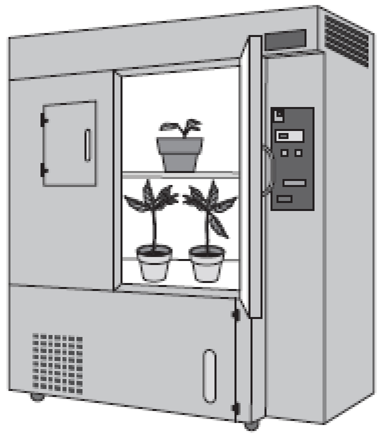
....

Waste energy per second = ... joules

(1)

(b) (i) A growth cabinet is used to investigate the effect of light on the rate of growth of plants.

The figure below shows a growth cabinet.



In the cabinet the factors that affect growth can be controlled.

A cooler unit is used to keep the temperature in the cabinet constant. The cooler unit is programmed to operate when the temperature rises above 20 °C.

The growth cabinet is lit using 50 halogen bulbs.

Changing from using halogen bulbs to LED bulbs would reduce the cost of running the growth cabinet.

Explain why.

....

....

....

....

....

....

(4)

(ii) A scientist measured the rate of growth of plants for different intensities of light.

What type of graph should be drawn to present the results?

....

Give a reason for your answer.

....

....

(1)

(c) **Table 2** gives further information about both a halogen bulb and a LED bulb.

Table 2

Type of bulb	**Cost to buy**	**Lifetime in hours**	**Operating cost over the lifetime of one bulb**
Halogen	£1.50	2 000	£16.00
LED	£30.00	48 000	£67.20

A householder needs to replace a broken halogen light bulb.

Compare the cost efficiency of buying and using halogen bulbs rather than a LED bulb over a time span of 48 000 hours of use.

Your comparison must include calculations.

....

....

....

....

....

....

....

....

(4)
(Total 12 marks)

32 (a) There are many isotopes of the element molybdenum (Mo).

What do the nuclei of different molybdenum isotopes have in common?

....

(1)

(b) The isotope molybdenum-99 is produced inside some nuclear power stations from the nuclear fission of uranium-235.

(i) What happens during the process of nuclear fission?

....

....

(1)

(ii) Inside which part of a nuclear power station would molybdenum be produced?

....

(1)

(c) When the nucleus of a molybdenum-99 atom decays, it emits radiation and changes into a nucleus of technetium-99.

$$^{99}_{42}Mo \longrightarrow ^{99}_{43}Tc + \text{Radiation}$$

What type of radiation is emitted by molybdenum-99?

....

Give a reason for your answer.

....

....

(2)

(d) Technetium-99 has a short half-life and emits gamma radiation.

What is meant by the term ‘half-life’?

....

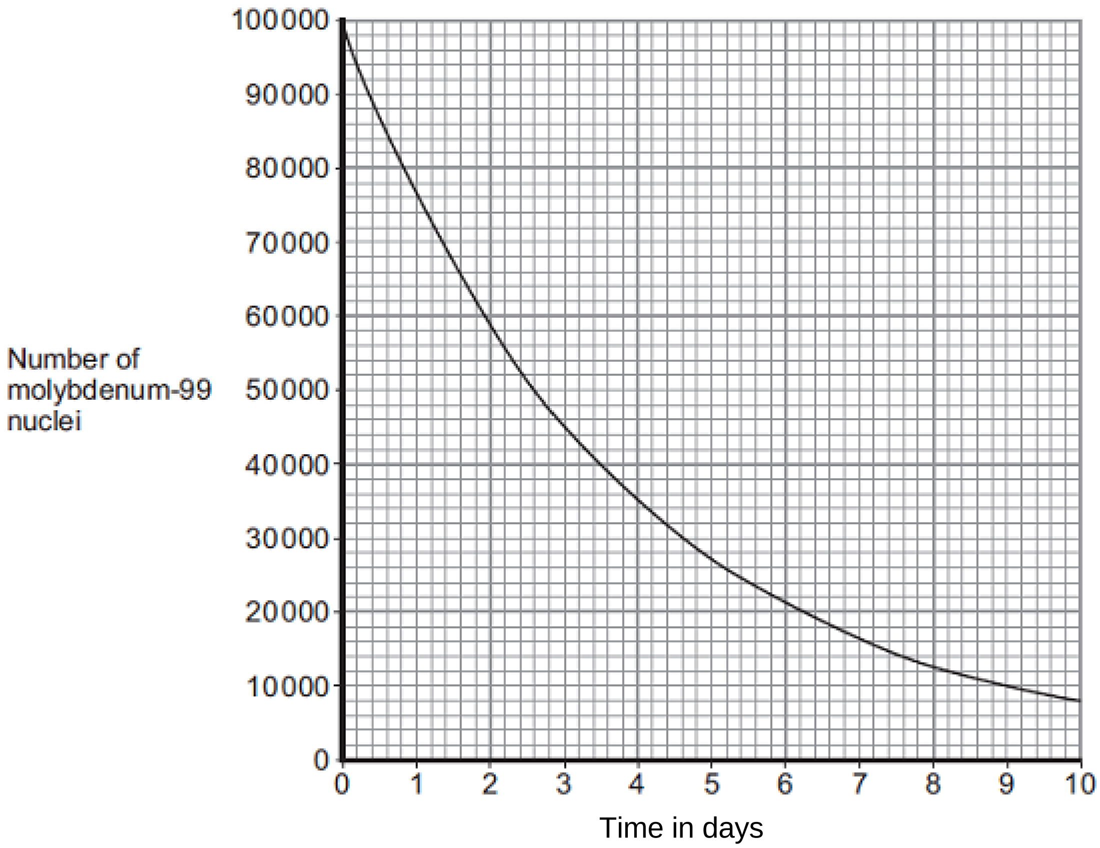
....

....

(1)

(e) Technetium-99 is used by doctors as a medical tracer. In hospitals it is produced inside a technetium generator by the decay of molybdenum-99 nuclei.

(i) The figure below shows how the number of nuclei in a sample of molybdenum-99 changes with time as the nuclei decay.



A technetium generator will continue to produce sufficient technetium-99 until 80% of the original molybdenum nuclei have decayed.

After how many days will a source of molybdenum-99 inside a technetium-99 generator need replacing?

Show clearly your calculation and how you use the graph to obtain your answer.

....

....

....

Number of days = ...

(2)

(ii) Medical tracers are injected into a patient's body; this involves some risk to the patient's health.

Explain the risk to the patient of using a radioactive substance as a medical tracer.

....

....

....

....

(2)

(iii) Even though there may be a risk, doctors frequently use radioactive substances for medical diagnosis and treatments.

Suggest why.

....

....

(1)
(Total 11 marks)

33 The figure below shows an X-ray image of a human skull.

Stockdevil/iStock/Thinkstock

(a) Use the correct answers from the box to complete the sentence.

absorbs	**ionises**	**reflects**	**transmits**

When X-rays enter the human body, soft tissue .... X-rays

and bone .... X-rays.

(2)

(b) Complete the following sentence.

The X-rays affect photographic film in the same way that .... does.

(1)

(c) The table below shows the total dose of X-rays received by the human body when different parts are X-rayed.

Part of body X-rayed	**Dose of X-rays received by human body in arbitrary units**
Head	3
Chest	4
Pelvis	60

Calculate the number of head X-rays that are equal in dose to one pelvis X-ray.

....

....

....

Number of head X-rays = ...

(2)

(d) Which **one** of the following is another use of X-rays?

Tick (✓) **one** box.

Cleaning stained teeth ☐

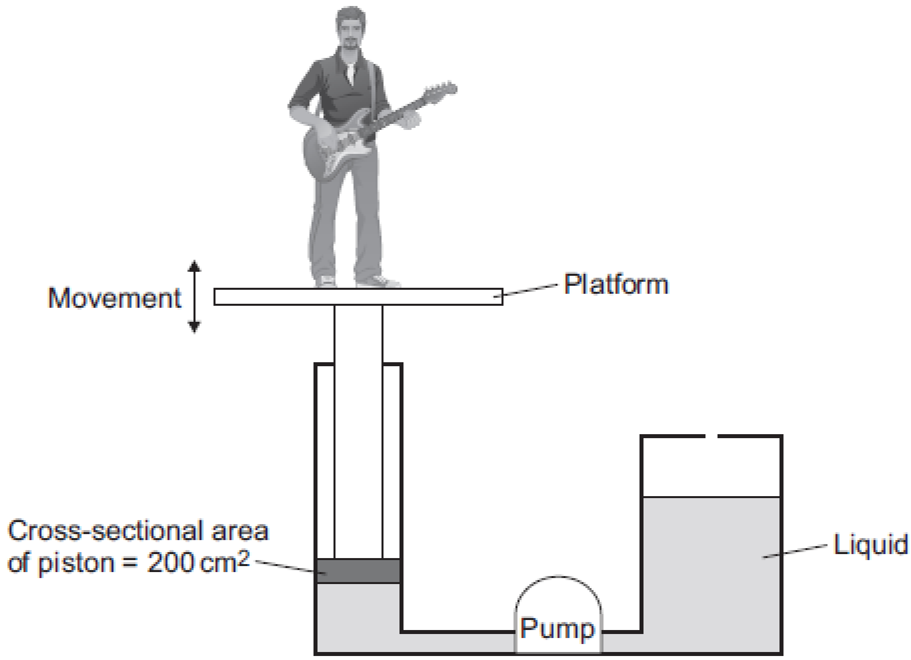
Killing cancer cells ☐

Scanning of unborn babies ☐

(1)
(Total 6 marks)

34 Musicians sometimes perform on a moving platform.

The figure below shows the parts of the lifting machine used to move the platform up and down.



(a) What name is given to a system that uses liquids to transmit forces?

Draw a ring around the correct answer.

electromagnetic **hydraulic** **ionising**

(1)

(b) To move the platform upwards, the liquid must cause a force of 1800 N to act on the piston.

The cross-sectional area of the piston is 200 cm^2.

Calculate the pressure in the liquid, in N / cm^2, when the platform moves.

....

....

....

Pressure = ... N / cm^2

(2)

(c) A new development is to use oil from plants as the liquid in the machine.

Growing plants and extracting the oil requires **less energy** than producing the liquid usually used in the machine.

Draw a ring around the correct answer to complete the sentence.

Using the oil from the plants gives	an environmental an ethical a social	advantage over the liquid

usually used.

(1)
(Total 4 marks)

35 (a) What is ultrasound?

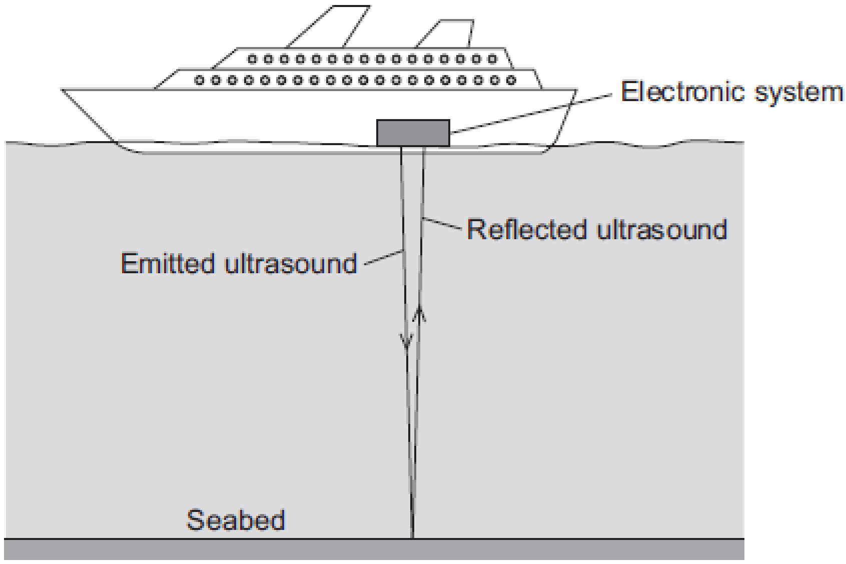
....

....

(1)

(b) **Figure 1** shows how ultrasound is used to measure the depth of water below a ship.

Figure 1



A pulse of ultrasound is sent out from an electronic system on-board the ship.

It takes 0.80 seconds for the emitted ultrasound to be received back at the ship.

Calculate the depth of the water.

Speed of ultrasound in water = 1600 m / s

....

....

....

....

Depth of water = ... metres

(3)

(c) Ultrasound can be used in medicine for scanning.

State **one** medical use of ultrasound scanning.

....

(1)

(d) Images of the inside of the human body can be made using a Computerised Tomography (CT) scanner. The CT scanner in **Figure 2** uses X-rays to produce these images.

Figure 2

monkeybusinessimages/iStock/Thinkstock

State **one** advantage and **one** disadvantage of using a CT scanner, compared with ultrasound scanning, for forming images of the inside of the human body.

Advantage of CT scanning ....

....

....

Disadvantage of CT scanning ....

....

....

(2)
(Total 7 marks)

36 Forces have different effects.

(a) (i) Use the correct answer from the box to complete the sentence.

slowing	**stretching**	**turning**

The moment of a force is the .... effect of the force.

(1)

(ii) What is meant by the centre of mass of an object?

....

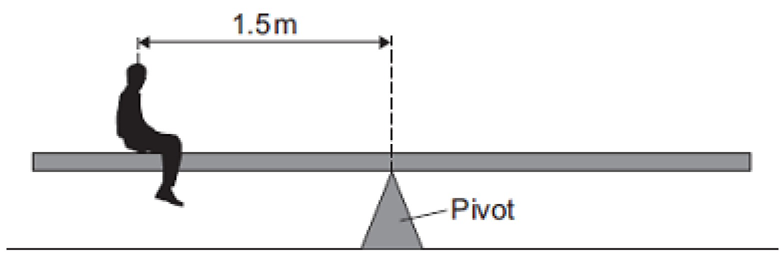
....

(1)

(b) Some children build a see-saw using a plank of wood and a pivot.
The centre of mass of the plank is above the pivot.

Figure 1 shows a boy sitting on the see-saw. His weight is 400 N.

Figure 1



Calculate the anticlockwise moment of the boy in Nm.

....

