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OCR GCSE PHYSICS A (J249): QUESTIONS BY TOPIC

Topic P8: Global challenges (H)

GCSE Physics A Higher Tier (J249) · Topic P8

42 questions · 215 marks · Mark schemes included

OCR GCSE (9–1) Physics A (Gateway Science) J249, June 2018 – June 2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic; within each sub-topic they run from the lowest mark tariff to the highest.

Click any heading or question row below to jump straight to it.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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QUESTIONS

42 questions · 215 marks · grouped by sub-topic, lowest tariff first



SUB-TOPIC P8.1

PHYSICS ON THE MOVE

12 questions in this sub-topic · 61 marks · lowest tariff first



9 A student measures the time it takes for a bicycle to stop in an emergency.

She repeats the measurement to get three results.

The average time for her results is 2.72 s.

The first two results are 2.66 s and 2.60 s.

What is the value of her third result?

A 2.63 s

B 2.66 s

C 2.72 s

D 2.90 s

Your answer

[1]



- 14** An adult on a bicycle travels at 8 m/s on a level road. She sees a hazard and applies her brakes using full force.

Estimate the force of the brakes.

- A** 5 N
- B** 50 N
- C** 500 N
- D** 5000 N

Your answer

[1]



- 14** A hamster has a mass of 100g. When the hamster moves it has a momentum of 0.50 kg m/s.

Calculate the velocity of the hamster.

Use the equation: momentum = mass $\times$ velocity

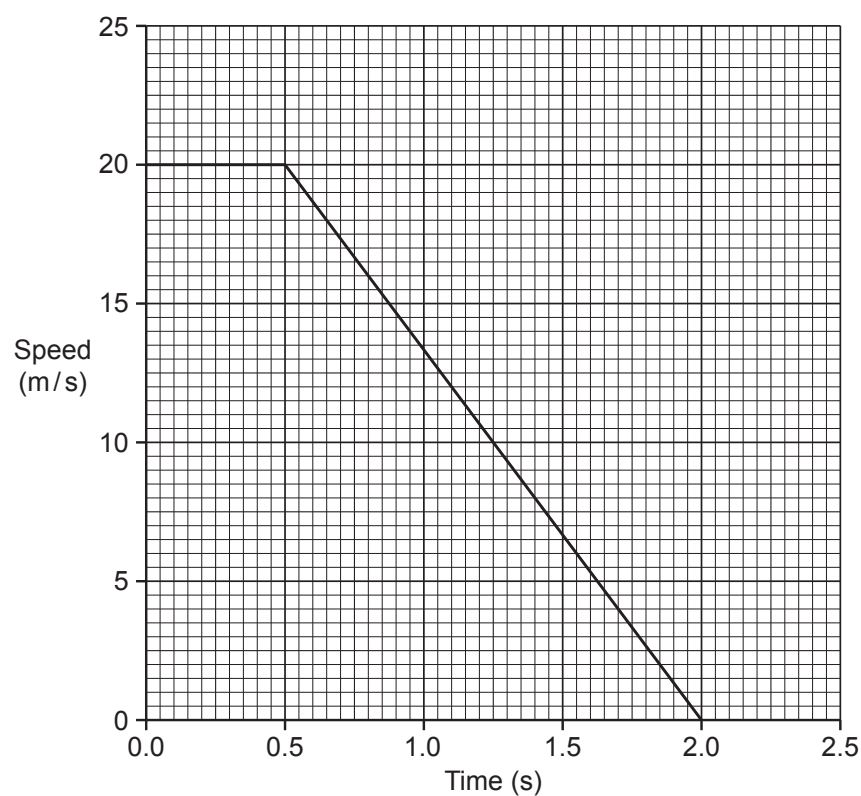
- A** 0.0050m/s
- B** 0.20m/s
- C** 5.0m/s
- D** 200m/s

Your answer

[1]



15 The graph shows how the speed of a car varies with time.



At time = 0.0 s, the driver sees an obstruction in the road.

At time = 0.5 s, the driver presses the brakes.

At time = 2.0 s, the car stops.

What is the thinking distance of this car?

Use the graph.

A 10 m

B 15 m

C 25 m

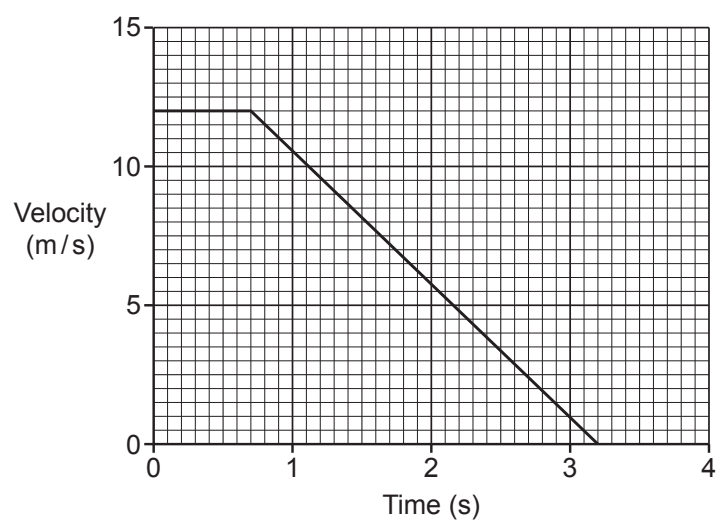
D 40 m

Your answer

[1]



- 8 The velocity–time graph shows how the velocity of a car changes after the driver sees a hazard in the road.



What is the braking distance of the car?

- A** 8.4 m
B 15.0 m
C 17.5 m
D 23.4 m

Your answer

[1]

3 Which factor will **increase** the braking distance of a car travelling on a road?

- A Drinking alcohol
- B Driving when tired
- C More people in the car
- D Using new brake pads

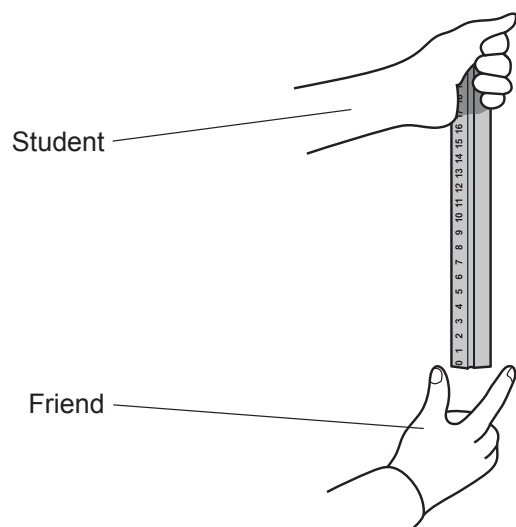
Your answer

☐

[1]



- 5 A student drops a ruler and a friend catches it.



The reaction time of the friend is calculated from the distance the ruler has fallen. The experiment is repeated.

What does the student do to determine an accurate value for the reaction time?

- A Check the reaction time with a stopwatch
- B Drop the ruler at random times
- C Drop the ruler from different heights above the friend's hand
- D Tell the friend when the ruler will be dropped

Your answer

[1]

21 (a) Fig. 21.1 is a speed-time graph for car P.

The driver of car P reacts to a traffic light at time = 0.00 s, then presses the brakes at time = 0.50 s.

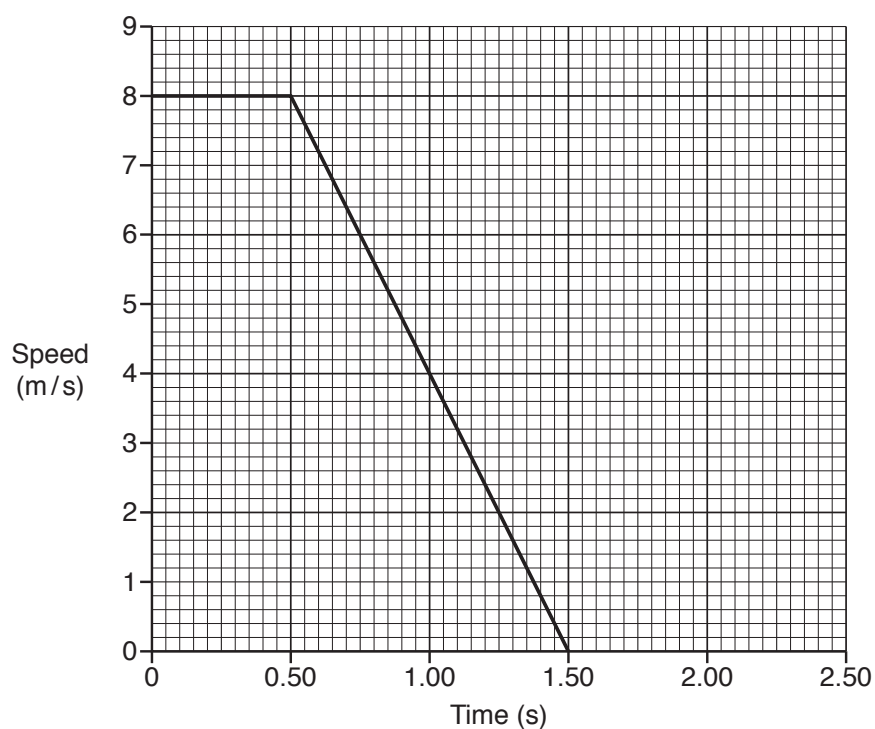


Fig. 21.1

(i) The braking distance is the same size as the thinking distance.

Explain how the graph in Fig. 21.1 shows this.

.....
 [1]

(ii) Add another line to the graph in Fig. 21.1 to show the journey of car Q.

- Car Q is travelling at 8 m/s.
- The driver of car Q reacts, then presses the brakes after 0.75 s.
- Car Q decelerates at the same rate as car P.

[2]

(b) Driver **P** measures the reaction time of driver **Q** using a 30 cm ruler.

Driver **P** drops a 30 cm ruler vertically and driver **Q** catches it.

(i) Explain how the ruler can be used to estimate reaction time.

.....
.....
..... [1]

(ii) State **one** precaution they can use to get accurate results.

.....
.....
..... [1]



- (c) In the brakes of a car there are brake pads and a brake disc, as shown in **Fig. 21.2**.

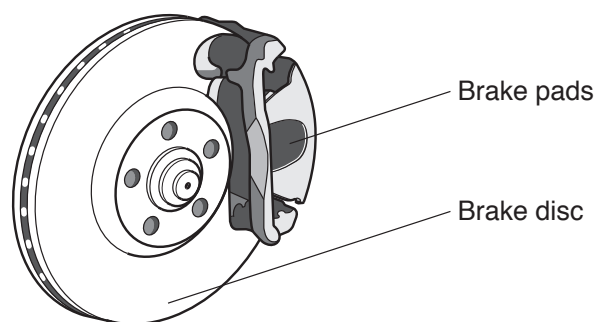


Fig. 21.2

When a car stops, energy transfers between stores.

The brake pads squeeze the brake disc and cause a friction force.

- (i) Explain how braking stops the car.

Include ideas about **energy stores** in your answer.

.....

.....

..... [2]

- (ii) High speed cars have ventilated brakes with air holes in the disc, as shown in **Fig. 21.3**.

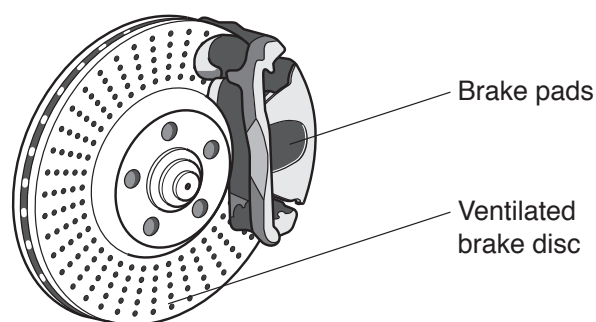


Fig. 21.3

The air holes allow more air to circulate around the disc.

Suggest how these brakes can reduce braking distances.

.....

..... [1]

22 A van travels along a road at a constant speed.

(a) The van brakes and decelerates at a constant rate:

- The initial speed of the van is 18 m/s .
- The deceleration of the van is 1.5 m/s^2 .

Calculate the time taken for the van to stop.

Use the equation: acceleration = change in velocity/time taken

Time = ... s **[3]**

(b) The same van travels on an **icy** road at 18 m/s .

Explain how the **stopping** distance changes.

Write about thinking and braking in your answer.

.....

.....

.....

.....

..... **[3]**

(c) If the van crashes, the time taken to stop is much smaller.

Explain why this is dangerous for the people in the van.

.....

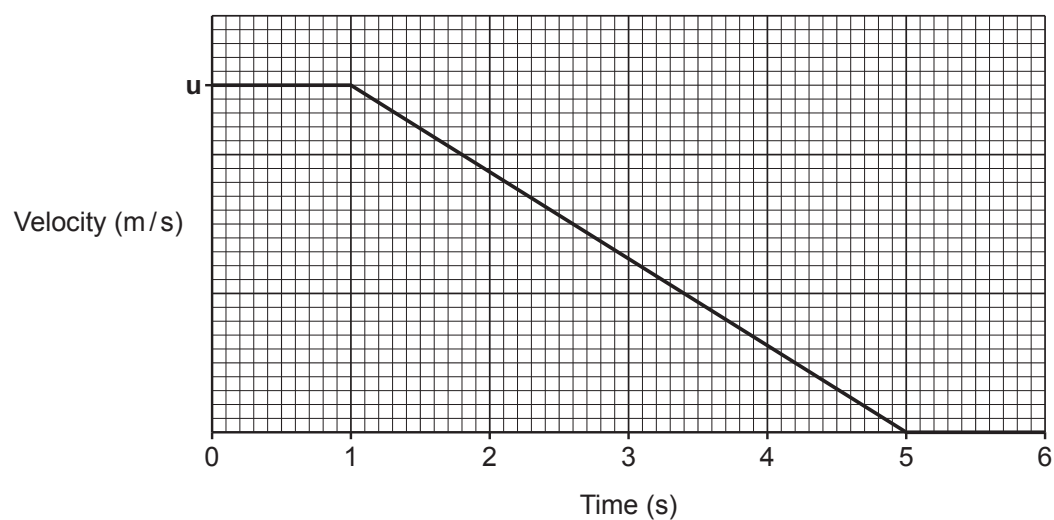
.....

..... **[2]**



20

- (a) The graph shows how the velocity of car **A** changes when the driver sees a hazard in the road at time = 0 seconds.



The braking distance is 30 m.

Calculate the initial velocity **u** of car **A**.

Use the graph.

Initial velocity **u** = ... m/s [3]



(b) Car **B** brakes and comes to a stop.

(i) The deceleration of car **B** is 6 m/s^2 .

The initial speed of the car is 18 m/s .

Calculate the braking distance of car **B**.

Use the Equation Sheet.

Braking distance = ... m [3]

(ii) Estimate the force acting on car **B** when it decelerates at 6 m/s^2 .

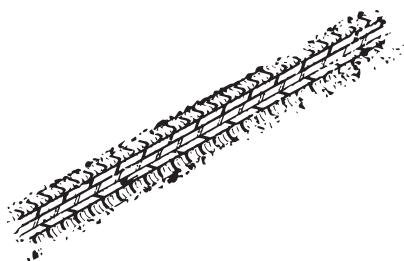
Use the equation: force = mass $\times$ acceleration

For the mass in the equation, use an estimate of the mass of car **B**.

Force = ... N [3]



(iii) The diagram shows a skid mark that car **B**'s tyre makes on the road when the car brakes.



The length of the skid mark is 25 m.

Suggest **two** reasons why the braking distance and the length of the skid mark are **not** the same.

1

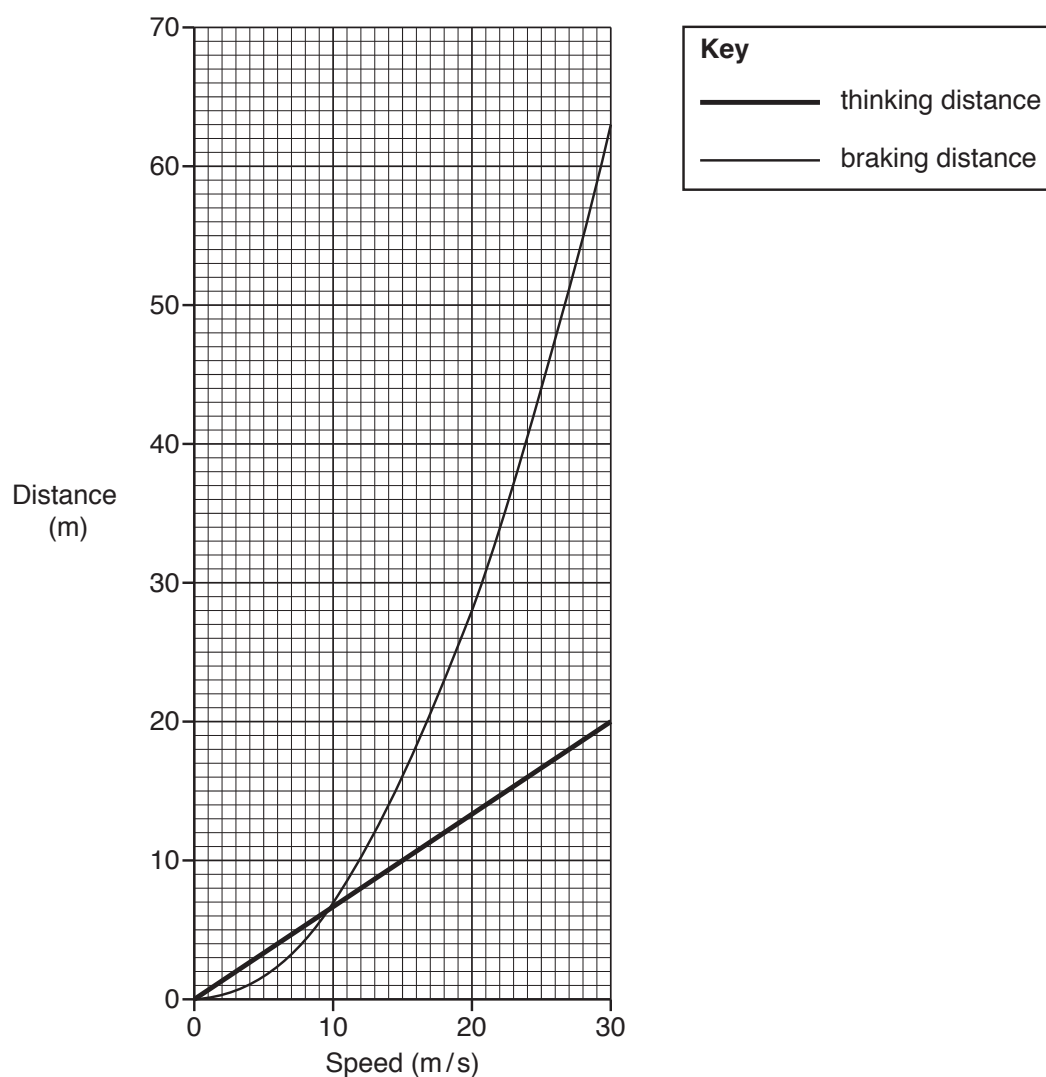
.....

2

.....

[2]

17 The graph shows thinking and braking distances for a car at different speeds.



(a) Describe how **thinking distance** varies with increasing speed.

Use data from the graph in your answer.

.....

.....

.....

..... [2]

- (b) (i) Use the graph to find the **thinking distance** at 24 m/s.

Thinking distance = ... m [1]

- (ii) Calculate the **thinking time** at 24 m/s.

Use your answer to (b)(i) and the equation: distance travelled = speed × time

Give your answer to 2 decimal places.

Thinking time = ... s [3]

- (c) (i) State **one** factor that could **increase** thinking distance.

..... [1]

- (ii) Calculate the **stopping distance** at 15 m/s.

Use the graph to help you.

Stopping distance = ... m [2]

- (d) How does the speed affect the **kinetic energy** and **braking distance** of the car?

Use the graph in your answer.

.....

 [3]



20 A scientist uses different drivers to test the stopping distances of the same car.

Look at the results.

Driver	Speed (m/s)	Thinking distance (m)	Braking distance (m)
A	8	6	6
B	16	13	24
C	32	24	96
D	16	12	24
E	8	5	6
F	32	30	120

(a) Most of the drivers tested the car on a dry day, on a level road.

Which driver tested the car on an **icy** road?

Driver tested the car on an **icy** road.

[1]

(b) Which driver has the **quickest** reaction time?

Driver has the **quickest** reaction time.

Calculate their reaction time.

Answer = ... s [3]

(c) Give **two** drivers that have the **same** reaction time.

Drivers have the **same** reaction time.

Explain your answer.

.....

.....

..... [2]



(d) Driver **C** travels at 32 m/s on the road and then stops. The car has a mass of 1200 kg.

(i) Show that the **kinetic energy** stored by the car at 32 m/s is 614 000 J.

[2]

(ii) Describe what happens to the kinetic energy of the car as it brakes and stops.

.....

 [2]

(iii) The braking distance of the car is 96 m.

Calculate the **braking force** on the car.

Give your answer to **4** significant figures.

Answer = ... N [3]

(e) Driver **B** travels at 16 m/s on the road. The thinking distance is 13 m and the braking distance is 24 m.

Driver **B** now drives the car **uphill** at the same speed on the same road.

How will driving the car **uphill** affect thinking, braking and stopping distances?

The reaction time will stay the same.

Complete the sentences.

The **thinking distance** will

The **braking distance** will

The **stopping distance** will [2]

SUB-TOPIC P8.2

POWERING EARTH

7 questions in this sub-topic · 76 marks · lowest tariff first



7 Which statement shows energy resources that are **all renewable**?

- A Bio-fuel, wind, hydro-electricity and tides.
- B Fossil fuels, bio-fuel, wind and hydro-electricity.
- C Fossil fuels, nuclear fuel, hydro-electricity and tides.
- D Nuclear fuel, bio-fuel, wind and tides.

Your answer

[1]

18* The UK generates some of its electrical power from wind turbines.

Fig. 18.1 shows the total electrical power generated by wind turbines in the UK.

The graph is for a single day in December which had very strong winds.

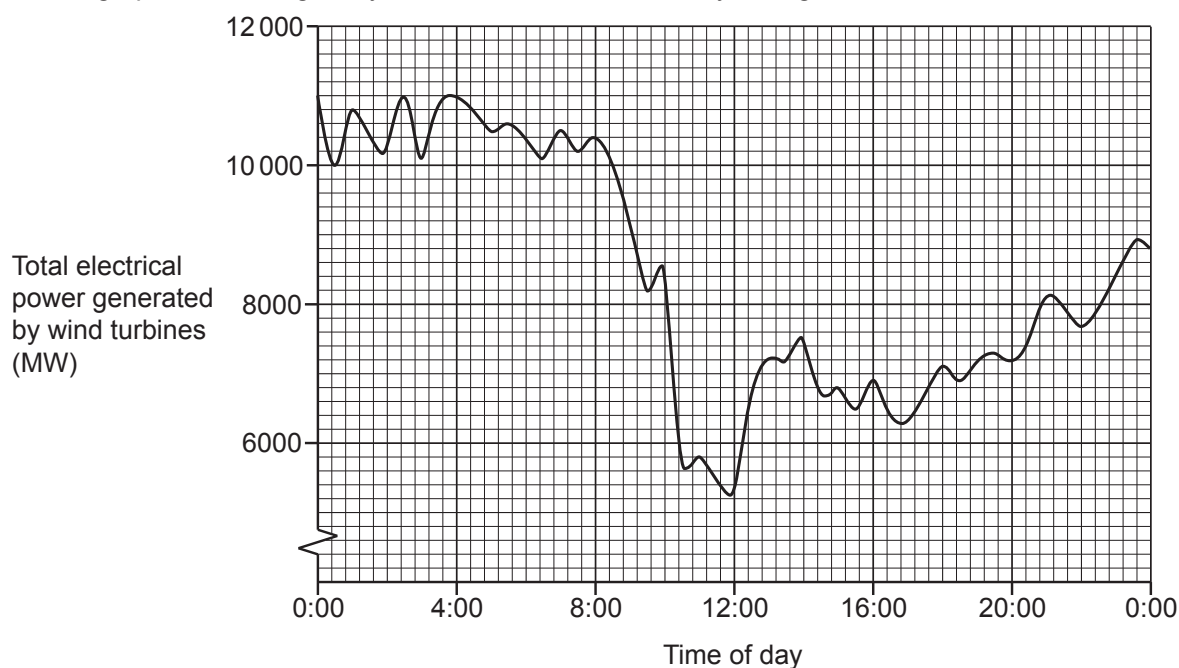


Fig. 18.1

Fig. 18.2 shows the total demand for electrical power in the UK on the same day.