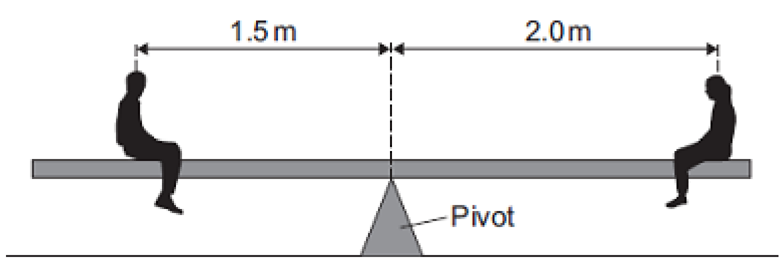
....

Anticlockwise moment = ... Nm

(2)

(c) **Figure 2** shows a girl sitting at the opposite end of the see-saw. Her weight is 300 N.

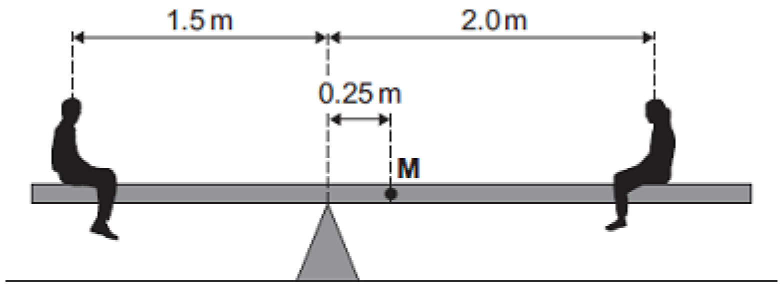
Figure 2



The see-saw is now balanced.

The children move the plank. Its centre of mass, **M**, is now 0.25 m from the pivot as shown in **Figure 3**.

Figure 3



The boy and girl sit on the see-saw as shown in **Figure 3**.

(i) Describe **and** explain the rotation of the see-saw.

....

....

....

....

....

....

....

(3)

(ii) The boy gets off the see-saw and a bigger boy gets on it in the same place. The girl stays in the position shown in **Figure 3**. The plank is balanced. The weight of the plank is 270 N.

Calculate the weight of the bigger boy.

....

....

....

....

....

....

Weight of the bigger boy = ... N

(3)

(Total 10 marks)

37 (a) Human ears can detect a range of sound frequencies.

(i) Use the correct answers from the box to complete the sentence.

2	**20**	**200**	**2000**	**20 000**

The range of human hearing is from about .... Hz to .... Hz.

(2)

(ii) What is ultrasound?

....

....

(1)

(iii) Ultrasound can be used to find the speed of blood flow in an artery.

State **one** other medical use of ultrasound.

....

(1)

(b) The speed of an ultrasound wave in soft tissue in the human body is 1.5×10^3 m / s and the frequency of the wave is 2.0×10^6 Hz.

Calculate the wavelength of the ultrasound wave.

....

....

Wavelength = ... m

(2)

(c) When ultrasound is used to find the speed of blood flow in an artery:

- an ultrasound transducer is placed on a person's arm
- ultrasound is emitted by the transducer
- the ultrasound is reflected from blood cells moving **away** from the transducer
- the reflected ultrasound is detected at the transducer.

Describe the differences between the ultrasound waves emitted by the transducer and the reflected waves detected at the transducer.

....

....

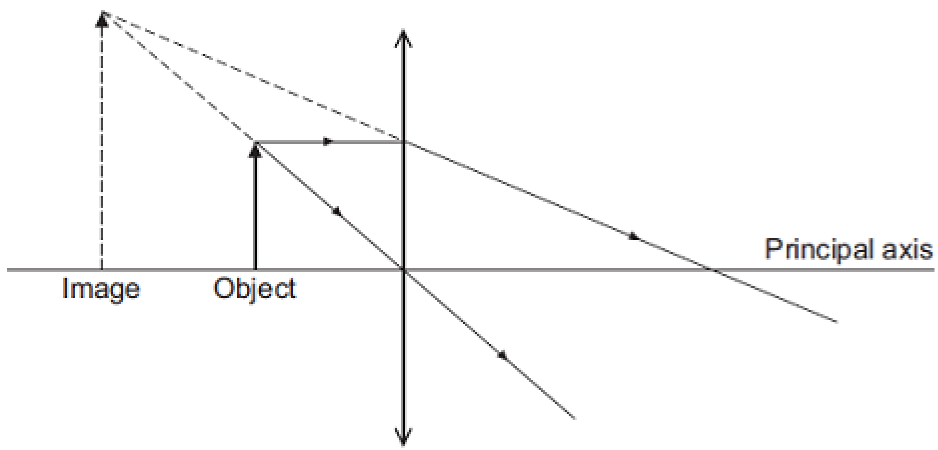
....

....

(2)
(Total 8 marks)

38 (a) The diagram shows how a convex lens forms an image of an object.

This diagram is **not** drawn to scale.



(i) Which **two** words describe the image?

Draw a ring around each correct answer.

diminished **inverted** **magnified** **real** **upright**

(2)

(ii) The object is 4 cm from the lens. The lens has a focal length of 12 cm.

Calculate the image distance.

....

....

....

Image distance = ... cm

(3)

(b) What does a minus sign for an image distance tell us about the nature of the image?

....

(1)
(Total 6 marks)

39 Nuclear fission and nuclear fusion are two processes that release energy.

(a) (i) Use the correct answer from the box to complete each sentence.

Geiger counter	**nuclear reactor**	**star**

Nuclear fission takes place within a ....

Nuclear fusion takes place within a ....

(2)

(ii) State **one** way in which the process of nuclear fusion differs from the process of nuclear fission.

....

....

(1)

(b) The following nuclear equation represents the fission of uranium-235 (U-235).

$$^{1}_{0}n + {}^{235}_{92}U \longrightarrow {}^{236}_{92}U \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n + \text{energy}$$

Chemical symbols:

Ba - barium

Kr - krypton

(i) Use the information in the equation to describe the process of nuclear fission.

....

....

....

....

....

....

....

....

(4)

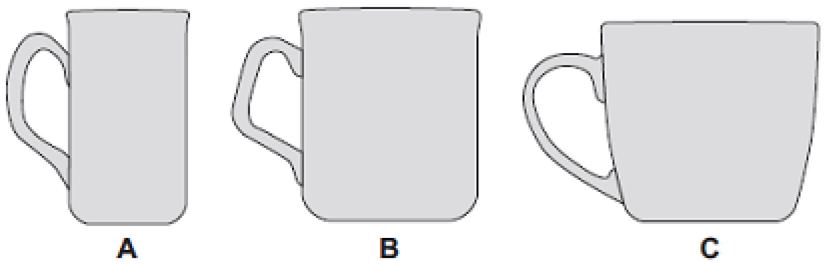
(ii) An isotope of barium is Ba-139.
Ba-139 decays by beta decay to lanthanum-139 (La-139).

Complete the nuclear equation that represents the decay of Ba-139 to La-139.

$$^{139}_{\cdots\cdots}\text{Ba} \longrightarrow {}^{139}_{\cdots\cdots}\text{La} + {}_{\cdots\cdots}$$

(3)
(Total 10 marks)

40 The diagram shows three cups **A**, **B** and **C**.



Energy is transferred from hot water in the cups to the surroundings.

(a) Use the correct answer from the box to complete each sentence.

condensation	**conduction**	**convection**

Energy is transferred through the walls of the cup by ....

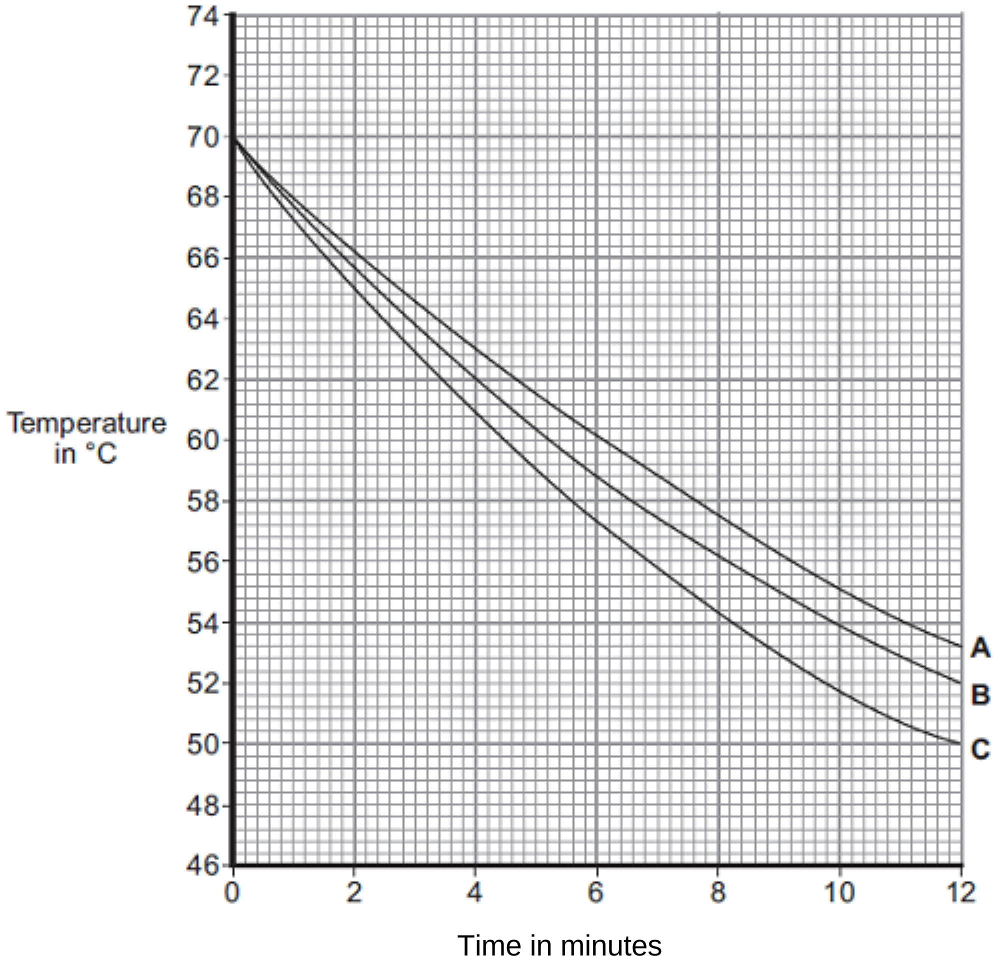
In the air around the cup, energy is transferred by ....

(2)

(b) Some students investigated how the rate of cooling of water in a cup depends on the surface area of the water in contact with the air.

They used cups **A**, **B** and **C**. They poured the same volume of hot water into each cup and recorded the temperature of the water at regular time intervals.

The results are shown on the graph.



(i) What was the starting temperature of the water for each cup?

Starting temperature = ... °C

(1)

(ii) Calculate the temperature fall of the water in cup **B** in the first 9 minutes.

....

Temperature fall = ... °C

(2)

(iii) Which cup, **A**, **B** or **C**, has the greatest rate of cooling? ☐

Using the graph, give a reason for your answer.

....

....

(2)

(iv) The investigation was repeated using the bowl shown in the diagram.

The same starting temperature and volume of water were used.

Draw on the graph in part **(b)** another line to show the expected result.

(1)

(v) After 4 hours, the temperature of the water in each of the cups and the bowl was 20°C.

Suggest why the temperature does **not** fall below 20°C.

....

(1)

(c) (i) The mass of water in each cup is 200 g.

Calculate the energy, in joules, transferred from the water in a cup when the temperature of the water falls by 8°C.

Specific heat capacity of water = 4200 J / kg°C.

....

....

....

Energy transferred = ... J

(3)

(ii) Explain, in terms of particles, how evaporation causes the cooling of water.

....

....

....

....

....

....

....

....

(4)
(Total 16 marks)

41 Electrical circuits have resistance.

(a) Draw a ring around the correct answer to complete the sentence.

When the resistance of a circuit increases, the current in the circuit	decreases. increases. stays the same.

(1)

(b) Use the correct answer from the box to complete each sentence.

a filament bulb	**an LED**	**an LDR**

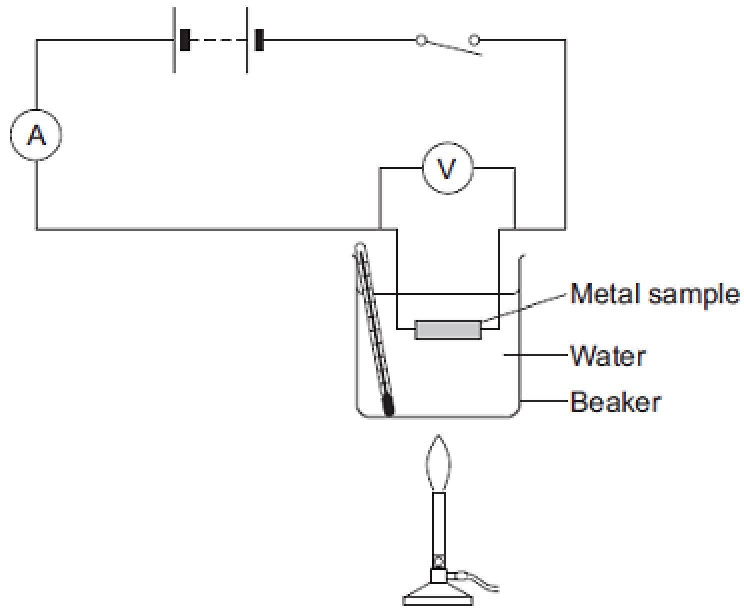
An electrical component which has a resistance that increases as the temperature increases is ....

An electrical component which emits light only when a current flows through it in the forward direction is ....

(2)

(c) When some metals are heated the resistance of the metal changes.

The equipment for investigating how the resistance of a metal changes when it is heated is shown in the diagram.



In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.

Describe an investigation a student could do to find how the resistance of a metal sample varies with temperature. The student uses the equipment shown.

Include in your answer:

- how the student should use the equipment
- the measurements the student should make
- how the student should use these measurements to determine the resistance
- how to make sure the results are valid.

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

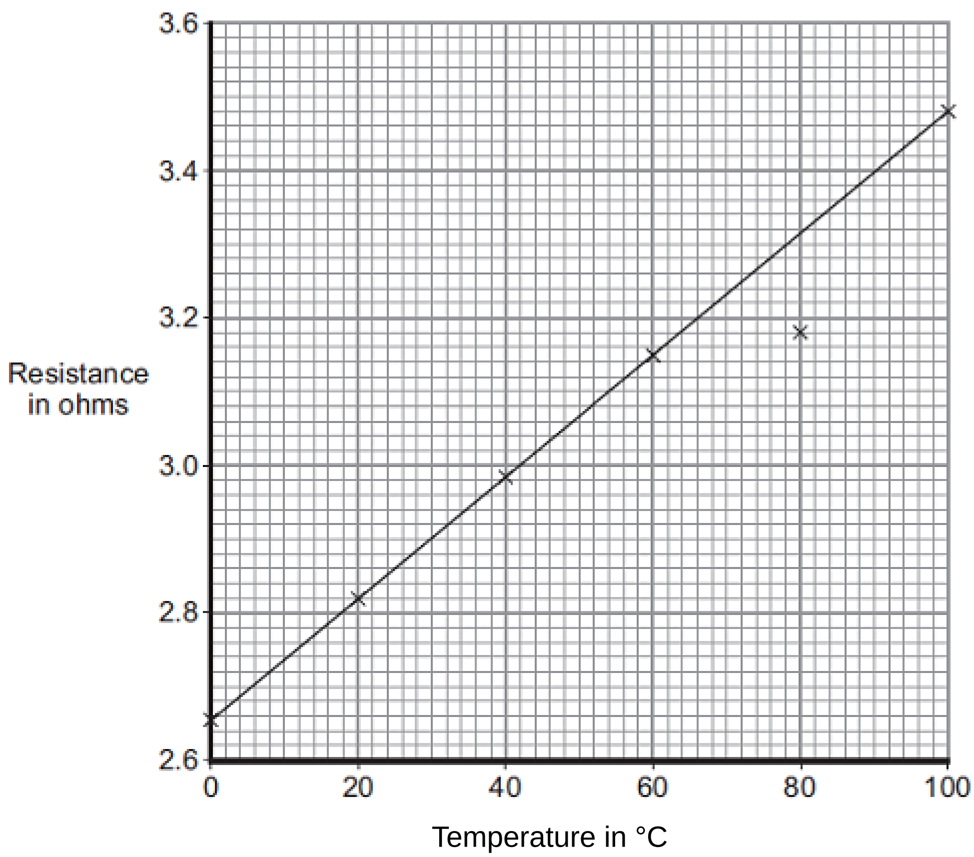
(6)

(d) The table shows some data for samples of four metals **P**, **Q**, **R** and **S**.

The metal samples all had the same cross-sectional area and were the same length.

Metal sample	Resistance at 0°C in ohms	Resistance at 100°C in ohms
P	4.05	5.67
Q	2.65	3.48
R	6.0	9.17
S	1.70	2.23

A graph of the results for one of the metal samples is shown.



(i) Which metal sample, **P**, **Q**, **R** or **S**, has the data shown in the graph? ☐

(1)

(ii) One of the results is anomalous. Circle this result on the graph.

(1)

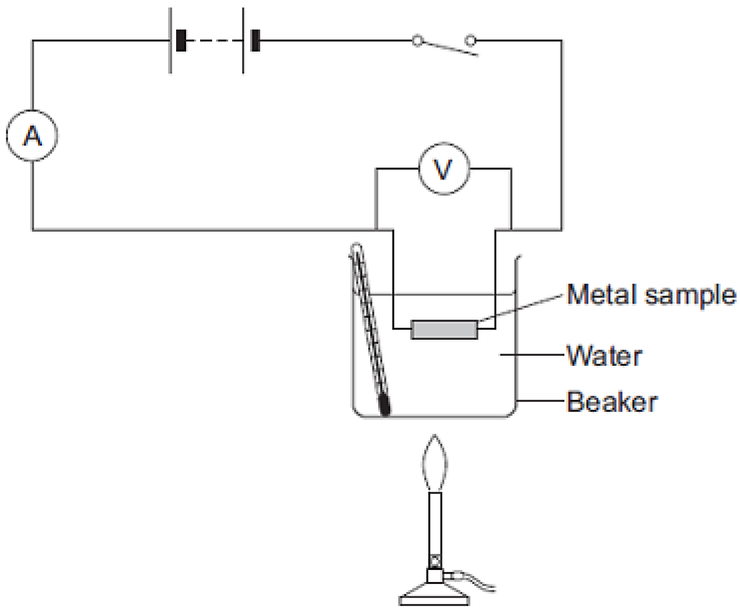
(iii) Suggest a reason for the anomalous result.

....

....

(1)

(iv) The same equipment used in the investigation could be used as a thermometer known as a ‘resistance thermometer.’



Suggest **two** disadvantages of using this equipment as a thermometer compared to a liquid-in-glass thermometer.

1 ....

....

2 ....

....

(2)
(Total 14 marks)

Mark schemes

1 (a) frequency

1

(b) echo(es)

1

(c) 340 (m/s)

*allow **1** mark for correct substitution ie 25 000 × 0.0136 provided no subsequent step*

or

*allow **1** mark for a correct calculation showing an incorrect value from conversion to hertz × 0.0136*

*an answer of 0.34 gains **1** mark*

2

(d) (a wave where the) oscillations are parallel to the direction of energy transfer

both marking points may appear as labels on a diagram

accept vibrations for oscillations
accept in same direction as for parallel to
allow direction of wave (motion) for direction of energy transfer

*allow **1** mark for a correct calculation showing an incorrect value from conversion to hertz × 0.0136*

1

causing (areas of) compression and rarefaction

accept correct description in terms of particles

mechanical wave is insufficient
needs a medium to travel through is insufficient

1

[6]

2 (a) any **one** from:

- high cost of installing overhead power lines or underground cables or pylons
- high cost as (very) long cables needed
- amount of electricity required is too low

allow not enough (surplus) electricity would be generated

1

(b) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should apply a 'best-fit' approach to the marking.

Level 3 (5 – 6 marks):
clear comparison of advantages **and** disadvantages of **each** method

Level 2 (3 – 4 marks):
at least **one** advantage **and one** disadvantage is stated for **one** method **and** a different advantage **or** disadvantage is stated for the other method

Level 1 (1 – 2 marks):
at least **one** advantage **or one** disadvantage of either method

Level 0 (0 marks):
No relevant information

examples of physics points made in the response

Advantages of both methods:

- both renewable sources of energy
- both have no fuel (cost)
- both have very small (allow 'no') running costs
- no carbon dioxide produced

accept carbon neutral

accept no greenhouse gases

accept doesn't contribute to global warming

Advantages of wind:

- higher average power output

produces more energy is insufficient

Advantages of hydroelectric:

- constant / reliable power (output)
- lower (installation) cost

Disadvantages of wind:

- higher (installation) cost
- variable / unreliable power output
- (may) kill birds / bats

Disadvantages of hydroelectric:

- lower power output
- (may) kill fish or (may) damage habitats
- more difficult to set up (within river)

Disadvantages of both methods:

- (may be) noisy
- visual pollution

ignore payback time unless no other relevant points made

ignore time to build for both

6

[7]

3 (a) **use of infrared:**

remote controls
fibre optic (communications)

1

use of microwaves:

mobile/cell phones

accept mobiles

accept phone signals

satellite (communications/TV)
wi-fi
Bluetooth

1

(b) any **two** from

- same speed
  or
  travel at the speed of light (in a vacuum)
- transverse
  accept a full description of a transverse wave
- transfer energy (from one place to another)
- can be reflected
- can be refracted
- can be diffracted
- can be absorbed / transmitted
- can travel through a vacuum/space
- can be polarised
  travels in straight lines is insufficient

2

[4]

4 (a) any **two** from:

- cost per kWh is lower (than all other energy resources)
  allow it is cheaper
  ignore fuel cost
  ignore energy released per kg of nuclear fuel
- infrastructure for nuclear power already exists
  accept cost of setting up renewable energy resources is high
  accept many renewable power stations would be needed to replace one nuclear power station
  accept (France in 2011 already had a) surplus of nuclear energy, so less need to develop more renewable capacity for increased demand in the future
  accept France benefits economically from selling electricity
- more reliable (than renewable energy resources)
  accept (nuclear) fuel is readily available
  ignore destruction of habitats for renewables

2

(b) any **two** from:

- non-renewable

  allow nuclear fuel is running out
- high decommissioning costs

  accept high commissioning costs
- produces radioactive / nuclear waste

  allow waste has a long half-life
- long start-up time
- nuclear accidents have widespread implications

  allow for nuclear accident a named nuclear accident

  eg Fukushima, Chernobyl

  ignore visual pollution

2

(c) 0.48 (kW)

*allow **1** mark for correct substitution*

ie 0.15 = P / 3.2

*an answer of 480 W gains **2** marks*

*an answer of 48 or 480 scores **1** mark*

2

(d) the higher the efficiency, the higher the cost (per m^2 to manufacture)

accept a specific numerical example

1

more electricity could be generated for the same (manufacturing) cost using lower efficiency solar panels

or

(reducing the cost) allows more solar panels to be bought

accept a specific numerical example

1

[8]

5 (a) gas

correct order only

1

gravity

1

protostar

accept correct word circled in box provided no answer given in answer space

1

(b) the explosion of a massive star

1

(c) The telescopes and measuring instruments were not sensitive enough.

1

[5]

6

(a) (i) 0.15 × 0.08 = 0.012

1

(ii) kg m/s

1

(iii) equal to

1

(b) momentum of the air increases
or
force backwards increases

accept air moves faster

accept momentum backwards increases

accept pushes more air back(wards)

1

so momentum of the toy must increase
or
the force forwards (on the toy) increases

accept momentum forwards must increase

it = toy

1

[5]

7

(a) neutrons

1

(b) generate electricity

accept produce electricity

accept heat water

accept produce steam

turns turbines is insufficient

1

(c) (i) a neutron

1

(ii) two particles **X** released from the uranium-235

1

uranium-235 shown splitting into two fragments
or
each particle **X** shown colliding with a uranium-235 and producing 2 further particles **X**

one uranium-235 shown splitting is sufficient, provided no contradiction shown

1

[5]

8 (a) 2 protons and 2 neutrons

accept 2p and 2n

accept (the same as a) helium nucleus

symbol is insufficient

do not accept 2 protons and neutrons

1

(b) (i) gamma rays

1

(ii) loses/gains (one or more) electron(s)

1

(c) any **one** from:

- wear protective clothing
- work behind lead/concrete/glass shielding
- limit time of exposure
- use remote handling

accept wear mask/gloves

wear goggles is insufficient

wear protective equipment/gear is insufficient

accept wear a film badge

accept handle with (long) tongs

accept maintain a safe distance

accept avoid direct contact

1

(d) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should apply a 'best-fit' approach to the marking.

Level 3 (5 – 6 marks):
There is a description of all three types of radiation in terms of at least two of their properties
or
a full description of two types of radiation in terms of all three properties.

Level 2 (3 – 4 marks):
There is a description of at least two types of radiation in terms of some properties
or
a full description of one type of radiation in terms of all three properties
or
the same property is described for all three radiations

Level 1 (1 – 2 marks):
There is a description of at least one type of radiation in terms of one or more properties.

Level 0 (0 marks):
No relevant information

examples of physics points made in the response

alpha particles

- are least penetrating
- are stopped by paper / card

- have the shortest range
- can travel (about) 5cm in air

- are (slightly) deflected by a magnetic field
- alpha particles are deflected in the opposite direction to beta particles by a magnetic field

beta particles

- (some are) stopped by (about) 2mm (or more) of aluminium/metal
- can travel (about) 1 metre in air
- are deflected by a magnetic field
- beta particles are deflected in the opposite direction to alpha particles by a magnetic field

accept (some are) stopped by aluminium foil

gamma rays

- are the most penetrating
- are stopped by (about) 10cm of lead
- have the longest range
- can travel at least 1 km in air
- are not deflected by a magnetic field

6

[10]

9 (a) (i) (enough) dust and gas (from space) is pulled together

accept nebula for dust and gas

accept hydrogen for gas

accept gas on its own

dust on its own is insufficient

mention of air negates this mark

1

by:
gravitational attraction
or
gravitational forces
or
gravitaty

ignore any (correct) stages beyond this

1

(ii) joining of two (atomic) nuclei (to form a larger one)

do not accept atoms for nuclei

1

(iii) more sensitive astronomical instruments / telescopes

or

infrared telescopes developed

accept better technology

more knowledge is insufficient

1

(b) (i) (other) planets / solar systems

do not accept galaxy

moons is insufficient

1

(ii) provided evidence to support theory

accept proves the theory

1

(c) elements heavier than iron are formed only when a (massive) star explodes

accept materials for elements

accept supernova for star explodes

accept stars can only fuse elements up to (and including) iron

1

[7]

10 (a) (force on the chain is) smaller (than the force of the toe)

1

(b) Tick in middle box

The moments are equal and opposite

1

(c) move the toe (up the pedal) away from the pivot

1

[3]

11 (a) an electromagnet can be switched off

accept a permanent magnet cannot be switched off

or

an electromagnet is stronger

accept control the strength

1

(b) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should apply a ‘best-fit’ approach to the marking.