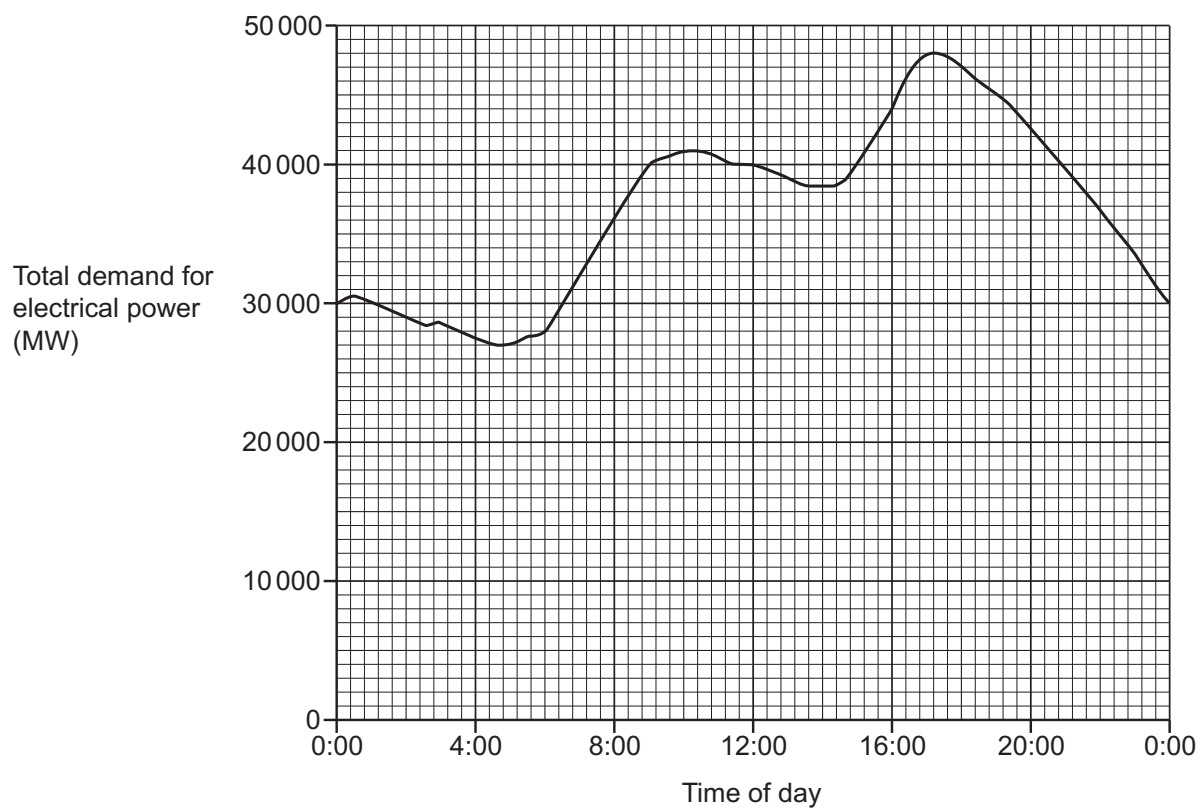


Fig. 18.2

Some experts believe the UK should generate most of its electrical power from wind.

Evaluate the advantages and disadvantages of this idea.

Use the graphs in **Fig. 18.1** and **Fig. 18.2** and your own ideas about wind turbines to support your answer.

[6]

- 19** The national grid makes predictions about the electrical power it can supply and the electrical power customers demand for two different winters.

The national grid calculates the system margin using the equation:

$$\text{system margin} = \text{electrical power supplied} - \text{electrical power demanded}$$

- (a)** The predictions for **winter 1** are:

Predicted supply = 64.2 GW

Predicted demand = 60.0 GW

Calculate the percentage system margin for **winter 1**.

Use the equation:

$$\text{percentage system margin} = \frac{(\text{predicted supply} - \text{predicted demand})}{\text{predicted demand}} \times 100\%$$

Percentage system margin = ... % **[2]**

- (b)** The predictions for **winter 2** are:

Lowest predicted system margin = 3.0 GW

Highest predicted system margin = 6.2 GW

Mean predicted system margin = 4.6 GW

- (i)** Suggest **two** reasons why the national grid predicts a range of values for the system margin.

1

.....

2

.....

[2]



- (ii) Calculate the percentage uncertainty in the predicted system margin for **winter 2**.

Use the equation: $\text{percentage uncertainty} = \frac{1}{2} \times \frac{\text{range of values}}{\text{mean value}} \times 100\%$

Percentage uncertainty = ... % [2]

(c)

- (i) Suggest why people working for the national grid may worry if the system margin is small.

.....
 [1]

- (ii) The electrical power that hydroelectric power stations are able to supply can be increased to help meet the customer demand.

On one winter's day:

- the electrical power demanded by customers = 1.0 GW
- the electrical power that can be supplied by a hydroelectric power station = 5.5 GW
- the system margin = 4.5 GW.

The electrical power that the hydroelectric power station is able to supply is then increased so that the system margin is increased by 4.0%.

Calculate the electrical power that the hydroelectric power station is able to supply after the system margin has been increased.

Electrical power supplied = ... GW [2]



17 A solar cell changes light into electricity. Solar panels contain solar cells.

(a) A student investigates a solar cell:

- They change the intensity of the light.
- They measure the potential difference across the solar cell.

(i) Table 17.1 shows the student's results:

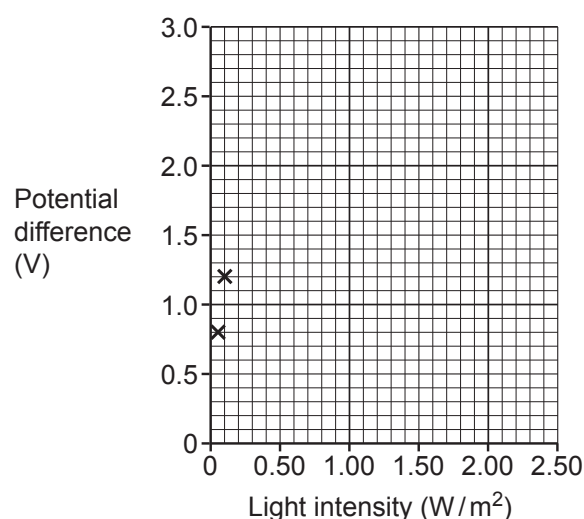
Light intensity (W/m^2)	Potential difference (V)
0.05	0.8
0.10	1.2
0.20	1.5
0.40	1.8
0.80	2.2
1.60	2.5

Table 17.1

Plot a graph of the results from Table 17.1. Two results have already been plotted for you.

Draw a line of best fit.

[3]



(ii) The light intensity is changed to $2.00 \text{ W}/\text{m}^2$.

Use your graph to predict the potential difference of the solar cell.

Show your working on the graph.

Potential difference = ... V [2]



- (iii) Suggest **one** way the student could improve their investigation.

.....
 [1]

- (b) (i) More people use solar panels to generate electricity compared to twenty years ago.

Suggest **two** reasons why.

1

 2
 [2]

- (ii) A homeowner fits solar panels to the roof of their house.

Table 17.2 gives the energy values for the house for **one** day:

Area of one solar panel	1.6 m ²
Area of roof that can be used	24 m ²
Maximum energy output of one solar panel	26 MJ
Energy needed by all appliances in the house	364 MJ

Table 17.2

Explain whether the energy needed by all the appliances can be generated using **only** solar panels.

Use **Table 17.2** and your knowledge of solar panels to explain your answer.

.....

 [3]



- 17** In 1986, there was an accident when a nuclear reactor in a power station exploded.

In the explosion, radioactive materials from inside the reactor were spread over the power station.

- (a)** Explain why workers at the power station were both contaminated **and** irradiated in the accident.

Contaminated because

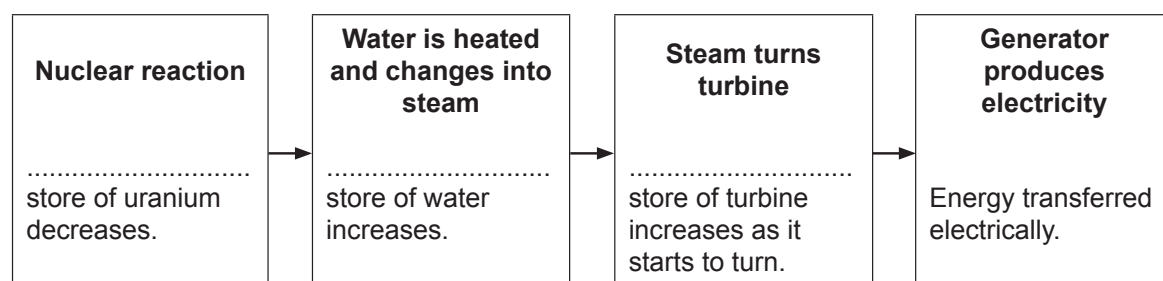
.....

Irradiated because

.....

[2]

- (b)** The flow diagram shows energy transfers when electricity is generated in a nuclear power station.



Complete the flow diagram to show the changes in energy stores.

[3]

- (c) One of the elements released in the accident when the nuclear reactor exploded was caesium-137.

Caesium-137 has a half-life of 30 years.

- (i) Explain what is meant by the phrase 'a half-life of 30 years'.

.....
 [1]

- (ii) Which sentence explains why we use the idea of half-life in radioactive decay?

Tick (✓) **one** box.

Radioactive decay is a random process.

☐

When a nucleus decays, it splits in half.

☐

With large numbers, it is easier to count half of the nuclei.

☐

[1]

- (iii) In the accident, 28 kg of caesium-137 was released into the atmosphere.

What mass of caesium-137 remains undecayed after 90 years?

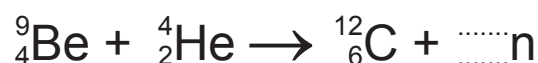
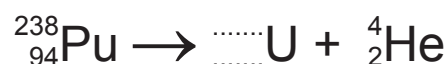
Mass = ... kg [2]

- (d) A nuclear reactor needs neutrons to start a nuclear fission reaction.

A plutonium nucleus (Pu) decays into a uranium nucleus (U) and an alpha particle (${}^4_2\text{He}$).

The alpha particle then joins with a beryllium nucleus (Be) to produce a carbon nucleus (C) and a neutron (n).

Complete the equations.

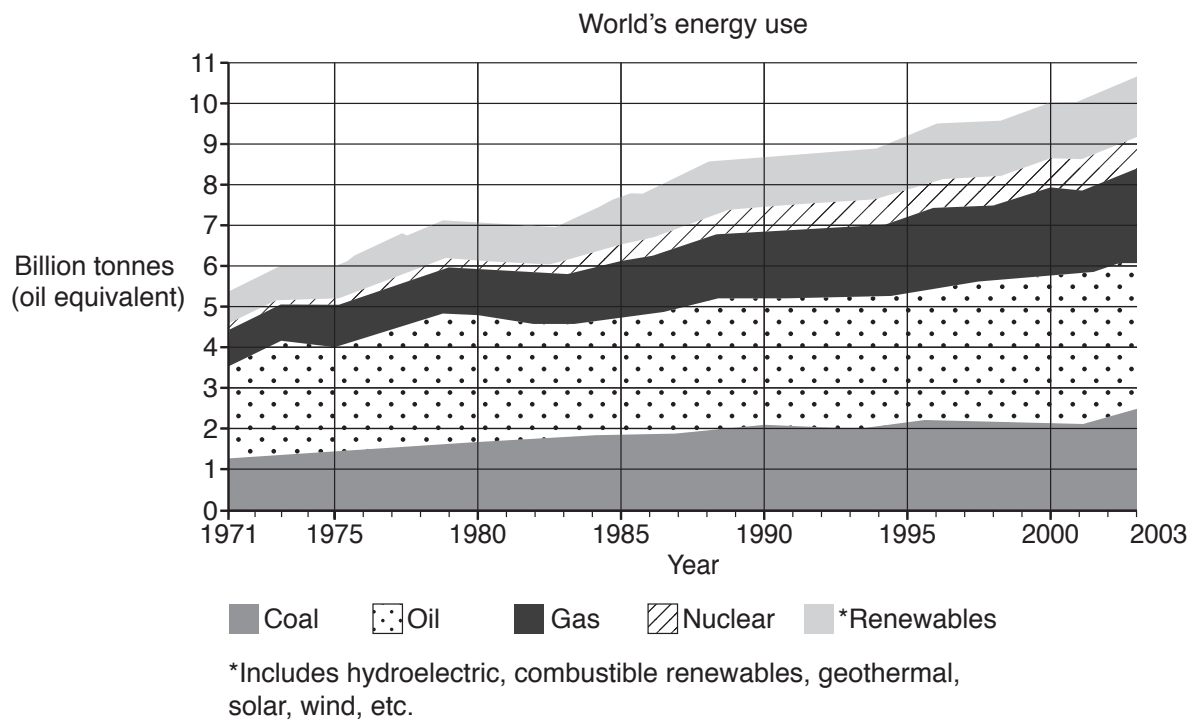


[3]



16 The graph shows how the World's energy use has changed from the year 1971 to the year 2003.

It also shows the amount of different energy sources used.