Level 3 (5 – 6 marks):
there is a description of how the electromagnet is made
and
there is a description of how the strength of the electromagnet can be varied
and
there is a description of how the strength of the electromagnet can be tested

Level 2 (3 – 4 marks):
there is a description of how the electromagnet is made
and either
there is a description of how the strength of the electromagnet can be varied
or
there is a description of how the electromagnet can be tested

Level 1 (1 – 2 marks):
there is a basic description of how to make an electromagnet
or
there is a basic description of how the strength of the electromagnet can be varied
or
there is a basic description of how the electromagnet can be tested

Level 0 (0 marks):
No relevant / correct content

examples of the points made in the response

Details of how to make an electromagnet

- wrap the wire around the nail
- connect the wire to the power supply (with connecting leads and croc clips)
- switch on the power supply

accept a current should be sent along the wire

Details of how to vary the strength of the electromagnet

- change the number of turns (on the coil)
- change the current (through the coil)
- change the separation of the turns

allow change the potential difference (across the coil)

accept wrap the coil more tightly

Details of how to test the electromagnet

- suspend paperclips from the electromagnet
- the more paperclips suspended, the stronger the electromagnet is
- clamp the electromagnet at different distances from the paperclip(s)
- the further the distance from which paperclips can be attracted the stronger the electromagnet is
- test before and after making alterations to change the strength
- compare the results from before and after making alterations
- use de-magnetised paper clips

accept count the number of paperclips

*with different current **or** p.d. **or** no. of turns*

***or** core and see if the number changes/increases*

6

[7]

12 (a) a magnetic field

accept electromagnetic field

heat is insufficient

1

that is alternating / changing

1

(b) 20

*allow **1** mark for correct*

substitution, ie

$$\frac{230}{11.5}$$

provided no subsequent step

2

(c) (most) transformers are not 100% efficient

allow energy / power is lost to the surroundings

allow energy / power is lost as heat / sound

power is lost is insufficient

1

(d) (i) 0.01 (V)

1

because there is a change in p.d. each time (the number of turns changes)

allow because all the results (to 2 decimal places) are different

accept if results were to 1 decimal place, there might not be a difference

1

(ii) student 2 moved the coil more slowly (than student 1)

accept student 2 moved the coil at a different speed to student 1

do not accept student 2 moved the coil faster (than student 1)

1

(iii) both sets of results show the same pattern

accept trend for pattern

results are similar is insufficient

results follow a pattern is insufficient

1

(iv) (electromagnetic) induction

accept it is induced

do not accept electric / magnetic induction

1

(e) any **one** from:

- more economical / cheaper for the consumer

  allow more convenient

- easier/cheaper to replace if broken/lost

  allow in case one gets lost

- since fewer transformers need to be made less resources are used

  allow fewer plug sockets are needed

  allow fewer transformers are needed

  environmentally friendly is insufficient

1

[11]

13 (a) ultrasound is not ionising

allow ultrasound does not harm the (unborn) baby

1

but X-rays are ionising

1

so X-rays increase the health risk to the (unborn) baby

accept specific examples of health risks, eg cancer, stunted growth, impaired brain function etc

X-rays are dangerous is insufficient

1

(b) ultrasound/waves are partially <u>reflected</u>

(when they meet a boundary) (between two different media / substances / tissues)

must be clear that not all of the wave is reflected

1

the time taken is measured (and is used to determine distances)

1

(c) 1600 (m/s)

*800 (m/s) gains **2** marks*

*160 000 (m/s) gains **2** marks*

*0.0016 (m/s) gains **2** marks*

*allow **2** marks for*

$$\frac{0.04}{25 \times 10^{-6}}$$

or

$$\frac{0.08}{50 \times 10^{-6}}$$

*80 000 (m/s) gains **1** mark*

*0.0008 (m/s) gains **1** mark*

*allow **1** mark for*

$$\frac{0.04}{25}$$

or

$$\frac{0.08}{50}$$

*allow **1** mark for evidence of doubling the distance or halving the time*

3

(d) (i) they are absorbed by bone

allow stopped for absorbed

X-rays are reflected negates this mark

1

they are transmitted by soft tissue

allow pass through for transmitted

allow flesh / muscle / fat

accept less (optically) dense material for soft tissue

1

(the transmitted) X-rays are detected

1

(ii) short

accept small

1

[12]

14 (a) the image would decrease in size

1

the image would change (from virtual) to real

accept that the image (of bulb M) can be projected on to a screen

1

the image would change (from non-inverted) to inverted

1

(b) a ray through the centre of the lens

rays should be drawn with a ruler

ignore arrows

1

a ray parallel to the principal axis and passing through the principal focus to the right of lens

accept solid or dashed lines

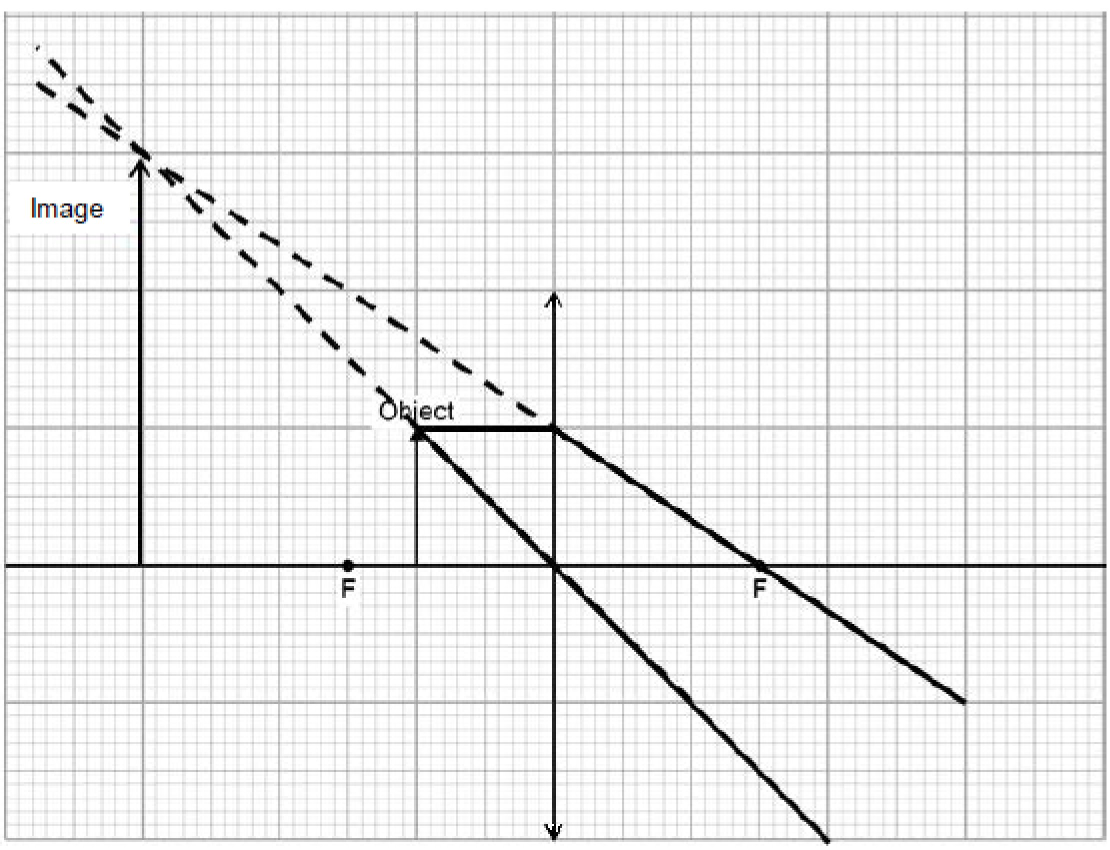
accept a ray drawn as if from the principal focus to the left of the lens, emerging parallel to the principal axis

1

image drawn where rays cross

image should be to left of the lens

1



(c) (i) (because the glass in) lens A has a greater refractive index

accept lens A is more powerful

accept lens A has a shorter focal length

1

(ii) when the magnification increases by 1, the image distance increases by 10 cm

*accept for **1** mark it is a linear pattern*

or

as the image distance increases, the magnification increases

*do **not** accept directly proportional*

2

(iii) diagram showing the surfaces of a convex lens C having greater curvature than lens B

the size of the lens drawn is not important

1

[10]

15 (a) (i) distance travelled under the braking force

accept distance travelled between applying the brakes and stopping

1

(ii) any **one** from:

- icy / wet roads

  accept weather (conditions)
- (worn) tyres
- road surface

  accept gradient of road
- mass (of car and passengers)

  accept number of passengers
- (efficiency / condition of the) brakes.

  friction / traction is insufficient

1

(iii) greater the speed the greater the braking force (required)

must mention both speed and force

1

(b) 22.5

*allow **1** mark for showing correct use of the graph with misread figures*

or

for showing e.g. 90÷4

*an answer 17 gains **1** mark*

any answer such as 17.4 or 17.5 scores 0

2

(c) (i) momentum before = momentum after

or

(total) momentum stays the same

accept no momentum is lost

accept no momentum is gained

ignore statements referring to energy

1

(ii) 5

*allow **2** marks for correctly obtaining momentum before as 12 000*

or

*allow **2** marks for*

1500 × 8 = 2400 × v

or

*allow **1** mark for a relevant statement re conservation of momentum*

or

*allow **1** mark for momentum before = 1500 × 8*

3

(d) the seat belt stretches

1

driver takes a longer (*impact*) time to slow down and stop (than a driver hitting a hard surface / windscreen / steering wheel)

1

for the (same) change of momentum

accept so smaller deceleration / negative acceleration

1

a smaller force is exerted (so driver less likely to have serious injury than driver without seat belt)

or

the seat belt stretches ***(1)***

do not accept impact for force

driver travels a greater distance while slowing down and stopping (than a driver hitting a hard surface / windscreen / steering wheel) ***(1)***

for (same) amount of work done ***(1)***

accept for (same) change of KE

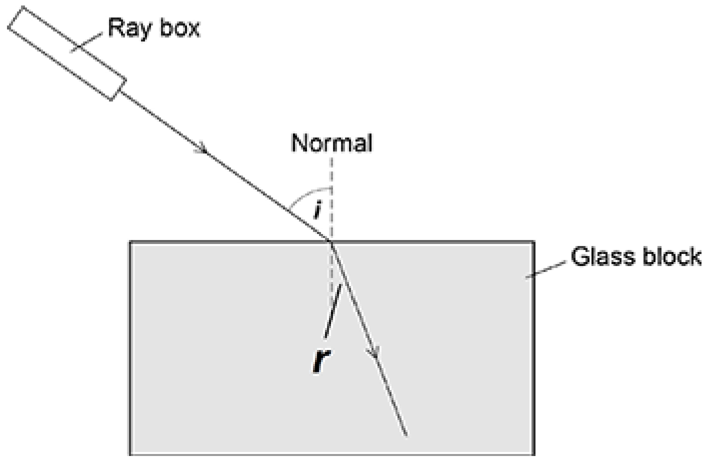
a smaller force is exerted (so driver less likely to have serious injury than driver without seat belt) ***(1)***

do not accept impact for force

1

[13]

16 (a) (i)



1

(ii) 1 degree

1

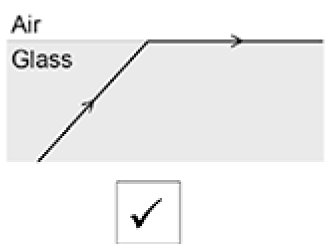
(iii) 1.6

*allow **1** mark for correct substitution, ie 0.80 / 0.5 provided no subsequent step shown*

working showing 1.59(9…..) scores zero

2

(b) 2nd diagram ticked



1

(c) (i) any **one** correct description:

- upright
- virtual
- diminished.

treat multiple words as a list

1

(ii) 0.25

*allow **1** mark for correct substitution, ie 1 / 4 or 5 / 20 provided no subsequent step shown*

ignore any unit

2

(iii) Correcting short sight

1

[9]

17 (a) refraction
1

(b) towards the normal
1

(c) (i) convex
1

(ii) principal focus

accept focal point
1

(d) parallel on left
1

refracted towards the normal at first surface
1

refraction away from normal at second surface
1

passes through or heads towards principal focus
1

(e) refractive index

accept material from which it is made
1

(radius of) curvature (of the sides)

accept shape / radius

*do **not** accept power of lens*

ignore thickness / length
1

[10]

18 (a) **solid**

<u>particles</u> vibrate about fixed positions
1

closely packed

accept regular
1

gas

<u>particles</u> move randomly

accept particles move faster

accept freely for randomly
1

far apart
1

(b) amount of energy required to change the state of a substance from liquid to gas (vapour)

1

unit mass / 1 kg

dependent on first marking point

1

(c) 41000 **or** 4.1×10^4 (J)

accept

41400 or 4.14×10^4

correct substitution of

$0.018 \times 2.3 \times 10^6$ *gains* ***1*** *mark*

2

(d) **AB**

changing state from solid to liquid / melting

1

at steady temperature

dependent on first ***AB*** *mark*

1

BC

temperature of liquid rises

1

until it reaches boiling point

dependent on first ***BC*** *mark*

1

[12]

19 (a) (i) generator

1

(ii) alternating current

1

(iii) voltmeter / CRO / oscilloscope / cathode ray oscilloscope

1

(b) (i) time

1

(ii) peaks and troughs in opposite directions

1

amplitude remains constant

dependent on first marking point

1

(c) any **two** from:

- increase speed of coil
- strengthen magnetic field
- increase area of coil

*do **not** accept larger*

2

[8]

20 (a) (i) frequency

1

wavelength

1

(ii) 10^{-15} to 10^{4}

1

(b) 2.0×10^{5}

correct substitution of

*3.0×10^{8} / 1500 gains **1** mark*

2

Hz

1

(c) (i) (skin) burns

1

(ii) skin cancer / blindness

1

(d) (i) any **one** from:

- (detecting) bone fractures
- (detecting) dental problems
- treating cancer

1

(ii) any **one** from:

- affect photographic film
- absorbed by bone
- transmitted by soft tissue
- kill (cancer) cells

*answer must link to answer given in **(d)(i)***

1

(iii) 9 / 36 = 0.25
0.5 / 2 = 0.25
4 / 16 = 0.25

accept:

36 / 9 = 4

2 / 0.5 = 4

16 / 4 = 4

2

conclusion based on calculation

*two calculations correct with a valid conclusion scores **2** marks*

*one correct calculation of k scores **1** mark*

1

[13]

21 (a) terminal

1

(b) 5.4 (kg)

*correct substitution of 54 = m × 10 gains **1** mark*

2

(c) (i) 0< a <10

1

some upward force

accept some drag / air resistance

1

reduced resultant force

1

(ii) 0

1

upward force = weight (gravity)

1

resultant force zero

1

[9]

22 (a) (i) **X** placed at 50 cm mark

1

(ii) <u>point</u> at which mass of object may be (thought to be) concentrated

1

(b) (i) **Y** placed between the centre of the rule and the upper part of mass

1

(ii) 16.5

*allow for **1** mark*
(16.5 + 16.6 +16.5) / 3

2

1.65

value consistent with mean value given

only penalise significant figures once

1

(iii) Marks awarded for this answer will be determined by the quality of communication as well as the standard of the scientific response. Examiners should apply a ‘best-fit’ approach to the marking.