- (a) (i) Approximately how much did the total World's energy use increase from the year 1971 to the year 2003?

Answer = ... billion tonnes (oil equivalent) **[1]**

- (ii) Which energy source had the **greatest** use in the year 2003?

..... **[1]**

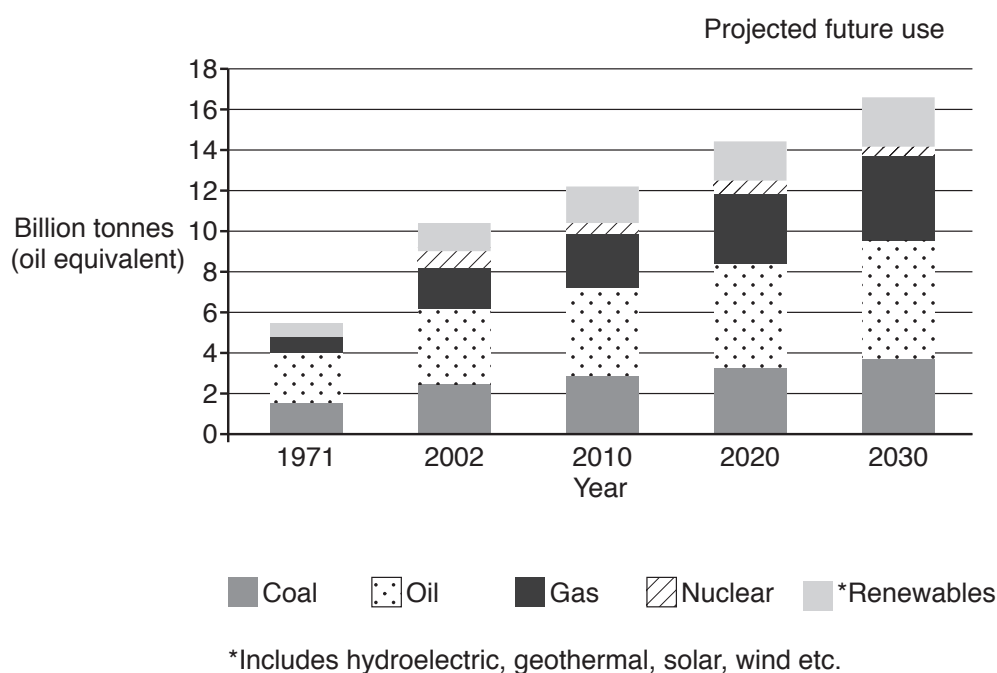
- (iii) The total energy use in the year 2003 was 10.6 billion tonnes (oil equivalent).

Approximately what percentage of this amount was due to fossil fuel use?



- (b) Scientists are researching the World's energy use for the future.

The graph shows some of their research.



- (i) The future demand for fossil fuels is expected to increase.

Give two reasons why scientists are worried about this increase in demand.

1.
 2.
- [2]

- (ii) In the UK the government is closing coal fired power stations and planning for new nuclear power stations to be built.

Suggest why the government wants more nuclear power stations.

-
-
- [2]

- (c) Power stations in the UK generate electricity at 25 kV a.c.

The voltage is then increased to 400 kV a.c. and distributed by power lines.

- (i) Write down the full name of the device used to **increase** the voltage.

..... [1]

- (ii) Why is it important to increase the voltage in these power lines?

..... [1]

- (iii) The high voltages across the power lines are reduced to 230 V a.c. for use in the home.

A phone charger changes the 230 V a.c. to a 5 V d.c.

Explain the difference between d.c. and a.c.

.....

 [2]

- (d) A domestic wind turbine has a power rating which varies from 1.0 kW to 3.0 kW.

- (i) The domestic wind turbine has an electrical resistance of $23\ \Omega$.

It generates a current of 11 A on a windy day.

Calculate the **power** output in kW of the turbine on this day.

Answer = ... kW [4]

- (ii) Suggest why the manufacturer gives a range for the power rating of the wind turbine.

.....
 [1]

- (iii) Using just **one** domestic wind turbine may be an unreliable source of power for a house.

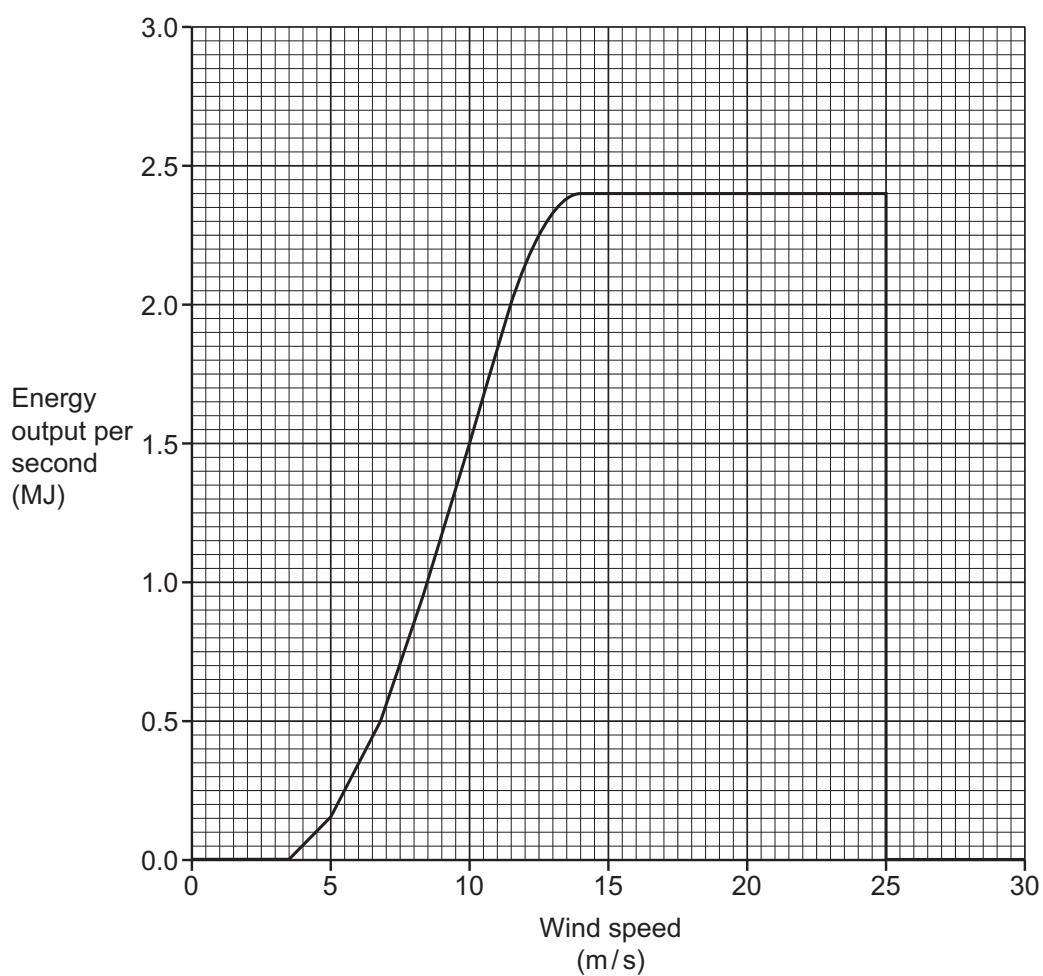
State a reason why.

.....
 [1]



- 21 (a) Fig. 21.1 shows how the energy output per second of a wind turbine depends on the wind speed.

Fig. 21.1



- (i) Suggest a reason why energy output per second is zero when the wind speed is:

- 1 Less than 3.5 m/s.

.....
.....

- 2 Greater than 25 m/s.

.....
.....

[2]

- (ii) The wind turbine has an efficiency of 0.35.

Calculate the input energy per second when the wind speed is 10 m/s.

Use **Fig. 21.1** and the Data Sheet.

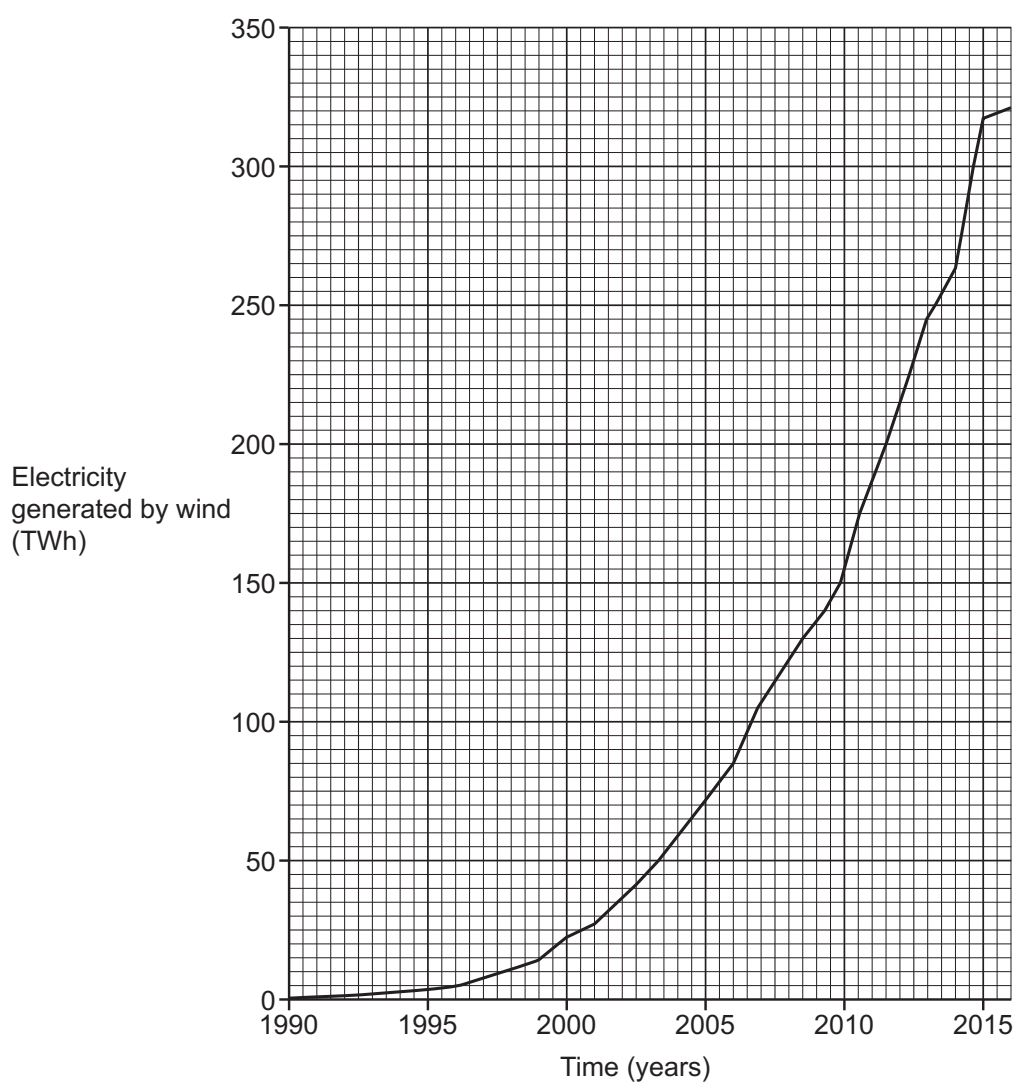
Give your answer to **2** significant figures.

Input energy per second = ... MJ [5]



- (b) Fig. 21.2 shows how the amount of electricity generated by wind in Europe has changed with time.

Fig. 21.2



- (i) State the amount of electricity generated by wind in 2012 in joules.

$$1 \text{ TWh} = 3.6 \times 10^{15} \text{ J}$$

Give your answer in standard form.

Electricity generated = ... J [2]



(ii) Suggest **two** reasons for the change shown in **Fig. 21.2**.

1

.....

2

.....

[2]

(c) The wind turbine generates electricity at 900 V.

The wind turbine is connected to the national grid using a transformer.

- (i) The potential difference across the primary coil is 900 V.
The potential difference across the secondary coil is 36 000 V.
The current in the primary coil is 2800 A.

Calculate the current in the **secondary** coil.

Use the Data Sheet.

Current = ... A [2]

(ii) Explain why the use of the transformer in (c)(i) reduces power loss in the national grid.

.....

.....

.....

.....

.....

..... [3]



(iii) Another transformer has a power input of 864 900 W.

The current in the primary coil is 1860 A.

Calculate the resistance of the primary coil.

Use the equation: $\text{power} = (\text{current})^2 \times \text{resistance}$

Resistance = ... Ω [3]



SUB-TOPIC P8.3

BEYOND EARTH

23 questions in this sub-topic · 78 marks · lowest tariff first



8 A planet moves in a circular orbit around its star.

Which statement is correct?

- A** The planet travels at changing speed and changing velocity.
- B** The planet travels at changing speed but constant velocity.
- C** The planet travels at constant speed and velocity.
- D** The planet travels at constant speed but changing velocity.

Your answer

[1]



12 An artificial satellite is kept in its low polar orbit by a gravity force from a planet.

The satellite is moved to a higher orbit above the planet.

Which statement is correct about the satellite in this higher orbit?

- A** The force of gravity is greater and its speed decreases.
- B** The force of gravity is greater and its speed increases.
- C** The force of gravity is less and its speed decreases.
- D** The force of gravity is less and its speed increases.

Your answer

[1]

13 Which row **A**, **B**, **C** or **D**, describes what has happened to light that has undergone red shift?

	Wavelength	Frequency
A	Decreases	Decreases
B	Decreases	Increases
C	Increases	Decreases
D	Increases	Increases

Your answer

[1]



- 9 The table contains statements about red-shift and galaxies.

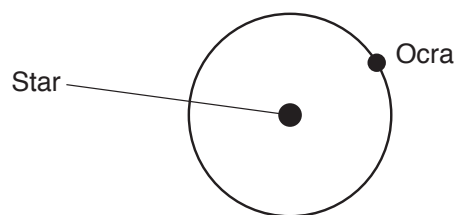
Which row in the table is correct?

	Statement 1	Statement 2
A	All galaxies move apart at the same speed.	They show both red-shift and blue-shift.
B	Distant galaxies show more red-shift.	The distant galaxies are moving apart faster than nearby ones.
C	Distant galaxies show more red-shift.	The distant galaxies are moving apart slower than nearby ones.
D	There are no galaxies that show blue-shift.	All galaxies are moving away from each other.

Your answer

[1]

11 Planet Ocra is in a circular orbit around a star.



Which statement is correct?

- A The acceleration of Ocra is zero.
- B The speed of Ocra is changing.
- C The velocity of Ocra is changing.
- D The velocity of Ocra is zero.

Your answer

☐

[1]

12 An artificial satellite orbits the Earth in a circular path.

The satellite is moved further away from Earth to another orbit.

Which row in the table is correct?

	Force of gravity	Speed in orbit	Time period
A	decreases	decreases	decreases
B	decreases	decreases	increases
C	decreases	increases	increases
D	increases	increases	increases

Your answer

[1]

- 6** Which statement about geostationary satellites is correct?
- A** They appear to be in a fixed position relative to a point on the Earth.
 - B** They are in a polar orbit.
 - C** They are positioned 400 km above the Earth's surface.
 - D** They take 2 hours to orbit the Earth.

Your answer

☐

[1]



14 Which statement about a star that explodes into a supernova is correct?

- A** The star has more mass than the sun.
- B** The star is older than the sun.
- C** The star will become a white dwarf.
- D** The star's core expands.

Your answer

[1]

15 Which statement about nuclear **fusion** is correct?

- A Energy is released because mass is converted to energy.
- B Helium is converted into hydrogen.
- C It is the main way in which nuclear power generates electricity.
- D It is the splitting of a heavy nucleus into smaller nuclei.

Your answer

[1]



1 Which row in the table correctly describes gravitational fields?

	Type of field	Strength of field
A	Attractive	Greater for massive objects
B	Attractive	Less for massive objects
C	Repulsive	Greater for massive objects
D	Repulsive	Less for massive objects

Your answer

[1]

8 Four stages in the lifecycle of a star are P, Q, R and S:

P	Nuclear fusion starts.
Q	The core collapses to form a white dwarf.
R	Dust and gas are pulled together by gravity.
S	The star expands to form a red giant.

What is the correct order of these stages?

A $P \rightarrow R \rightarrow Q \rightarrow S$

B $P \rightarrow S \rightarrow R \rightarrow Q$

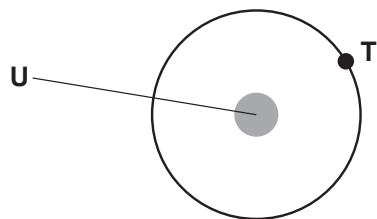
C $R \rightarrow P \rightarrow S \rightarrow Q$

D $R \rightarrow Q \rightarrow P \rightarrow S$

Your answer

[1]

- 14 Object **T** moves at a constant speed in a circular orbit around object **U**.



Why does the velocity of **T** change?

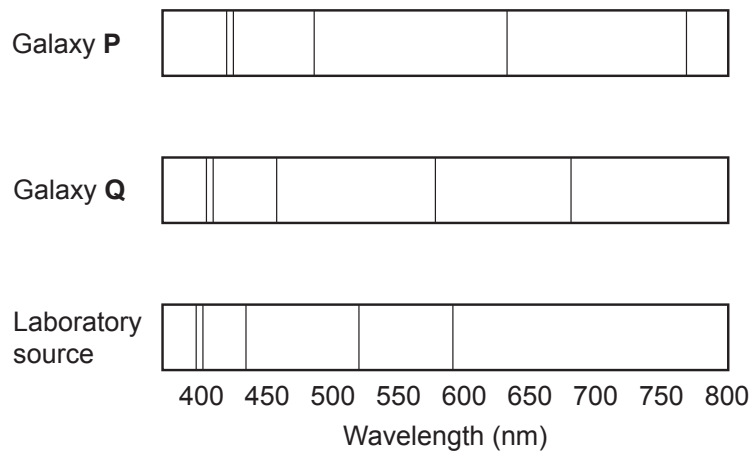
- A** The force of gravity is at right angles to the velocity of **T**.
- B** The forces acting on **T** are balanced.
- C** The force of **U** on **T** equals the force of **T** on **U**.
- D** The forces acting on **U** are balanced.

Your answer

[1]

11 The diagram shows the emission spectra obtained from stars in two different galaxies.

The same spectrum is shown from a laboratory source on the Earth.



Which statement is correct?

- A Galaxy P is further away from the Earth than galaxy Q.
- B Galaxy P is moving away from the Earth more slowly than galaxy Q.
- C Galaxy P is moving towards the Earth.
- D Galaxy P shows a smaller red-shift than galaxy Q.

Your answer

[1]

13 Which sentence explains why the Sun maintains a constant size?

- A** The force due to gravity is balanced by the repulsive force between positively charged hydrogen nuclei in the high temperature gas.
- B** The force due to gravity is balanced by the force due to the energy released from nuclear fission inside the core of the star.
- C** The force due to gravity is balanced by the force due to gas pressure caused by the energy released from fusion.
- D** The force due to gravity is balanced by the force from the radiation emitted from the high temperature gas inside the star.

Your answer

[1]

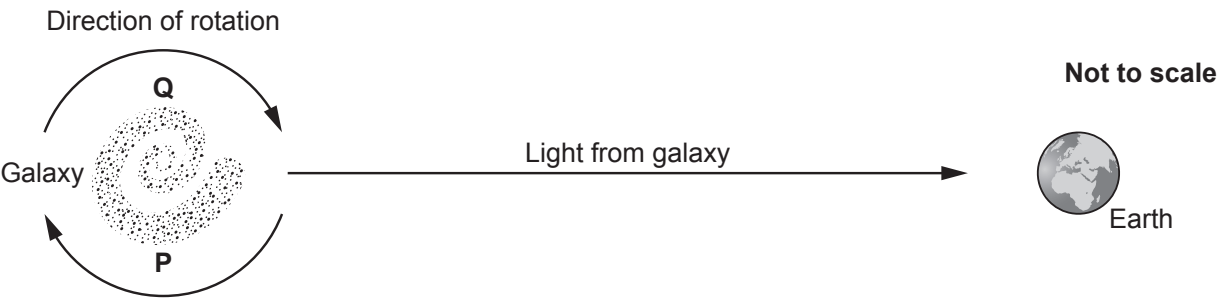


15 The diagram shows a distant galaxy that is receding from the Earth. The galaxy is rotating in the direction shown.

Visible light from both sides of the galaxy is detected on the Earth.

The galaxy recession and its rotation cause redshift of this visible light.

Which row correctly compares the wavelengths of the visible light detected on the Earth from side **Q** of the galaxy, from side **P** of the galaxy and from the Sun?



	Shortest wavelength → Longest wavelength		
A	Light from P	Light from Q	Light from Sun
B	Light from Q	Light from P	Light from Sun
C	Light from Sun	Light from P	Light from Q
D	Light from Sun	Light from Q	Light from P

Your answer

[1]

19 (a) Nuclear **fusion** is a reaction that happens in stars. This equation for fusion is incomplete.



(i) What else is produced in this reaction?

.....
 [1]

(ii) Stars are formed from dust and gas.

What causes the dust and gas to undergo fusion?

.....
 [1]

(b) (i) Describe one **similarity** between nuclear fission and nuclear fusion.

.....
 [1]

(ii) Describe one **difference** between nuclear fission and nuclear fusion.

.....
 [1]

(c) Nuclear fission can be used as a power source to produce electricity.

Give one **advantage** and one **disadvantage** of using nuclear power to produce electricity.

advantage.....

.....

disadvantage

.....

[2]

19 A radio signal is sent to Mars.

- (a) **Table 19.1** shows the distance from the Sun to Earth and the distance from the Sun to Mars, when Mars and Earth are closest.

Distance from the Sun to Earth	$1.50 \times 10^{11} \text{ m}$
Distance from the Sun to Mars	$2.28 \times 10^{11} \text{ m}$

Table 19.1

The radio signal travels at $300\,000\,000 \text{ m/s}$.

Calculate the minimum time for the radio signal to travel from Earth to Mars.

Use the data in **Table 19.1** and the equation: distance = speed $\times$ time

Time = ... s [4]

- (b) The average surface temperature on Earth is 15°C .

Suggest whether the average temperature on Mars is higher or lower than 15°C .

Use the data in **Table 19.1** to explain your answer.

.....

.....

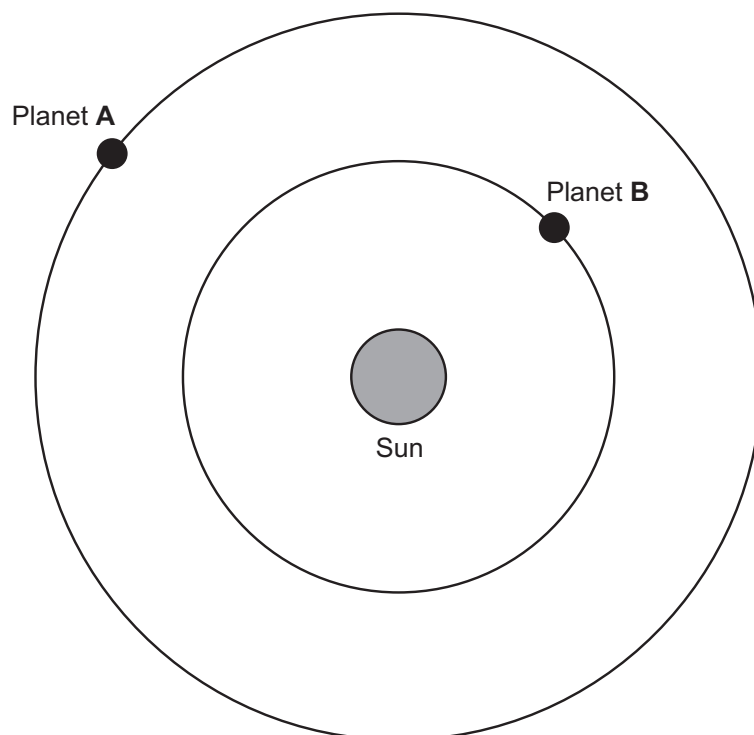
.....

.....

..... [2]



22 The diagram shows two planets orbiting the Sun in our Solar System.



(a) Read the two statements about planet **A**:

- The speed of planet **A** is constant.
- The velocity of planet **A** is changing.

Explain why these two statements are correct. Write about forces.

.....

.....

.....

.....

.....

.....

.....

[3]

(b) The table shows data for the planets.

	Radius of orbit (metres)	Time to orbit Sun (years)	Mean orbital speed (km/s)
Planet A	2.28×10^{11}	1.88	24
Planet B	1.08×10^{11}	0.62	35

(i) Explain why the speed of a planet changes when the radius of orbit changes.