0 marks
No relevant content

Level 1 (1 – 2 marks)
A description of a method which would provide results which may not be valid

Level 2 (3 – 4 marks)
A clear description of a method enabling some valid results to be obtained. A safety factor is mentioned

Level 3 (5 – 6 marks)
A clear and detailed description of experiment. A safety factor is mentioned. Uncertainty is mentioned

examples of the physics points made in the response:

additional apparatus

- stopwatch

use of apparatus

- measure from hole to centre of the mass
- pull rule to one side, release
- time for 10 swings and repeat
- divide mean by 10
- change position of mass and repeat

fair test

- keep other factors constant
- time to same point on swing

risk assessment

- injury from sharp nail
- stand topple over
- rule hit someone

accuracy

- take more than 4 values of *d*
- estimate position of centre of slotted mass
- small amplitudes
- discard anomalous results
- use of fiducial marker

6

(c) (i) initial reduction in *T* (reaching minimum value) as *d* increases

1

after 30 cm *T* increases for higher value of *d* 1

(ii) (no)

any **two** from:

- fourth reading is close to mean
- range of data 0.2 s / very small
- variation in data is expected

2

[16]

23 (a) (enough) dust / gas (from space) 1

are pulled together 1

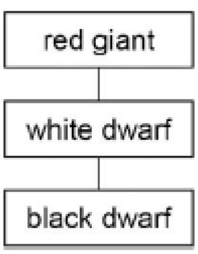
by gravitational attraction 1

(b) fusion

accept fusion circled in box 1

(c) forces within it are balanced 1

(d)



correct order only 1

ignore reference to planetary nebula 1

1

[8]

24 (a) (i) short sight

accept myopia 1

(ii) diverging 1

(b) light 1

(c) Marks awarded for this answer will be determined by the quality of communication as well as the standard of the scientific response. Examiners should also apply a 'best-fit' approach to the marking.

0 marks
No relevant content

Level 1 (1–2 marks)
There is a basic description of one advantage ***or*** disadvantage of using **either** of the methods

Level 2 (3–4 marks)
There is a *description* of some advantages **and / or** disadvantages of using **both** methods
or
a full, detailed description of the advantages and disadvantages of using **either** of the methods.

Level 3 (5–6 marks)
There is a *clear description* of the advantages and disadvantages of using **both** methods.

examples of the points made in the response

extra information

laser surgery

advantages:

- *appearance*
- *permanent effect*
- no glasses which need changing

disadvantages:

- risks associated with surgery
- large cost
- not able to drive etc straightaway
- (still) might need glasses for reading

wearing glasses

advantages:

- able to function straightaway
- any problems easy to sort out

disadvantages:

- *easily broken*
- *easily lost*
- need changing
- overall cost might be greater if several changes in vision
- might eventually need two pairs of glasses

6

(d) move lens 1

closer to film 1

[11]

25 (a) pitch 1

loudness 1

(b) (i) as length (of prongs) decreases frequency / pitch increases

accept converse

accept negative correlation

ignore inversely proportional

1

(ii) 8.3 (cm)

accept 8.3 ± 0.1 cm

1

(iii) (8.3 cm is) between 7.8 (cm) and 8.7 (cm)

*ecf from part **(ii)***

1

(so *f* must be) between 384 (Hz) and 480 (Hz)

1

410 (Hz) ≤ *f* ≤ 450 (Hz)

*if only the estimated frequency given, accept for **1** mark an answer within the range*

1

(c) (i) electronic

1

(ii) frequency is (very) high

accept frequency above

*20 000 (Hz) **or** audible range*

1

so tuning fork ***or*** length of prongs would be very small (1.2 mm)

1

(d) 285.7 (Hz)

accept any correct rounding 286, 290, 300

*allow **2** marks for 285*

*allow **2** marks for correct substitution 0.0035 = 1 / f*

*allow **1** mark for T = 0.0035 s*

*allow **1** mark for an answer of 2000*

3

[13]

26 (a) (average) time taken for the amount / number of nuclei / atoms (of the isotope in a sample) to halve

or

time taken for the count rate (from a sample containing the isotope) to fall to half

accept (radio)activity for count rate

1

(b) *60 ±3* (days)

1

indication on graph how value was obtained

1

(c) (i) cobalt(-60)

1

gamma not deflected by a magnetic field

or

gamma have no charge

dependent on first marking point

accept (only) emits gamma

gamma has no mass is insufficient

*do **not** accept any reference to half-life*

1

(ii) strontium(-90)

1

any **two** from:

- *<u>only</u>* has beta
- alpha would be absorbed
- gamma unaffected
- *beta penetration / absorption depends on thickness of paper*

*if thorium(-232) or radium(-226) given, max **2** marks can be awarded*

2

(iii) cobalt(-60)

1

shortest half-life

accept half-life is 5 years

dependent on first marking point

1

so activity / count rate will decrease quickest

1

(iv) *americium(-241) / cobalt(-60) / radium(-226)*

1

gamma emitter

1

(only gamma) can penetrate lead *(of this box)*

do not allow lead fully absorbs gamma

1

[14]

27 (a) (black) is a good absorber of (infrared) radiation

1

(b) (i) amount of energy required to change (the state of a substance) from solid to liquid (with no change in temperature)

melt is insufficient

1

unit mass / 1kg

1

(ii) 5.1×10^6 (J)

accept 5×10^6

*allow **1** mark for correct substitution ie* $E = 15 \times 3.4 \times 10^5$

2

(c) (i) mass of <u>ice</u>

allow volume / weight / amount / quantity of <u>ice</u>

1

(ii) to distribute the salt throughout the ice

1

to keep all the ice at the same temperature

1

(iii) melting point decreases as the mass of salt is increased

allow concentration for mass

accept negative correlation

*do **not** accept inversely proportional*

1

(d) 60 000 (J)

accept 60 KJ

*allow **2** marks for correct substitution ie E = 500 × 2.0 × 60*

*allow **2** marks for an answer of 1000 **or** 60*

*allow **1** mark for correct substitution ie*

*E = 500 × 2.0 **or** 0.50 × 2.0 × 60*

*allow **1** mark for an answer of 1*

3

(e) Marks awarded for this answer will be determined by the Quality of Communication (QC) as well as the standard of the scientific response. Examiners should also apply a 'best-fit' approach to the marking.

0 marks
No relevant content

Level 1 (1–2 marks)
There is *an attempt at a description of some advantages or disadvantages.*

Level 2 (3–4 marks)
There is a basic description of *some advantages* ***and / or*** *disadvantages for some of the methods*

Level 3 (5–6 marks)
There is a clear description of the advantages and disadvantages of all the methods.

examples of the points made in the response

extra information

energy storage

advantages:

- no fuel costs
- no environmental effects

disadvantages:

- expensive to set up and maintain
- need to dig deep under road
- dependent on (summer) weather
- digging up earth and disrupting habitats

salt spreading

advantages:

- easily available
- cheap

disadvantages:

- can damage trees / plants / drinking water / cars
- needs to be cleaned away

undersoil heating

advantages:

- not dependent on weather
- can be switched on and off

disadvantages:

- costly
- bad for environment

6

[18]

28 (a) (i) any **two** from:

- length of coils increased
- coils have tilted
- length of loop(s) increased
- increased gap between coils
- *spring has stretched / got longer*
- *spring has got thinner*

2

(ii) remove mass

accept remove force / weight

1

observe if the spring returns to its original length / shape *(then* it is behaving elastically)

1

(b) (i) 8.0 (cm)

1

extension is directly proportional to force *(up to 4 N)*

for every 1.0 N extension increases by 4.0 cm (up to 4 N)

evidence of processing figures eg 8.0 *cm* is half way between 4.0 *cm* and 12.0 *cm*

1

allow spring constant (k) goes from to $\frac{1}{4}$ to $\frac{5}{22}$

1

(ii) any value greater than 4.0 N and less than or equal to 5.0 N

1

the increase in extension is greater than 4 cm per 1.0 N (of force) added

dependent on first mark

1

(c) (i) elastic potential energy

1

(ii) misread stopwatch

1

timed too many complete oscillations

1

(iii) 4.3 (s)

accept 4.33 (s)

1

(iv) stopwatch reads to 0.01 s

1

reaction time is about 0.2 s
or
reaction time is less precise than stopwatch

1

(v) use more masses

1

smaller masses eg 50 g

not exceeding limit of proportionality

1

[17]

29 (a) (i) electrical

correct order only

1

kinetic

1

sound

1

(ii) transferred into surroundings / atmosphere

accept warms the surroundings

allow released into the environment

becomes heat or sound is insufficient

1

(b) 0.7 / 70 %

an answer of 70 without % or with the wrong unit ***or*** *0.7 with a unit gains* ***1*** *mark*

2

[6]

30 (a) conduction

1

(b) 35 000

1

(c) 500

their (b) = 2 x c x 35 correctly calculated scores ***2*** *marks*

allow ***1*** *mark for correct substitution,*

ie 35000 = 2 x c x 35
or
their (b) = 2 x c x 35

2

J / kg°C

1

(d) energy lost to surroundings

or

energy needed to warm heater

accept there is no insulation (on the copper block)

*do **not** accept answers in terms of human error or poor results or defective equipment*

1

[6]

31 (a) (i) 5.88 (watts)

*an answer of 5.9 scores **2** marks*

*allow **1** mark for correct substitution ie*

$0.42 = \frac{\text{power out}}{14}$

*allow **1** mark for an answer of 0.0588 or 0.059*

2

(ii) 8.12

allow 14 – their (a)(i) correctly calculated

1

(b) (i) input power / energy would be (much) less (reducing cost of running)

accept the converse

electricity is insufficient

1

(also) produce less waste energy / power

accept 'heat' for waste energy

1

(as the waste energy / power) increases temperature of the cabinet

1

so cooler on for less time

1

(ii) line graph

need to get both parts correct

accept scattergram or scatter graph

both variables are continuous

allow the data is continuous

1

(c) number of bulbs used-halogen=24 (LED=1)

1

total cost of LED = £30 + £67.20 = £97.20

accept a comparison of buying costs of halogen £36 and LED £30

1

total cost of halogen= 24 x £1.50 + 24 x £16.00 = £420
or
buying cost of halogen is £36 **and** operating cost is £384

accept a comparison of operating costs of halogen £384 and LED £67.20

*allow for **3** marks the difference in total cost is £322.80 if the number 24 has not been credited*

1

statement based on correct calculations that overall LED is cheaper

*must be **both** buying **and** operating costs*

an alternative way of answering is in terms of cost per hour:

buying cost per hour for LED $\left(\frac{£30.00}{48000}\right)$ = 0.0625p/£0.000625

buying cost per hour for halogen = $\left(\frac{£1.50}{2000}\right)$ = 0.075p/£0.00075

*a calculation of both buying costs scores **1** mark*

operating cost per hour for LED = $\left(\frac{£67.20}{48000}\right)$ = 0.14p/£0.0014

operating cost per hour for halogen= $\left(\frac{£16.00}{2000}\right)$ = 0.8p/£0.008

*a calculation of both operating costs scores **1** mark*

all calculations show a correct unit

***all** units correct scores **1** mark*

statement based on correct calculations of **both** buying **and** operating costs, that overall LED is cheaper

*correct statement scores **1** mark*

1

[12]

32 (a) (same) number of protons

same atomic number is insufficient

1

(b) (i) nuclei split

*do **not** accept atom for nuclei / nucleus*

1

(ii) (nuclear) reactor

1

(c) beta

1

any **one** from:

- atomic / proton number increases (by 1)

  accept atomic / proton number changes by 1
- number of neutrons decreases / changes by 1
- mass number does not change

  (total) number of protons and neutrons does not change
- a neutron becomes a proton

1

(d) (average) time taken for number of nuclei to halve

or

(average) time taken for count-rate / activity to halve

1

(e) (i) 6.2 (days)

Accept 6.2 to 6.3 inclusive

*allow **1** mark for correctly calculating number remaining as 20 000*

or

*allow **1** mark for number of*

80 000 plus correct use of the graph (gives an answer of 0.8 days)

2

(ii) radiation causes ionisation

allow radiation can be ionising

1

that may then harm / kill healthy cells

accept specific examples of harm, eg alter DNA / cause cancer

1

(iii) benefit (of diagnosis / treatment) greater than risk (of radiation)

accept may be the only procedure available

1

[11]

33 (a) transmits

correct order

1

absorbs

1

(b) light

allow ultra violet ***or*** *UV* ***or*** *infrared* ***or*** *IR* ***or*** *gamma*

1

(c) 20

allow ***1*** *mark for correct working, ie* $\frac{60}{3}$ *provided no subsequent step*

2

(d) Killing cancer cells

1

[6]

34 (a) hydraulic

1

(b) 9

allow ***1*** *mark for a correct substitution, ie* $\frac{1800}{200}$ *provided no subsequent step*

2

(c) an environmental

1

[4]

35 (a) (sound waves) which have a frequency higher than the upper limit of hearing for humans
or
a (sound) wave (of frequency) above 20 000 Hz

sound waves that cannot be heard is insufficient

a wave of frequency 20 000 Hz is insufficient

1

(b) 640

*an answer of 1280 gains **2** marks*

*allow **2** marks for the correct substitution*

ie 1600 × 0.40 provided no subsequent step

*allow **2** marks for the substitution* $\frac{1600 \times 0.80}{2}$
provided no subsequent step

*allow **1** mark for the substitution 1600 × 0.80 provided no subsequent step*

*allow **1** mark for the identification that time (boat to bed) is 0.4*

3

(c) any **one** from:

- pre-natal scanning / imaging
- imaging of a named organ (that is not surrounded by bone), eg stomach, bladder, testicles

  accept heart

  *do **not** allow brain **or** lungs (either of these negates a correct answer)*
- Doppler scanning blood flow

1

(d) advantage

any **one** from:

- (images are) high quality or detailed or high resolution

  clearer / better image is sufficient
- (scan) produces a slice through the body
- image can be viewed from any direction

  allow images are (always) 3D / 360°
- an image can be made of <u>any</u> part (inside the body)

  allow whole body can be scanned
- easier to diagnose **or** see a problem (on the image)

1

disadvantage

any **one** from:

- (the X-rays used **or** scans) are <u>ionising</u>

  allow a description of what ionising is
- mutate cells **or** cause mutations **or** increase chances of mutations

  allow for cells:

  DNA / genes / chromosomes / nucleus / tissue

- turn cells cancerous **or** produce abnormal growths **or** produce rapidly growing cells
- kill cells

    damage cells is insufficient
- shielding is needed

    can be dangerous (to human health) unqualified, is insufficient

1

[7]

36 (a) (i) turning

accept turning ringed in the box

1

(ii) point at which mass (or weight) may be thought to be concentrated

accept the point from which the weight appears to act

allow focused for concentrated

*do **not** accept most / some of the mass*

*do **not** accept region / area for point*

1

(b) 600 (Nm)

*400 × 1.5 gains **1** mark provided no subsequent steps shown*

2

(c) (i) plank rotates clockwise

accept girl moves downwards

*do **not** accept rotates to the right*

1

(total) CM > (total) ACM

accept moment is larger on the girl's side

1

weight of see-saw provides CM

answer must be in terms of moment

*maximum of **2** marks if there is no reference to the weight of the see-saw*

1

(ii) W = 445 (N)

*W × 1.5 = (270 × 0.25) + (300 × 2.0) gains **2** marks*

*allow for **1** mark:*

total CM = total ACM either stated or implied

or

(270 × 0.25) + (300 × 2.0)

if no other marks given

3

[10]

37 (a) (i) 20

1

20 000

either order

accept ringed answers in box

1

(ii) (frequency) above human range

accept pitch for frequency

or

(frequency) above 20 000 (Hz)

*do **not** accept outside human range*

*allow ecf from incorrect value in **(a)(i)***

1

(iii) any **one** from:

- pre-natal scanning

  accept any other appropriate scanning use

  *do **not** accept pregnancy testing*
- removal / destruction of kidney / gall stones
- repair of damaged tissue / muscle

  accept examples of repair, eg alleviating bruising, repair scar damage, ligament / tendon damage, joint inflammation

  accept physiotherapy

  accept curing prostate cancer or killing prostate cancer cells
- removing plaque from teeth

  cleaning teeth is insufficient

1

(b) 7.5×10^{-4} (m)

*$1.5 \times 10^3 = 2.0 \times 10^6 \times \lambda$ gains **1** mark*

2

(c) for reflected waves

must be clear whether referring to emitted or detected / reflected waves

if not specified assume it refers to reflected wave

any **two** from:

- frequency decreased
- wavelength increased
- intensity has decreased

  allow amplitude / energy has decreased
  allow the beam is weaker

2

[8]

38 (a) (i) magnified

1

upright

1

(ii) v = −6(cm)

*max **2** marks if no minus sign*

*6(cm) gains **2** marks*

1/v = 1/12 − 1/4 = −1/6
*gains **2** marks*

1/12 = 1/4 + 1/v
*gains **1** mark*

−5.99(cm)
*using decimals gains **3** marks*

3

(b) it is virtual

1

[6]

39 (a) (i) nuclear reactor

1

star

1

(ii) nuclei are joined (not split)

accept converse in reference to nuclear fission

*do **not** accept atoms are joined*

1

(b) (i) any **four** from:

- neutron
- (neutron) absorbed by U (nucleus)

  ignore atom
  *do **not** accept reacts*
  *do **not** accept added to*
- forms a larger nucleus
- (this larger nucleus is) unstable
- (larger nucleus) splits into two (smaller) nuclei / into Ba and Kr
- releasing three neutrons and energy

  accept fast-moving for energy

4

(ii) 56 (Ba)

1

57 (La)

*if proton number of Ba is incorrect allow **1** mark if that of La is 1 greater*

1

$^{0}_{-1}\beta$

accept e for β

$^{139}_{56}Ba \longrightarrow ^{139}_{57}La + ^{0}_{-1}\beta$

*scores **3** marks*

1

[10]

40 (a) conduction

must be in correct order

1

convection

1

(b) (i) 70

accept ± half a square
(69.8 to 70.2)

1

(ii) 15

*accept 14.6 to 15.4 for **2** marks*

*allow for **1** mark 70 − 55*

ecf from (b)(i) ± half a square

2

(iii) C

1

biggest drop in temperature during a given time

accept it has the steepest gradient this is a dependent

1

(iv) starting at 70 °C and below graph for C
must be a curve up to at least 8 minutes

1

(v) because 20 °C is room temperature

accept same temperature as surroundings

1

(c) (i) 6720

*correct answer with or without working gains **3** marks*

*6 720 000 gains **2** marks*

*correct substitution of E = 0.2 × 4200 × 8 gains **2** marks*

*correct substitution of E = 200 × 4200 × 8 gains **1** mark*

3

(ii) the fastest particles have enough energy

accept molecules for particles

1

to escape from the surface of the water

1

therefore the mean energy of the remaining particles decreases

accept speed for energy

1

the lower the mean energy of particles the lower the temperature (of the water)

accept speed for energy

1

[16]

41 (a) decreases

1

(b) a filament bulb

allow bulb

1

an LED

1

(c) Marks awarded for this answer will be determined by the Quality of Communication (QoC) as well as the standard of the scientific response.

0 marks
No relevant content.

Level 1 (1−2 marks)
There is a basic description of the method. This is incomplete and would not lead to any useful results.

Level 2 (3−4 marks)
There is a description of the method which is almost complete with a few minor omissions and would lead to some results.

Level 3 (5−6 marks)
There is a detailed description of the method which would lead to valid results.
To gain full marks an answer including graph, or another appropriate representation of results, must be given.

examples of the physics points made in the response:

- read V and I
- read temperature
- apply heat

  allow hot water to cool
- read V and I at least one other temperature
- determine R from V / I
- range of temperatures above 50 °C

extra detail:
- use thermometer to read temperature at regular intervals of temperature
- remove source of heat and stir before taking readings
- details of attaining 0 °C or 100 °C
- last reading taken while boiling
- graph of R against T
- at least 3 different temperatures

6

(d) (i) Q

1

(ii) (80, 3.18)

1

(iii) any **one** from:

- measurement of V too small
- measurement of I too big
- incorrect calculation of R
- thermometer misread

  allow misread meter

  ignore any references to an error that is systematic

1

(iv) any **two** from:

- not portable

  allow requires a lot of equipment allow takes time to set up
- needs an electrical supply
- cannot be read directly

  accept it is more difficult to read compared to liquid-in-glass

2

[14]

Examiner reports

1

Foundation

(a) Two fifths of students scored this mark.

(b) Less than a fifth of students scored a mark for this question. Many incorrect responses stated 'longitudinal', or another wave property like 'refraction' of 'diffraction.'

(c) Almost four fifths of students scored 1 mark for the answer of '0.34' failing to convert 25.0 kHz into Hz. If a conversion was attempted it needed to be seen before the calculation otherwise it counted as a subsequent (incorrect) step, which means they scored zero.

(d) Four fifths of students scored 0 marks for this question, most students believing that a longitudinal sound wave is a long sound wave. Most responses referred to amplitude, wavelength or frequency.

Higher

(a) Three quarters of students scored a mark for this question.

(b) Just under half the students scored a mark for this question. Many students, however, were baffled and gave an assortment of answers that ranged from wave behaviour (e.g. refraction) to wave properties (e.g. wavelength).

(c) The vast majority of students scored 1 mark for the answer of ‘0.34’. Some students incorrectly rearranged the equation and scored zero. A few students realised that the frequency needed converting, but didn’t do this correctly, but scored 1 mark for their final answer. One fifth of students scored 2 marks for the correct answer.

(d) Lots of partial descriptions of ‘waves parallel to energy transfer’, without stating what was parallel, the word oscillation (or vibration) was needed for this mark. Compressions and rarefactions was more likely to be credited. A third of students scored 1 mark, but less than a tenth of students scored 2 marks.

2

Foundation

(a) Less than a tenth of students scored this mark. There seemed to be a general belief that the National Grid only supplies electricity generated by non-renewable sources so it wouldn't be appropriate considering the small community is planning to generate renewable electricity. Many students thought that visual pollution or damage to habitats counted as an economic reason, which was insufficient.

(b) Approximately half the students scored 3 or more marks for this question, the mean was 2.71 and a good range of responses were seen. It was pleasing to see that students didn't just re-state information given in the question, but added value and made comparisons, too. To achieve Level 1, students needed to make 1 or 2 statements which could have been advantages or disadvantages, or 1 of each. Comparison statements did not count as both an advantage and as a disadvantage. To achieve Level 2 students needed to have at least an advantage and a disadvantage of 1 method and either an advantage or a disadvantage of the other method. To achieve Level 3 students needed at least 1 advantage and 1 disadvantage of each method that were separate ideas. 'Both renewable' would count as one idea.

Higher

(a) A third of students correctly answered by describing reasons why connecting to the grid would be expensive, cost to build pylons, cables, etc. Responses which specified cost but without stating what was expensive were insufficient. Answers in terms of the ‘small community’ needed to state that either the amount of electricity required (from the National Grid), or the amount of electricity they may sell back (to the National Grid) was too low.

(b) Four fifths of students scored 4 or more marks, the mean for the question was 4.42 and a good range of responses were seen. Students who failed to give Level 3 responses usually did so because they didn’t give at least one advantage and one disadvantage for each energy source. Comparative responses in terms of cost, power output or reliability only counted as an advantage of one or as the disadvantage of the other source. Therefore, a minimum number of four separate ideas needed to be described in order to be counted as a Level 3 answer.

3 (a) Two fifths of students scored 2 marks, while one third of students scored 1 mark. The vast majority of students scored 2 marks for 'remote controls' and 'mobile phones'. A reasonable number of students misread the question and wrote down any use of infrared (conventional oven) and microwave (the microwave) which were insufficient for communications. 'Phone' by itself was insufficient, but 'phone signals' was creditworthy, as was 'sending text messages'. While some mobile phones do have infrared ports, this was insufficient for a use of infrared as not all mobile phones have this facility. Satellite (communications) was another common answer seen for use of microwaves. TV alone was insufficient. Other insufficient answers included: key fobs for remote locking of cars, computer peripherals and walkie talkies, all of which typically use radio frequencies.

(b) A quarter of students scored 2 marks, while a fifth of students scored only 1 mark. Students should be reminded of the list principle: if two answers are required, only give two answers, otherwise incorrect answers can negate correct answers. One student stated 5 properties that were the same for both waves; fortunately for the student they were all correct. Insufficient responses included 'can't be seen with the human eye', 'not harmful', 'can heat food', 'used for communication'. Incorrect responses included 'same amplitude / frequency / wavelength'. A student who stated 'travel through a vacuum at the speed of light' and didn't write anything on the second line would score 2 marks for their single statement.

4 (a) This question was well answered with half the students scoring 1 mark and a third of students scoring 2 marks. The most common correct answers referred to the cost per kWh and the economic benefits, 'France can sell their excess electricity to other countries' type of statement. Insufficient responses included 'it's cheap', which wasn't comparative; or references to no CO2 released, as the renewables mentioned don't release CO2 either. Reliability was another commonly seen response, which was creditworthy.

(b) Just under a third of students scored 2 marks for this question. Answers that were insufficient were 'dangerous', or 'radiation may leak'. Naming nuclear accidents was insufficient for a mark, the idea of widespread or major implications was necessary too. Commissioning or decommissioning time was insufficient as the question was about generating electricity, so while the cost was an issue, time was too vague. A number of students thought that 'nuclear is a fossil fuel so contributes greatly to global warming', which is clearly incorrect.

(c) Three fifths of students scored 2 marks for this question. Some students incorrectly multiplied their answer by 100(%) and got an answer of 48, which scored 1 mark, or multiplied the power in W by 0.15 and got an answer of 480, which also scored 1 mark.

(d) Three fifths of students scored 1 mark for the idea that higher cost meant higher efficiency solar panel, quite a lot of students also scored 1 mark for the idea that if cheaper, more would be bought. Many students, however, incorrectly thought that if you purchased a larger number of solar panel C, the overall efficiency would increase. These students are likely to have scored a maximum of 1 mark for the idea that more could be bought, depending how they worded their answer. Only a tenth of students scored 2 marks for a well-reasoned answer e.g. The more efficient solar panels cost more, but you could buy more solar panel C for £40, that would generate more electricity than 1 solar panel A.

5

(a) Most students scored at least one mark with about one third scoring all three marks. A common error was to give 'friction' as the force that pulls particles together.

(b) The majority of the students scored this mark.

(c) The majority of the students scored this mark.

6

(a) (i) This was well answered with most students making the correct choice to calculate the momentum.

(ii) Just under half of the students correctly identified the unit of momentum.

(iii) Surprisingly few students understood that the backward and forward momentum would be the same.

(b) Most students scored zero with very few scoring both marks. The main problem was students not identifying either the directions of forces or the increased magnitude of the forces. Those who mentioned momentum often neglected to identify if it was the air or the toy they were referring to or the fact that it had increased. The most common point that gained credit was the air moving quicker or more air being forced backwards by the fan. Many of the students simply repeated information from the stem of the question stating that the toy went faster.

7

(a) Few of the students correctly gave 'neutrons'. The most popular answer was 'protons'.

(b) There were many incorrect answers such as ' power stations ' with the students not stating that in most nuclear reactors the energy released was to heat water to eventually generate electricity. Many students simply wrote the word "electricity" and did not score the mark.

(c) (i) Again few students correctly identified particle X as 'a neutron'.

(ii) Half of the students scored zero. A common error was to show only one neutron released from each U-235 nucleus or to show only one fragment produced. Others students showed 2 neutrons released from the given U-235 nuclei but did not show any fragments. A small number of students who did this went on to draw further U-235 nuclei which then released neutrons. This gained both marks as it did show the start of a chain reaction.

8 **Foundation**

(a) Nearly a quarter of the students did not attempt this question. Most of the students that did attempt the question scored zero.

(b) (i) Less than half of the students scored this mark.

(ii) There were very few correct answers to this question. Most of the incorrect answers were in terms of an atom changing size or shape or splitting into smaller fragments.

(c) A small majority of the students scored this mark by suggesting sensible precautions to limit the risk to their health from sources of radiation. However there were a large number of unacceptable suggestions such as 'wear a lead suit'.