.....

.....

.....

..... [2]

(ii) Two students look at the data.

Student P says, ‘The time to orbit the Sun is proportional to the radius of orbit.’

Student Q disagrees.

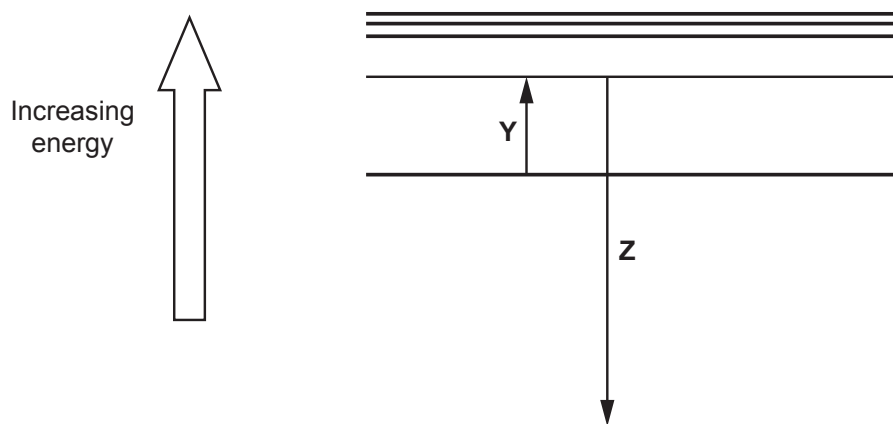
Use the data in the table to show that **Student Q** is correct.

.....

..... [2]

- 19 (a)** Atoms can emit or absorb electromagnetic radiation when electrons move between energy levels.

The diagram shows electron transitions **Y** and **Z** between energy levels in an atom.



- (i) Draw an arrow on the diagram showing the transition of an electron in the **lowest** energy level when it is lost from the atom. [2]

- (ii) Complete each sentence about the electron transitions in the diagram.

Use the words in the list.

absorbed	emitted	excited	ionised
higher than	lower than	the same as	

When an electron is, as shown by arrow **Y**, electromagnetic radiation is by the atom.

The frequency of electromagnetic radiation involved in transition **Z** is the frequency of the electromagnetic radiation involved in transition **Y**.

[2]

(b) Line spectra give astronomers information about the motion of distant galaxies.

The table gives the wavelength of a line in the spectrum of hydrogen observed in a laboratory on the Earth.

The table also gives the wavelength of the **same** line in the spectrum of hydrogen observed from galaxy **A** and galaxy **B**.

Source	Wavelength of line (nm)
Laboratory on the Earth	656
Galaxy A	712
Galaxy B	739

Explain how the data in the table can be used to compare the motion of galaxy **A** with galaxy **B**.

.....

.....

.....

.....

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.....

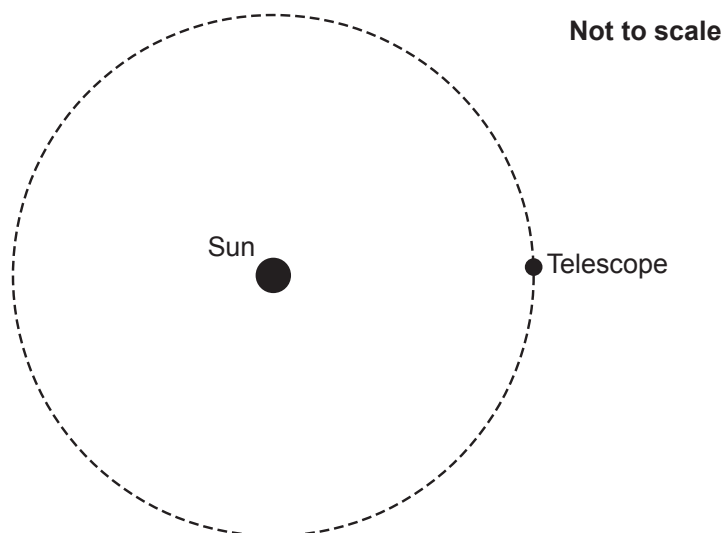
.....

..... **[4]**

- 18** The James Webb space telescope orbits the Sun in a circular orbit.

Fig. 18.1 shows the orbital path of the telescope around the Sun.

Fig. 18.1



- (a)** A force acts on the telescope to keep it in orbit around the Sun.

- (i)** State the name of this force.

..... [1]

- (ii)** Draw an arrow on **Fig. 18.1** to show the direction of the force acting on the telescope. [1]

- (b)** The telescope is accelerating towards the Sun.

Explain why the telescope is accelerating even though its speed remains constant.

.....

 [2]

- (c)** The James Webb space telescope is always within 1.5 million kilometres of the Earth.

The telescope is in constant use by scientists on the Earth.

Suggest a reason why it is important for the telescope to remain close to the Earth.

.....
 [1]

- (d) The James Webb space telescope detects electromagnetic radiation from stars and galaxies.

Some telescopes on the Earth's surface also detect electromagnetic radiation from stars and galaxies.

Describe an advantage of using the James Webb space telescope to detect this radiation instead of a telescope on the Earth's surface.

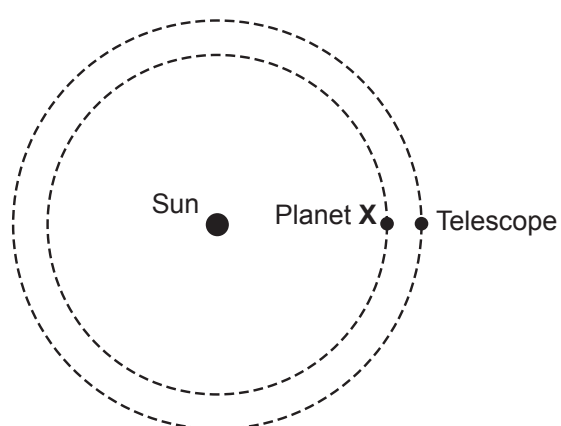
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.....

..... [1]

- (e) Fig. 18.2 shows the paths of the orbits around the Sun of both the James Webb space telescope and a planet labelled X.

Fig. 18.2



Not to scale

Compare the speeds of planet X and the telescope.

Explain your answer.

.....

.....

.....

..... [2]

21 Scientists are working on nuclear fusion technology so that, in the future, nuclear fusion power stations could be built to generate electricity.

(a) The expected power output of a nuclear fusion power station in the future is $1.3 \times 10^9 \text{ W}$.

The average energy output of an individual fusion reaction is $2.8 \times 10^{-12} \text{ J}$.

Calculate the number of fusion reactions that would occur per second in the power station.

Number of fusion reactions per second = ... **[2]**



20 (a) The Sun is a star.

Describe how the Sun was formed.

.....

.....

.....

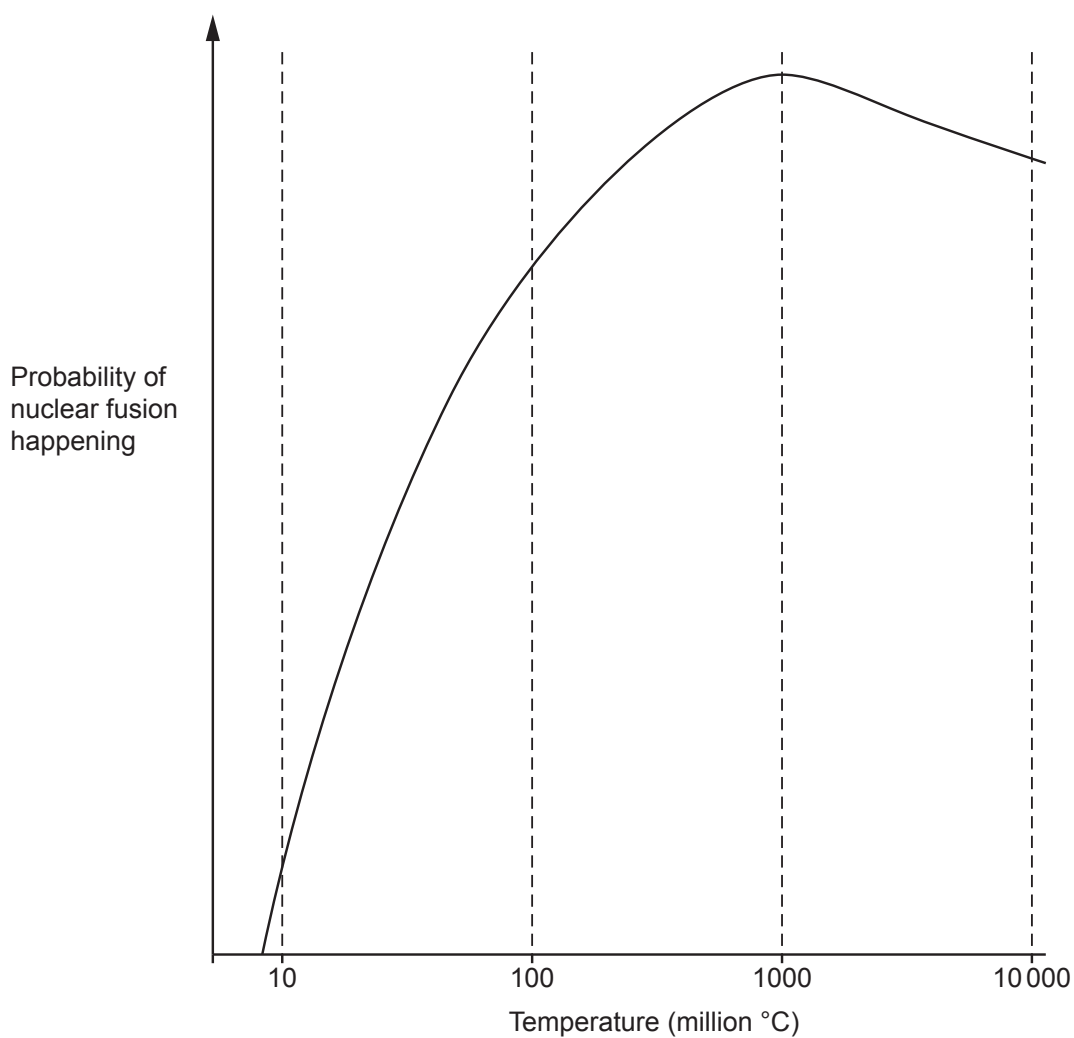
.....

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..... [3]

(b)* Nuclear power stations use nuclear fission rather than nuclear fusion to generate energy.

This graph shows how the probability of a nuclear fusion reaction changes with temperature.



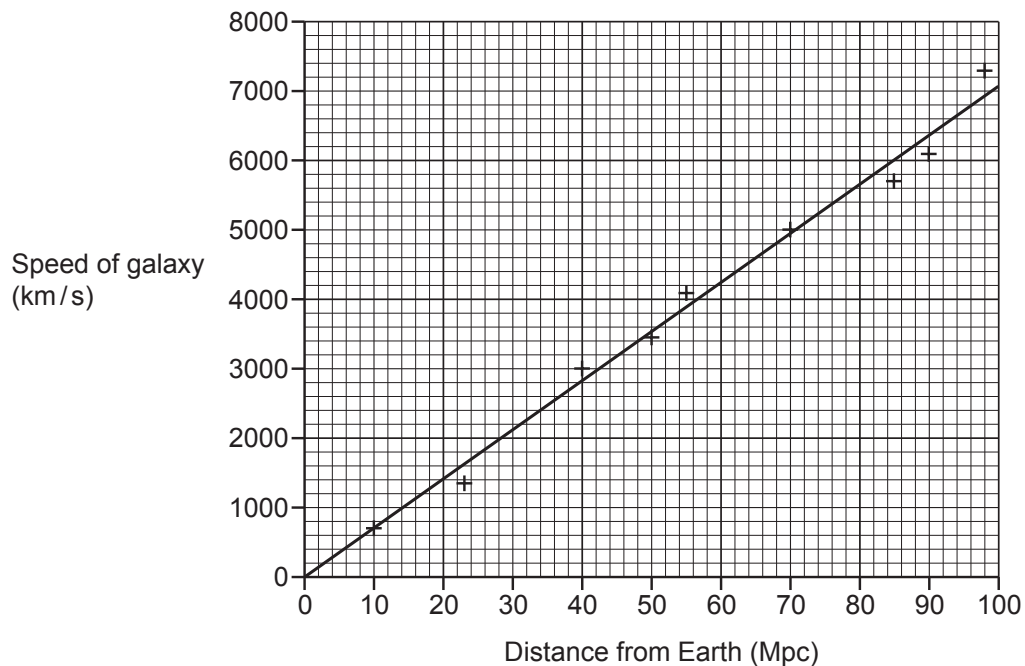
22 Edwin Hubble discovered that all distant galaxies were moving away from the Earth.

(a) Explain how he could tell that all distant galaxies were moving away from the Earth.

.....

 [2]

(b) This graph shows how the speed of a galaxy changes with distance from the Earth.



(i) Use data from the graph to show that the speed of the galaxy is proportional to the distance from the Earth.

.....

 [2]

(ii) Explain how data from the graph provides evidence for the Big-Bang.

.....

 [1]

- (c) Before Edwin Hubble could publish his results, his work was peer reviewed.

Suggest why peer review is important.

.....
..... [1]

- (d) The parsec (pc) is a unit used for measuring large distances in the Universe.

- (i) A galaxy is at a distance of 82 Mpc from the Earth.

Use the graph to determine the speed of this galaxy.

Give your answer in metres per second (m/s).

Speed = ... m/s [2]

- (ii) Calculate the time it takes for the galaxy to travel 2.53×10^{24} m.

Use your answer to **22(d)(i)** to help you.

Time = ... s [3]



MARK SCHEMES

official Pearson Edexcel mark schemes



Question				Answer	Marks	AO element	Guidance
9				D ✓	1	1.2	



Question				Answer	Marks	AO element	Guidance
14				C ✓	1	2.2	



Question				Answer	Marks	AO element	Guidance
14				C ✓	1	2.1	



Question			Answer	Marks	AO element	Guidance
15			A ✓	1	2.2	



Question	Answer	Marks	AO element	Guidance
8	B	1	2.2	



Question	Answer	Marks	AO element	Guidance
3	C	1	1.1	



Question	Answer	Marks	AO element	Guidance
5	B	1	1.2	



21	(a)	(i)	Area (under line) for thinking (distance) is same as for braking (distance) / area under horizontal line = area under diagonal line / area of rectangle = area of triangle / AW ✓	1	3.1a	ALLOW both areas show 4(m)
		(ii)	A line starting at (0.75, 8) ✓ Diagonal line drawn parallel to original line and finishing at the x axis ✓	2	2×1.2	Mark independently
	(b)	(i)	(Idea of measuring) a length/distance on the ruler ✓	1	1.2	
		(ii)	Any one from: drop ruler from same height above hand ✓ (idea of) change the time taken before dropping the ruler each time ✓ make sure hand of catcher not moving / fingers are the same distance apart ✓	1	1.2	ALLOW suitable answers that refer to reducing named random or systematic errors e.g. measure from same place on the ruler (relative to hand) ALLOW (idea of driver Q being) unaware of when ruler is being dropped ALLOW repeat and calculate mean
	(c)	(i)	(Store of) KE (in moving car) ✓ (transferred thermally) to (store of) thermal energy / heat (in brakes/pads/discs/tyres) ✓	2	2×2.1	
		(ii)	Any one from: (Idea of) heat dissipated/transferred (to air) more quickly ✓ KE is reduced more quickly ✓	1	2.1	IGNORE to thermal energy of road/surroundings

22	(a)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 12.0 (s) award 3 marks (time =) change in velocity ÷ acceleration ✓ (time =) $(18 - 0) \div 1.5$ ✓ (time =) 12.0 (s) ✓	3	1 × 1.2 2 × 2.1	ALLOW 12 (s)
	(b)	Any one from: Thinking distance unchanged (by ice) ✓ Stopping distance = thinking distance + braking distance ✓ AND any two from: Friction/force between tyres and road reduced ✓ Initial kinetic energy of van is the same ✓ Since distance = work done ÷ force (or energy ÷ force) ✓ Braking distance becomes greater / stopping distance is greater ✓	3	1.1 2 × 2.1	
	(c)	Any two from: Acceleration will increase ✓ Force = mass × acceleration ✓ So greater force (acting on occupants) ✓ And this could lead to injury (of occupants of the van) ✓	2	2 × 2.1	ALLOW Higher ideas about momentum ALLOW Rate of change of momentum is greater ✓ ALLOW Force = rate of change of momentum ✓

20	(a)	First check the answer on the answer line If answer = 15 (m / s) award 3 marks Evidence for use of area under line / distance = area under (v-t) graph ✓ $30 = \frac{1}{2} \times u \times 4$ OR $u = 2 \times 30 \div 4$ ✓ (u =) 15 (m / s) ✓	3	3 × 2.2	ALLOW e.g. $5u \div 2$ OR $0.5 \times b \times h$ ALLOW evidence seen on graph ALLOW use of higher level answers using SUVAT equations of motion e.g. $s = (u + v)t \div 2$
	(b)	(i) First check the answer on the answer line If answer = 27 (m) award 3 marks Select and rearrange: (distance =) final velocity² – initial velocity² ÷ 2 × acceleration OR $(s =) v^2 - u^2 \div 2 \times a$ ✓ Substitution: $(s =) -18^2 \div -12$ OR $18^2 \div 12$ OR $324 \div 12$ ✓ (s =) 27 (m) ✓	3	1.2 2 × 2.1	ALLOW correct substitution into unrearranged equation for 1 mark e.g. $0 - 18^2 = 2 \times -6 \times s$ OR $18^2 - 0 = 2 \times 6 \times s$ ALLOW d for s ALLOW -27 (m) ALLOW other correct use of SUVAT equations of motion

Question	Answer	Marks	AO element	Guidance
	(ii) First check the answer on the answer line If answer = 2400 – 21 000 (N) award 3 marks Estimation of mass of car = 1500 (kg) ✓ (F =) 1500×6 ✓ (F =) 9000 (N) ✓	3	1.1 2 × 2.1	ALLOW 2 marks for force correctly calculated if mass is outside of range ALLOW 400 - 3500 (kg) ALLOW candidate's mass estimate × 6 for 1 mark ALLOW candidate's mass estimate × 6 correctly calculated for 2 marks
	(iii) Any two from: Skid mark may not have clear start or end ✓ Skid mark may be curved / difficult to measure ✓ (Idea that) car may not have produced a skid for whole of braking (distance) / AW ✓ (Idea that) skid mark only occurs when the wheels stop turning ✓	2	2 × 3.2a	ALLOW skid marks don't appear as soon as braking starts / deceleration is not always large enough to produce skids marks

17	(a)	As speed increases, (thinking) distance increases / OR A ✓ BUT (thinking) distance is (directly) proportional to speed / as speed doubles, (thinking) distance doubles / linear relationship through the origin ✓ ✓	2	3.1a 3.2b	ALLOW numerical values from graph, e.g. at 15 (m/s), td = 10m but at 30 (m/s) td = 20(m). ALLOW numerical values from graph, e.g. at 15 (m/s), td = 10 (m) but at 30 (m/s) td = 2×10 = 20 (m) for 2 marks
	(b) (i)	16 (m) ✓	1	3.1a	
	(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.67 (s) award 3 marks Rearrangement to give Time = distance / speed ✓ Time = 16 / 24 ✓ Time = 0.67 (s) (2 decimal places) ✓	3	1.2 2.1 2.1	ALLOW ECF from (b)(i) ALLOW 0.6 or 0.7 or 0.66(6...) (s) for 2 marks ALLOW one mark for any calculated answer to 2dp
	(c) (i)	(Driver under influence of) alcohol / drugs / tired / (named) distraction / ill / <u>old</u> -age / intoxication / high(er) speed ✓	1	1.1	IGNORE just age ALLOW increase in driver's reaction time
	(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 26 (m) award 2 marks (Stopping distance =) braking (distance) + thinking (distance) OR 16 OR 10 ✓ (sd =) 26 (m) ✓	2	2×2.2	

Question	Answer	Marks	AO element	Guidance
(d)	Maximum 2 marks from: Higher speed increases braking distance ✓ BUT Double speed quadruples braking distance / braking distance is (directly) proportional to the speed squared AW ✓ ✓ Maximum 2 marks from: (Idea that) higher speed (car has) more KE ✓ BUT Double speed quadruples KE / KE is (directly) proportional to the speed squared / AW ✓ ✓	3	2.1 3.1a x2 2.1 3.1a x2	ALLOW numerical values from graph, e.g. at 10 (m/s), bd = 7.5 (m) but at 20 (m/s) bd = 30 (m). ALLOW numerical values from graph, e.g. at 10 (m/s), bd = 7.5 (m) but at 20 (m/s) bd = 4×7.5 (= 30m) for 2 marks



20	a		F ✓	1	3.3a	
	b		E ✓ FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 0.6 (s) award 2 marks 5 ÷ 8 ✓ =0.6 (s) ✓	3	3.1a 1.2 2.2	ALLOW 0.625 or 0.63 (s)
	c		Any two from: A, C or D ✓ Thinking distance / reaction time is proportional to speed / AW ✓	2	3.2b 3.2b	ALLOW as speed doubles, thinking distance doubles / ratio of speed:distance or distance:speed is the same / both have reaction time of 0.75 (s)
	d	i	recall of correct equation, $KE = \frac{1}{2} mv^2$ ✓ $\frac{1}{2} \times 1200 \times 32 \times 32 = 614\,000$ ✓	2	1 x 2.1 1 x 1.2	
		ii	KE transferred to thermal energy / heat in brakes / surroundings / AW ✓ ✓ OR (KE of car) is reduced / transferred ✓ Brakes gain / absorb thermal energy / heat ✓	2	1.1 1.2	ALLOW surroundings gain thermal energy / heat dissipated to surroundings IGNORE just brakes get hot

Question			Answer	Marks	AO element	Guidance
		iii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 6396N then ✓ ✓ ✓ force = work done × distance or force = work done / distance ✓ = 614000/96 or 614400/96 ✓ If answer is incorrect or incomplete, then 6395 or 6395.8333333 etc. ✓ ✓ If answer is incorrect or incomplete then or 614 000 ÷ 96 ✓	3	2 x 2.1 1.2	
	e		(The thinking distance will) stay the same (The braking distance will) decrease (The stopping distance will) decrease All three correct ✓ ✓ Two correct ✓	2	3.2a 3.2a	

Question			Answer	Marks	AO element	Guidance
7			A ✓	1	1.1	



18*	Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) Detailed evaluation of the advantages and disadvantages of wind power AND Analysis of Fig. 18.1 and Fig. 18.2 AND An attempt to give a conclusion about the use of wind power <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Evaluation of the advantages and disadvantages of wind power AND Analysis of Fig. 18.1 and Fig. 18.2 OR Evaluation of the advantages and disadvantages of wind power AND An attempt to give a conclusion about the use of wind power OR Analysis of Fig. 18.1 and Fig. 18.2 AND An attempt to give a conclusion about the use of wind power	6	2 × 1.1 2 × 3.1a 3 × 3.2b AO1.1 Demonstrates knowledge and understanding of advantages and disadvantages of wind power Advantages • Wind is renewable • Does not create greenhouse gases (CO₂) • Does not contribute to global warming/climate change • Cheap to run (once built) • Less fossil fuels used Disadvantages • Unreliable – when wind drops so does power output / turbines switched off if it is too windy • Takes up lots of land • Some people think they are unsightly/noisy • Expensive to build AO3.1a Analyses information by interpreting graphs of power output and use • Wind pattern/power generated does not follow demand • Power generation is (always) below that of demand • Demand peaks at 17.00, lowest at ~5.00 • Peak demand is ~48000MW or Lowest demand is ~27000MW • Greatest power generation is ~11000MW or lowest power generation is ~5300MW • Power generation fluctuates
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Question	Answer	Marks	AO element	Guidance
	<i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) Evaluation of the advantages or disadvantages of wind power OR Analysis of Fig. 18.1 or Fig. 18.2 OR An attempt to give a basic conclusion about the use of wind power <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks <i>No response or no response worthy of credit.</i>			AO3.2b Analyses information to draw conclusions about use of wind power • Current wind power cannot meet the demand for the UK • To meet the demand lots more wind turbines need to be built • Even more land/sea will be taken up with wind turbines • Expensive to build as so many wind turbines required • There will still be some days when wind cannot meet the demand requirements • There will need to be other power generation systems (examples given) • We need to be able to store the energy generated