(d) A large number of students did not attempt this question. Nearly one third of the students scored zero. The majority of the students that did score at least one mark were operating at Level 1 or 2 in terms of their knowledge, understanding, organisation of their answer and accuracy of their spelling, punctuation and grammar. Students scoring zero marks were either giving a reiteration of the question stem or a description of radiation properties or uses of radiation that were not relevant to this question. Of the three specific properties asked for, few candidates were able to provide creditable statements for the deflections (or not) of the radiations in a magnetic field. Many students thought that the radiations produced their own magnetic field or mistook deflection to mean reflection. References to positive and negative poles of a magnet were common. Of the other two properties, most candidates were able to order correctly the degree of penetration and often quote specific examples of the correct materials. Many candidates were also able to order the range of the radiations in air. However, in many cases, there were not specific references to what beta radiation could or could not actually do, other than be placed in the middle of the student's ordering.

Higher

(a) This was generally well done with almost half of the students scoring the mark although mention of electrons was frequent and negated the mark. Some students did not read the stem of the question carefully and described the properties of an alpha particle e.g. is ionising, and so did not score the mark. This question had one of the highest non-completion rates.

(b) (i) Nearly two thirds of the students scored this mark.

(ii) Only 40% of the students scored this mark. Many students confused ionisation with fission. Others knew that the atom would lose some parts but were not sure which so incorrectly guessed protons or neutrons so did not get the mark.

(c) Nearly four fifths of the students answered this correctly. However, students should think about how realistic their answers are when they write things like 'wear suits made out of lead'.

(d) There were mixed results on this question. Many students spent an unnecessary time discussing the ionising ability of the particles. Some students referred to the gold foil experiment, which didn't give relevant information. Most students did not gain full credit because they did not address all three properties (range, penetration, deflection in a magnetic field) for all three types of radiation. Most students responded reasonably well in terms of penetration and range but there was less clarity about the effect of magnetic fields. Many students wrote about being attracted to 'positive' or 'negative' sides without actually mentioning magnetic fields. Of those that did describe all the properties, most did well and got high marks. Over a third of the students gave a Level 3 answer.

9 (a) (i) Nearly half of the students failed to score a mark, with the other half split roughly equally between 1 and 2 marks. Many good answers were as per the mark scheme, with the term nebula quite often used for dust and gas. Incorrect responses included "rocks in the atmosphere / air", or dust on its own. Many students also did not refer to gravity being the attracting force. Many students incorrectly referred to fission. Some students referred to fusion, but this was not relevant to the question.

(ii) Just over a third of the students scored this mark. The most common error was to use "atom" for nuclei. Some students confused fusion and fission. This question was not attempted by a significant minority of the students.

(iii) "Better / Improved Technology ", was the most frequent correct answer given. Quite a few answers confused telescopes with microscopes. Similarly satellites were often mentioned without any further indication how they might improve observations. Some students did not score the mark because they thought that the reason scientists had not detected them before was because they did not know what to look for or because light from these stars had only just reached us (in order to be observed).

(b) (i) "Other/different Planets", was the most common correct answer, scored by just over half of the students. It was strange to see that many students mentioned that the evidence might have proved there were other life forms in the universe as this didn't seem to be linked to the question.

(ii) Although the mark was scored by nearly half of all students, many correct answers were imprecise in their explanation of "proving / supporting ", the theory.

(c) Nearly one tenth of the students did not attempt this question. Of those that did less than a quarter scored the mark, as students failed to identify the key idea of "only". Too often the information in the stem of the question was fed back using slightly different words or simply the same words in a slightly different order.

10

(a) Despite the length of the arrows on the diagram giving a clue to this answer, only about a quarter of students answered this question correctly.

(b) Just under half of students correctly identified the moments as equal and opposite.

(c) This question proved to be challenging for students with nearly a fifth gaining the mark. A significant minority of students confused the moment of a force with the pressure created by a force, and referred to putting a larger area of the foot on the pedal. Most recognized that the distance of the force from the pivot needed to be increased. A very common response, that gained no credit, was to say that the length of the chain could be changed.

11

Foundation

(a) Many students thought that an electromagnet could somehow be adjusted to pick up a variety of specific metals. It was also not uncommon to see students stating that the electromagnet could separate metals, failing to realise that they were comparing the electromagnet with a permanent magnet, which would also be able to separate metals.

(b) The vast majority of students attempted this question, but many struggled to describe how to put an electromagnet together, and in particular it was not uncommon for students to connect the ends of the nail to the power supply. There was also a small minority of students who tried to express the intention to strip the ends of the insulating wire and attach crocodile clips to this, but actually described stripping the entire insulating wire. A few students thought that the insulating wire was to keep their electromagnet thermally insulated. Of those who did manage to describe the construction of an electromagnet well, most could describe a test to see if their electromagnet was working, but many struggled to increase the strength of the electromagnet, with comments indicating that they should turn up the power on the power supply, rather than increasing p.d., current or number of turns on the coil. Just less than half of students accessed Levels 2 or 3.

Higher

(a) Nearly four fifths of students answered this question correctly. The most common reason for not answering correctly was for stating that the electromagnet could separate metals, failing to realise that they were comparing the electromagnet with a permanent magnet, which would also be able to separate metals.

(b) Many students struggled to describe how to construct an electromagnet; in particular it was not uncommon to see students connecting the ends of the nail to the power supply, or failing to make clear whether the insulating wire or the iron nail was connected to the power supply. Most students who managed to do this correctly went on to describe a test for the strength of the electromagnet, although a significant number of students merely tested whether the electromagnet could pick up paperclips, and did not count how many. A number of students were confused between changing the strength of the electromagnet and testing the strength of it; it was not uncommon to see students stating that an electromagnet could be tested by adding more turns to the coil on the nail. About a third of students gave Level 3 responses to this question. A common reason for a student reaching Level 2 but not getting into Level 3 was that they talked about increasing the power from the power supply, rather than increasing the current or potential difference. Just under a quarter of students gave Level 2 responses.

12 Foundation

(a) Less than a quarter of students realised that a magnetic field was produced, whereas other students thought that a current or p.d. was produced in the iron core. It was not common for students to gain the mark for realising that the magnetic field produced would be changing.

(b) This calculation was handled well by students, with just under three quarters gaining both marks.

(c) Many students confused the loss of power with it being a step-down transformer. The most common way of students gaining the mark was for noting that energy is transferred by heating. Just under one fifth of students answered correctly.

(d) (i) Few students were able to correctly identify the resolution, although many more students were along the right lines, with an answer of 2 decimal places occurring regularly. The reason for this being appropriate was less well answered with many students answering how they knew that this was the resolution, rather than answering the question of why this was a suitable resolution for this experiment. Just under a fifth of students gained marks on this question.

(ii) Just under one tenth of students correctly stated why the results were different.

(iii) Slightly more than a tenth of students answered this question correctly. Many students thought that a lack of anomalous results made the experiment reproducible, or just the fact that two students had carried out the experiment made it reproducible. Many students just quoted numbers given in the table.

(iv) Induction was clearly something which students struggled with, and the question was only attempted by about two thirds of students. Only a few students knew the name of the process.

(e) Just over half of students were able to suggest an advantage of the transformer. It was not uncommon for those who got the question wrong to have just repeated the stem of the question.

Higher

(a) Approximately two thirds of students realised that a magnetic field was produced, whereas other students thought that a current or p.d. was produced in the iron core. Only about a quarter of students realised that the magnetic field produced would be changing.

(b) This calculation was handled well by students, with the vast majority gaining both marks.

(c) Many students confused the loss of power with it being a step-down transformer. The most common way of students gaining the mark was for noting that energy is transferred by heating. Just under four tenths of students answered correctly.

(d) (i) Many students struggled to identify the correct resolution, although some were along the right lines, with answers of 2 decimal places or 0.00 occurring regularly. The reason for it being appropriate was less well done with many students answering how they knew that this was the resolution, rather than answering the question of why this was a suitable resolution for this experiment. Less than half of students gained marks on this question.

(ii) About a third of students answered this question correctly. Many students stated that part of the equipment being used was different, despite the stem of the question clearly stating that the two students used exactly the same equipment.

(iii) Just over a third of students answered this question correctly. Many students thought that similar results made it reproducible, rather than there being a similar pattern in results.

(iv) Fewer than half the students stated the correct process.

(e) Over two thirds of students suggested a correct advantage. Unrewarded responses frequently just repeated the stem of the question.

13 (a) The vast majority of students gained at least one mark, but less than half went on to give a complete answer including a reference to the ionising properties of X-rays.

(b) Just under half of students gained marks on this question. Many students understood that the sound reflected, but did not add that it was only partial reflection. The notion of time being recorded and used to calculate distance was only expressed by about one tenth of students.

(c) This calculation caused problems for students with only a tiny minority managing to obtain the correct final answer. The majority of students neglected to either halve the time or double the distance from the mother's skin to the fetus.

(d) (i) A common misconception here was that bone reflected X-rays and the reflected X-rays were then detected. It was also not uncommon to see students stating that X-rays contained gamma rays or alpha particles. Many students who gained two marks neglected to mention that the X-rays passing through are detected. Around a quarter of students gained three marks.

(ii) This question was well answered with just over three quarters of students identifying why X-rays are able to produce detailed images.

14

(a) Just under two thirds gained at least one mark on this question, with just under a fifth gaining all three marks. Many students who gained no marks referred to the image being blurry or more focussed, rather than describing the image as being inverted or upright, diminished or magnified and real or virtual.

(b) Slightly more than two thirds of students gained at least one mark on this question, with just under a third gaining all three marks. Many students forced their rays to cross to the right of the lens rather than forming a virtual image to the left of the lens.

(c) (i) Just under a fifth of students gained this mark, with many just stating that the refractive indices were different which was insufficient. A significant proportion of students suggested that the lenses were of different shapes, whereas the question stated that they were identical.

(ii) About half of students gained one mark on this question, but it was rare for students to gain both marks. The common cause of students failing to gain any credit was to describe the link between object distance and magnification, rather than image distance as was asked for.

(iii) Just under one third of students were able to show how the lens was different.

15 (a) (i) Less than half of the students scored this mark. A large number of students incorrectly stated that it was the time taken to stop under braking force. A small number of responses related braking distance to the total stopping distance or thinking distance, without answering the question asked.

(ii) Almost all of the students could state one correct factor. Incorrect answers generally related to thinking distance, such as the driver was tired, distracted or under the influence of alcohol. Despite being given speed in the question, some of the students still gave various versions of speed − how fast etc. as their answer.

(iii) Where students did not give a correct response it was clear that they had not read the question correctly. Many comments related increased speed to increased braking distance or increased time it would take to stop. Just fewer than half of the students scored this mark.

(b) Only a small proportion of the students correctly calculated the maximum speed of the car from the graph. Many chose to calculate the average speed. Those that calculated average speed often made errors in reading data from the graph, taking the distance to be 174 m. A few students calculated speed incorrectly by multiplying distance and time.

(c) (i) For a straight recall question this was surprisingly poorly answered with only about half of the students scoring the mark. Many incorrect responses suggested that momentum stopped or momentum is added. Some answers were in terms of conservation of energy and others simply stated that momentum is mass x velocity. A minority of the students confused momentum with moments, referring to clockwise and anticlockwise moments.

(ii) There were some well-presented correct answers with one third of the students scoring all three marks. However, a further eighth of the students did not understand how to complete the calculation and so scored two marks. Students who did correctly calculate the initial momentum often failed to calculate the combined mass of the two cars when substituting into the final equation. Other students were unable to correctly rearrange the equation. In some cases the wrong equation was used.

(d) Just over half of the students scored zero and only a very small proportion of the students scored all four marks.

The most common correct points given by students were that the time taken to slow down increased and that there was a smaller force exerted on the driver. The vast majority of incorrect responses were descriptive answers that did not contain any physics. Students often stated that without a seatbelt the driver would go through the windscreen. Some students incorrectly wrote about slowing down the time of impact. A significant minority of students wrote about how the seat belt spreads the force out across your body in an attempt to discuss reducing pressure rather than force. Very few students knew that seat belts stretch, although some did refer to them being elasticated or similar.

16 (a) (i) This question was well answered with three quarters of the students scoring the mark.

(ii) Slightly less than half of the students scored this mark, the most popular choice was 10 degrees.

(iii) About two thirds of the students scored both marks. The most common error was from students who failed to realise that sin *i* and sin *r* had already been calculated for them. These students then calculated sin (sin *i*) / sin (sin *r*) which gave a numerical answer almost equal to the correct answer, however this mistake meant that they scored zero.

(b) Surprisingly, fewer than one fifth of the students scored this mark.

(c) (i) More than two thirds of the students scored this mark.

(ii) Almost all of the students scored both marks on this calculation.

(iii) More than half of the students scored this mark.

23 (a) Nearly half of the responses gained all three marks available for this question. However, many went on to describe the process of nuclear fusion after the star was formed, and the end of a star's life.

(b) Around four-fifths of students answered this correctly, the most common incorrect answer being 'fission'.

(c) Whilst many answers gave the correct idea, the mark was not always scored due to incorrect terminology, for instance equating 'gravitational force' with 'energy' or 'radiation'.

(d) Around two-thirds of answers scored all three marks available. 'Red dwarf' and 'brown dwarf' were common incorrect answers.

24

(a) (i) Around three-quarters of students correctly identified the defect as 'short sight'. Many others attempted to explain the defect, without naming it.

(ii) This question was well answered with the majority of students answering correctly. A very small minority of students failed to include an answer. Students should be encouraged not to leave blank spaces where a choice of answers is listed.

(b) Almost all students answered this question correctly.

(c) The Quality of Communication question was very well answered, with almost all students scoring four or more marks out of the six available. A number of students answered in bullet point form, but failed to write in full sentences. The information at the beginning of the question reminds students that they will be assessed on using good English, amongst other criteria. A well thought-out answer including many salient points is preferable to an extended account where the same point is repeated several times.

(d) Around a fifth of responses scored one of the two marks for the suggestion of moving the lens, but failed to score the second mark by being vague about the direction of movement; 'up', 'down' 'backwards' and 'forwards' were often seen. There were also a number of answers relating to inserting a diverging lens in front of the camera lens, as in the correction of eye defects. The specification makes a distinction between the two methods of focusing for the eye and the camera.

25

(a) Nearly all students knew that frequency determines the pitch of a sound and that amplitude determines the loudness of a sound.

(b) (i) Nearly all students correctly described the trend shown in the table of length of tuning fork prong and frequency.

(ii) Nearly all students correctly measured the length of a tuning fork prong.

(iii) Over half of the students were able to correctly estimate the frequency of the tuning fork measured in part (i) from a table listing prong lengths and frequency. Some students mistakenly assumed a relationship of direct proportionality between prong length and frequency.

(c) (i) Nearly all students knew that ultrasound waves were produced by electronic systems.

(ii) Less than half of the students could explain that ultrasound waves could not be produced by a tuning fork because the very high frequency would require an extremely small fork according to the evidence given. Many wrote that 'tuning forks can only produce frequencies within the human audible range' so scored neither mark.

(d) Just under half of the students scored full marks for correctly determining a frequency from a trace on an oscilloscope screen. Many calculated frequency from 1 / 0.0005 instead of from 1 / (7 × 0.0005).

26

(a) Just over half of the students gave a correct definition of half-life.

(b) The vast majority of students were able to obtain a value of half-life from a graph of count rate against time.

(c) Parts (i), (ii), (iii) and (iv) required students to look at the type of radiation emitted and the half-life of five radioactive isotopes shown in the table, and select one for a particular task or set of circumstances. Marks were often dropped by students not naming the source.

(i) Over three-quarters of students knew the source that emits radiation that is not deflected by a magnetic field.

(ii) The majority of students were able to score at least one mark. Less than a quarter of students could explain which source should be used for monitoring the thickness of paper during production.

(iii) Over three-quarters of students knew which source would have to be replaced most often, but very few could give a full explanation.

(iv) Half of the students knew which of the sources emitted radiation that could penetrate the box and a further third of students gave an adequate explanation.

27

(a) Three-quarters of students knew why an energy storage system would work if the road surface was black. Many answers stated that 'black surfaces absorb heat' rather than 'absorb heat well'.

(b) (i) A quarter of students gave a correct definition of specific latent heat of fusion. However, many incorrect responses referred to melting rather than a change from solid to liquid.

(ii) Nearly all students correctly calculated the amount of energy required to melt the ice.

(c) (i) Two-thirds of students correctly stated that the variable to be controlled was mass of ice. The remainder stated that the mass of salt had to be controlled.

(ii) Two-thirds of students correctly ticked two boxes with suggestions as to why the student stirred the crushed ice.

(iii) Nearly all students could correctly describe the pattern of how mass of salt added to some crushed ice affected the melting point of the ice.

(d) Just under half of students scored full marks for a calculation of energy transferred given values of power and time in non-SI units. Conversion from: kW to W; and minutes to seconds, was required. The spread of marks demonstrated this, with a third of students dropping one mark.

(e) The Quality of Communication question brought together the elements of the entire question and asked for advantages and disadvantages of using energy storage, salt and undersoil heating for keeping a road free from ice in the winter. Most students used the available space and many used additional pages.

Three-quarters of students scored four marks or more. Some excellent work was seen, but many students wasted time by repeating much of what was in the question. Also they ended a very good account with an unnecessary summary. Some very well written work only addressed either an advantage or a disadvantage of each system.

28 (a) (i) Over three-quarters of students correctly described two ways in which a spring changed shape when a mass was suspended from it. Some stated the same thing twice with 'got longer' and 'extended' or 'bigger distance between the loops'.

(ii) Nearly three-quarters of students correctly described how the spring could be tested to see if it behaved elastically.

(b) (i) Nearly all students were able to score at least two out of three marks for completing **Table 1** with a value of extension and explaining their value.

(ii) Just less than half of the students correctly suggested a value of force at which the spring exceeded its limit of proportionality and gave a reason.

(c) (i) Nearly all students knew that the type of energy stored in the loaded spring was elastic potential energy.

(ii) Less than a third of students gave the correct two reasons out of five stating why a value in **Table 2** was anomalous.

(iii) Over four-fifths of students calculated the correct mean value of time in **Table 2** leaving out the anomalous value.

(iv) Hardly any students scored a mark where they were asked why raw values of time were given to three significant figures and mean values given to two significant figures. Instead of referring to the precision of a stopwatch and comparing this with human reaction time, they thought that it was something to do with making the plotting of a graph easier.

(v) Just under three-quarters of students correctly suggested that extra masses would be needed to get more results, but relatively few stated that that they should be smaller masses eg 50 g. Many of those who scored both marks also correctly referred to the value of force beyond which the spring may no longer behave elastically.

29 (a) (i) Just over a half of all students correctly identified the energy transfers for an electric car.

(ii) Just under two fifths of the students were able to state that waste energy is transferred into the surroundings. Weaker students forgot that the question was about an electric car and confused the wasted energy with exhaust gases. Others thought the waste energy is recycled and used again.

(b) The majority of students were able to substitute the energy values given in the question into a correct equation. Most tried to express the answer as a percentage, but about one third of students failed to gain maximum marks because they either neglected to insert the % sign after the number 70 or they quoted the efficiency as 0.7 but then put either a % sign or a unit after the number.

30 (a) A very small amount of students did not identify conduction as the process by which energy is transferred through copper.

(b) The majority of students answered correctly, of those who did not score the mark, the most common error was misreading the number on the x-axis (for a temperature increase of 35°C) as 30,500 instead of 35,000.

(c) Around half of students scored two of the three marks available. This was usually for performing the calculation correctly, but failing to give the correct unit.

(d) A very low proportion of students did not attempt this question, with less than a fifth scoring the mark. The most common incorrect answers referred to faulty apparatus, incorrect measurements or values not as stated in the question, e.g. the block was not 2kg.

31 (a) (i) Three fifths of the students were able to substitute into the equation and rearrange it to find the useful power output. The main error was not selecting the equation using efficiency as a fraction rather than as a percentage.

(ii) Around half of the students answered correctly. Common incorrect responses were to subtract their answer to the previous part from 1 or from 100.

(b) (i) Around three-quarters of students scored at least one mark, usually for stating that the input power was less for the LED bulbs. Whilst many appreciated that the efficiency was also less, few explained the consequence of this in terms of less energy wasted meaning the temperature of the cabinet would increase more slowly, resulting in the cooler unit being used less often.

(ii) This was a standard demand question. Whilst the majority of answers recognised that a line graph (or scattergram) should be drawn, a small proportion gave a correct reason by saying that both variables were continuous. It would appear that many students do not think to transfer their knowledge from ISAs to this written paper.

(c) Around a fifth of students scored full marks. Good answers included clearly drawn, mathematically-based conclusions, showing all calculations. Those who chose to write a larger amount of prose often missed a vital part of the information, for instance just comparing the purchase costs and ignoring the operating costs.

32

(a) Nearly three fifths of the students gave the correct answer, 'number of protons'. Many of the students did not understand the term 'in common' and instead, wrote about the differences between isotopes.

(b) (i) About two fifths of the students correctly stated that nuclei are split in nuclear fission. Most of the remaining students had an idea of what happens but used ambiguous and vague terminology, using 'break apart', 'divide' 'particles' without supporting explanation and thus lacked sufficient clarity to obtain the mark.

(ii) A lack of clarity again stopped students obtaining this mark with only about two fifths naming the reactor as the part where molybdenum is produced.

(c) About two thirds of the students identified the radiation as beta. However the reasons given were often confused, imprecise and sometimes contradictory. Examples seen include: 'atomic number stays the same but number of protons goes up', 'nucleus loses a proton and gains a neutron', 'nucleus loses a neutron but gains a proton and an electron', etc. Less than a third of the students gave complete answers that correctly gave the marking points in the mark scheme.

(d) Only less than a third of the students gave answers sufficient to score the mark. A small proportion of the students gave an answer in terms of the count rate halving.

(e) (i) About two thirds of the students recognised that the number remaining was 20,000 but then less than half of these students used the graph to correctly identify 6.2-6.3 days as the time required. A small amount of students drew lines on the graph at 80,000 and identified 0.8 days but half of them, then carried out further calculations on this and consequently lost the compensation mark.

(ii) Fewer than a third of the students scored the mark for the ionising effect of radiation; of those who did, they usually went on to score the second mark. Most of the students that scored the second mark did so for general terms about radiation 'causing cancer' or some form of harm. Few students linked the ionising effect of radiation to damage or harm to individual cells or DNA.

(iii) Many of the students reiterated statements from part e(ii) about the dangers of radiation rather than answering the question asked. Students' phrasing of their response was often confused with only about a fifth being able to describe that the benefits outweighed the risks.

33

(a) A very low proportion of students scored both marks, with a fifth of the students gaining 1 mark. Over two thirds of students scored zero.

(b) Just under a third of students gained the mark for identifying light.

(c) Most students gained 2 marks for completing this calculation successfully.

(d) Just under two thirds of students identified the correct answer of killing cancer cells.

34

(a) The vast majority of students could identify the system as hydraulic.

(b) The majority of students scored both marks for the calculation.

(c) Most students correctly identified the advantage as environmental.

35

(a) Many students attempted to describe how ultrasound is used rather than defining it. Other answers were vague, eg ‘cannot be heard’ but without further qualification. Some thought ultrasound was an electromagnetic wave and some thought ultrasound was the gel applied when a scan is carried out.

(b) Few students gained all 3 marks for this calculation. Over two thirds of the students failed to take the echo into account and so scored 2 marks. About one student in ten failed to gain any marks.

(c) Just under two thirds of the students stated a correct medical use of ultrasound scanning. Many students who did not gain the mark were often not specific enough in their answer; ‘baby scanning’ was a common response that was not sufficient.

(d) Many students did not read the question carefully, so the advantages and disadvantages given were not comparative. Many responses were about patient perceptions or cost. A number of students reversed their responses giving the advantages as disadvantages.

36

(a) (i) Nearly all students knew that the moment of a force is the turning effect of the force.

(ii) Less than half of the students were able to state what is meant by centre of mass of an object. Many referred to a region within the object rather than a point.

(b) Almost all students were able to calculate a moment of a force.

(c) (i) Very few students scored the three marks for describing and explaining the movement of a previously-balanced plank whose pivot had been moved away from the centre of mass of the plank. The idea that the weight of the plank now provided a moment was not understood.

(ii) This high-demand calculation was successfully performed by about a quarter of the students.

37

(a) (i) Three-quarters of the students knew the frequency range of human hearing.

(ii) Three-quarters of students knew what ultrasound is.

(iii) Nearly all students could state a medical use of ultrasound. Most referred to viewing a fetus but other statements such as ‘pregnancy testing’ and ‘looking at babies’ did not score the mark.

(b) The calculation which involved rearranging the wave equation and using data given in standard form was very well answered by the vast majority of students.

(c) Ultrasound waves were emitted and the reflected waves from an object, moving away, were detected. Less than one-fifth of the students could correctly describe the differences between the emitted and reflected waves because it was often not clear which wave was being referred to in the answers.

38 (a) (i) Less than three-quarters of students identified the image in the ray diagram as being magnified and upright.

(ii) More than half of the students gained full marks for a calculation using the lens formula that required a minus sign in the answer. Most of the remaining students forgot to invert the value for the final answer.

(b) Most students knew that a minus sign meant that the image was virtual.

39 (a) (i) Nearly all students knew that nuclear fission takes place within a reactor and that nuclear fusion takes place within a star.

(ii) Less than half of the students could state a way in which fusion differs from fission. Many statements referred to atoms or elements instead of nuclei.

(b) (i) A nuclear equation representing fission was given and students were asked to use the information in the equation to describe the process of fission.

This was well answered, with just under half of the students gaining all four marks. Many statements relating to fission were seen which ignored the given equation. For example ‘two or three neutrons are released’ when the equation clearly showed three.

(ii) Only a quarter of students could complete a nuclear equation depicting beta minus emission by adding subscripts for atomic number and a correct symbol for a beta particle.

Many students are unclear concerning the symbol, subscript and superscript for a beta particle.

40 (a) Nearly all students recognised two situations that represented conduction and convection.

(b) (i) Almost all students were able to read the starting value of temperature from a cooling curve.

(ii) Nearly all students correctly calculated the temperature fall from the cooling curve. Those who got it wrong gave the value of the temperature reached rather than the change in temperature.

(iii) The given graph showed the cooling curves for three cups of different cross-sectional areas. Students were asked which cup showed the greatest rate of cooling. Only half of the students were able to give a reason because they did not refer to temperature drop in a given time.

(iv) A diagram of a fourth container was given and students had to draw the expected cooling curve on the same axes. This was well done with four-fifths of students scoring full marks.

(v) Nearly all students recognised that the lowest temperature reached after four hours was also room temperature.

(c) (i) The calculation of energy transferred from the water, where the mass of water was given in grams, was correctly done by two-thirds of the students.

(ii) The explanation of evaporation causing the cooling of water was very poorly answered with half of the students scoring zero marks. Many students described convection and very few referred to the reduction in the mean energy of the particles when the most energetic had escaped from the surface of the water. Only a tenth of students scored three or four marks.

41 (a) Nearly all students knew that when the resistance of a circuit increases the current in it decreases.

(b) Nearly three-quarters of the students recognised the description of a filament bulb and a LED.

(c) The Quality of Communication question was a description of an experiment where the change in resistance of metal with temperature was investigated.

Many students wasted time, and used a substantial fraction of the answer lines, describing the electrical circuit provided. Just under half of the students scored four marks out of six for an adequate account that could be repeated to give sufficient data.

Students who scored more than four marks often included a graph of resistance against temperature or some detail such as removing the Bunsen burner and stirring the water before taking readings.

Those who scored three marks or less often did not state how resistance could be calculated from the meter readings, or did not state that the meters had to be read at all but that ‘resistance had to be recorded’ at each temperature.

(d) (i) Almost all students could relate a range of resistance values in a table to those represented on a graph.

(ii) Almost all students were able to circle an anomalous value on the graph.

(iii) Surprisingly, less than half the students were able to suggest a reason for the anomalous results such as misreading the thermometer or meters or incorrectly calculating resistance.

(iv) About a third of students were able to suggest a disadvantage of a resistance thermometer compared to a liquid-in-glass thermometer. About one tenth could suggest two, including the need for an electrical supply and that temperature could not be read directly.