19	(a)	First check the answer on the answer line If answer = 7 (%) award 2 marks (% system margin $\Rightarrow$) $(64.2 - 60.0) \div 60.0 \times 100$ ✓ (% system margin $\Rightarrow$) 7 (%) ✓	2	2 × 2.1	
	(b) (i)	Any two from: (Idea that) demand may change ✓ (Idea that) supply (capacity) may change ✓ Weather may change / may be warmer or colder than expected ✓	2	2 × 3.2a	ALLOW don't know the exact demand / customers may use more or less electricity/heating (than predicted) ALLOW don't know the exact supply (capacity) ALLOW wind speed will change IGNORE seasons change
	(ii)	First check the answer on the answer line If answer = 35 (%) award 2 marks (% uncertainty $\Rightarrow$) $0.5 \times (6.2 - 3.0) \div 4.6 \times 100$ ✓ (% uncertainty $\Rightarrow$) 35 (%) ✓	2	2 × 3.3b	ALLOW answers that round to 35 (%)
	(c) (i)	(Idea that) demand may be greater than supply / possibility of power cuts / may not be able to supply enough electricity (to customers) / AW ✓	1	3.2b	
	(ii)	First check the answer on the answer line If answer = 5.68 award 2 marks 4.5×0.04 OR 0.18 OR 4.5×1.04 OR 4.68 ✓ 5.68 ✓	2	2 × 2.2	ALLOW 5.7



17	(a)	(i)	2 or 3 correctly plotted points to within $\frac{1}{2}$ small square ✓ 4 points correctly plotted to within $\frac{1}{2}$ small square ✓ Smooth curved line of best fit through most points ✓	3	3 × 2.2	DO NOT ALLOW a straight line of best fit ALLOW ECF from incorrectly plotted points
		(ii)	Candidate's line of best fit extended to 2.00 AND their value of p.d. is correct for their graph ✓ Value of p.d. = 2.55 – 2.70 ✓	2	2 × 3.2b	IGNORE line of best fit past 2.00
		(iii)	Any one from: Repeat readings and calculate the mean/discard anomalies ✓ Carry out investigation in the dark / reduce ambient light ✓ Use a greater range / more values of light intensity ✓ Use higher light intensities ✓ Use a light meter to check light intensity ✓	1	3.3b	
	(b)	(i)	Any two from: To reduce energy bills / sell electricity (back to national grid) ✓ People are more aware of environmental issues / they are better for the environment ✓ To reduce reliance on/use of fossil fuels / fossil fuels are running out ✓ To reduce CO ₂ / greenhouse emissions / global warming ✓ They are cheaper (than 20 years ago) ✓ The government has encouraged people to install them / grants available to fit them ✓ More efficient / better/newer panels/technologies are now available ✓	2	2 × 3.2a	IGNORE people are more environmentally friendly/green. ALLOW they use a renewable energy resource IGNORE they weren't available twenty years ago.

Question			Answer	Marks	AO element	Guidance
17		(ii)	Maximum two from: (24 ÷ 1.6 =) 15 panels ✓ (15 × 26 =) 390 MJ / maximum energy he could generate > energy required / maximum energy is 26 MJ greater ✓ OR (364 ÷ 26 =) 14 panels ✓ (14 × 1.6 =) 22.4 m ² / area of panels required < area of roof / area of panels is 1.6 m ² greater ✓ And any one from: When it is night/cloudy/dark/sun not at highest point energy output would/could be too low ✓ Would need (batteries) to store energy / to obtain energy at night / may need back-up power/generator ✓ Amount of energy generated can change with weather/seasons so may be less ✓	3	3 × 3.1b	ALLOW 390 MJ / maximum energy is 26 MJ greater for 2 marks ALLOW 22.4 m ² / area of panels is 1.6 m ² greater for 2 marks



17	(a)	Contaminated because radioactive material touched the workers / was breathed in ✓ Irradiated because workers were exposed to radiation (from outside of the body) ✓	2	2 × 1.1	ALLOW it is in contact with (workers) / went on/inside them DO NOT ALLOW answers which also include ideas about irradiation e.g. radiation touches the workers/is inhaled ALLOW in presence of radiation/radiation passes into body DO NOT ALLOW answers which also include ideas about contamination
	(b)	Nuclear ✓ → Thermal ✓ → Kinetic ✓	3	3 × 2.1	IGNORE heat
	(c) (i)	(It takes) 30 years / (average) time taken for number of (un-decayed or unstable) nuclei to halve / for activity to halve / for count rate to halve / for mass of undecayed nuclei to halve ✓	1	1.1	ALLOW atoms for nuclei ALLOW mass (of it/caesium) to halve / half of it/substance to decay IGNORE reactivity / time taken for a nucleus to halve
	(ii)	Radioactive decay is a random process. ☒ When a nucleus decays, it splits in half. ☐ With large numbers, it is easier to count half of the nuclei. ☐ ✓	1	1.1	
	(iii)	First check the answer on the answer line If answer = 3.5 (kg) award 2 marks (idea that 90 years =) 3 (half-lives) ✓ (mass = $28 \times (\frac{1}{2})^3$) 3.5 (kg) ✓	2	2 × 2.2	ALLOW evidence of 3 half-lives e.g. 28 → 14 → 7 → 3.5
	(d)	$\begin{array}{c} {}^{238}_{94}\text{Pu} \rightarrow {}^{234}_{92}\text{U} + {}^4_2\text{He} \\ {}^9_4\text{Be} + {}^4_2\text{He} \rightarrow {}^{12}_6\text{C} + {}^1_0\text{n} \end{array}$ Correct mass for U ✓ Correct atomic number for U ✓ Correct mass and atomic number for n ✓	3	3 × 2.2	

16	a	i	5.2 (billion tonnes oil equivalent) ✓	1	3.1a	ALLOW answers between 5.0 and 5.5 IGNORE wrong units
		ii	Oil ✓	1	3.1a	
		iii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 78 (%) award 2 marks 8.3 / 10.6 (x 100) ✓ =78 (%) ✓	2	2 x 3.1a	ALLOW answers that round between 77(%) and 80(%) ✓✓ ALLOW 8.2 / 10.6 (x 100) OR 8.4 / 10.6 (x 100) OR 8.5 / 10.6 (x 100) OR answers that round between 0.77 and 0.80
	b	i	Fossil fuel may run out / is non-renewable / be in short supply / become very costly ✓ Named damage to environment: Eg (increased) greenhouse gases / global warming / sea levels rise / carbon dioxide / climate change / acid rain ✓	2	3.1b 3.1b	ALLOW being used faster than being produced / finite resource ALLOW ice caps melting / droughts and storms / more polluting gases / other named polluting gases e.g. SO ₂ / carbon emissions IGNORE just pollution or bad for the environment / more CFCs
		ii	To meet demand for electricity / not enough energy from renewable resources ✓ Less named damage to environment: (decreased) greenhouse gases / global warming / sea levels may fall / carbon dioxide / climate change / acid rain / ORA for coal ✓	2	1.2 1.2	ALLOW will not run out as fast (as coal) / to preserve fossil fuels / produces more energy (per kg than coal) ALLOW less polluting gases / carbon emissions / ice caps melting / droughts and storms IGNORE just less pollution or just better for the environment / less CFCs
	c	i	Step-up transformer ✓	1	1.1	

Question			Answer	Marks	AO element	Guidance
		ii	Reduce energy wastage / loss ✓	1	1.1	ALLOW less heat loss / reduce current / reduce power loss / more useful power out / more efficient / less heating of wires DO NOT ALLOW no energy losses / prevent energy loss / AW
		iii	d.c – (current / voltage / charge flow / it) has one direction or polarity ✓ a.c.- (current / voltage / charge flow / it) (continually) changes direction or polarity ✓	2	1.1 1.1	ALLOW dc only positive / only negative IGNORE electricity ALLOW current / voltage alternates OR positive and negative
	d	i	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 2.8 (kW) award 4 marks (P =) I ² x R ✓ 11 x 11 x 23 or 11 ² x 23 or 121 x 23 ✓ = 2783 ✓ Conversion to kW = 2.8 ✓	4	 1.2 2.1 2.1 2.1	ALLOW 2.78 kW or 2.783 kW ✓✓✓✓ ALLOW equation in any form ALLOW ECF candidates answer to 3 rd marking point converted to kW
		ii	Wind speed varies / AW ✓	1	2.1	ALLOW it depends on the strength of the wind / how windy it is / AW IGNORE there might not be any wind / wind changes direction / AW
		iii	(Idea of) not always enough wind / demand may exceed supply / AW ✓	1	2.1	ALLOW (it) may not generate enough power / energy / AW

Question	Answer	Marks	AO element	Guidance
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21	(a)	(i)	1 Not enough wind/force/energy/speed to turn the turbine ✓ 2 (Speed too high so) could damage the turbine / turbine is shut down to stop damage/for safety reasons ✓	2	2 × 3.2a	ALLOW turbine does not turn ALLOW idea of (the turbine/it) being damaged/broken
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 4.3 (MJ) award 5 marks (Useful output energy transfer per second =) 1.5 (MJ) ✓ Efficiency = Useful output energy transfer ÷ Input energy transfer ✓ (Input energy transfer =) $1.5 \div 0.35$ ✓ (Input energy transfer =) 4.2857... ✓ (Input energy transfer =) 4.3 (MJ) ✓	5	2.2 1.2 2 × 2.1 1.2	ALLOW equation in any form ALLOW 4.2857... × 10 ⁶ or 4.3 × 10 ⁶ for 4 marks ALLOW an incorrect answer rounded to 2 sig. fig. for this mark
	(b)	(i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 7.7×10^{17} (J) award 2 marks 215 (TWh) from graph ✓ ($215 \times 3.6 \times 10^{15}$ =) 7.7×10^{17} (J) ✓	2	2 × 1.2	ALLOW 210 – 220 (TWh) from graph ALLOW 1 mark for any correct conversion into J e.g. $210 \times 3.6 \times 10^{15} = 7.6 \times 10^{17}$ (J) $220 \times 3.6 \times 10^{15} = 7.9 \times 10^{17}$ (J) IGNORE answer not in standard form

Question			Answer	Marks	AO element	Guidance
21	(b)	(ii)	Any two from: More wind turbines have been built ✓ Modern turbines have a better design / are more efficient ✓ (wind turbines) do not produce air pollution/harmful gases/ carbon dioxide/greenhouse gases / do not contribute to global warming/greenhouse effect/climate change ✓ (idea that wind turbines) conserve/reduce use of fossil fuels ✓ (Idea of) renewable energy ✓ (wind turbines) have low fuel/running costs once set up ✓	2	2 × 1.1	IGNORE increased demand ALLOW better technology IGNORE no pollution / better for the environment unless qualified IGNORE sustainable ALLOW reduce use of finite resources / fossil fuels are running out ALLOW high cost of fossil fuels
	(c)	(i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 70 (A) award 2 marks Rearrangement: Current in secondary coil = current in primary coil × potential difference across primary coil ÷ potential difference across secondary coil OR $2800 \times 900 \div 36000$ ✓ (Current in secondary coil =) 70 (A) ✓	2	2 × 2.1	ALLOW rearranged equation in symbols or numbers

Question			Answer	Marks	AO element	Guidance
21	(c)	(ii)	Any three from: It is a <u>step-up</u> transformer / to increase p.d. ✓ Decrease current (in power lines) ✓ less energy wasted/lost / less heat in power lines / less thermal transfer ✓ (idea that) power loss depends on current² ✓	3	3 × 1.1	ALLOW voltage ALLOW ORA for high current IGNORE just ideas about efficiency DO NOT ALLOW so no power wasted / no energy wasted (as heat in power lines) / no thermal transfer IGNORE less power loss
		(iii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.25 (Ω) award 3 marks Rearrangement: resistance = power ÷ (current)² ✓ (Resistance =) 864 900 ÷ 1860² or 864 900 ÷ 3 459 600 ✓ (Resistance =) 0.25 (Ω) ✓	3	1 × 1.2 2 × 2.1	Allow ¼ (Ω)



Question				Answer	Marks	AO element	Guidance
8				D ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
12				C ✓	1	2.1	



Question				Answer	Marks	AO element	Guidance
13				C ✓	1	1.1	



Question			Answer	Marks	AO element	Guidance
9			B ✓	1	1.1	



Question			Answer	Marks	AO element	Guidance
11			C ✓	1	1.1	



Question			Answer	Marks	AO element	Guidance
12			B ✓	1	2.1	



Question			Answer	Marks	AO element	Guidance
6			A ✓	1	1.1	



Question			Answer	Marks	AO element	Guidance
14			A ✓	1	1.1	



Question			Answer	Marks	AO element	Guidance
15			A ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
1				A ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
8				C ✓	1	1.1	



Question	Answer	Marks	AO element	Guidance
14	A	1	1.1	



Question	Answer	Marks	AO element	Guidance
11	A	1	2.1	



Question	Answer	Marks	AO element	Guidance
13	C	1	1.1	



15	D	1	2.1	
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19	(a)	(i)	Neutron(s) ✓	1	1.1	IGNORE gamma
		(ii)	Any one from: Gravity ✓ (very) high temperatures ✓ high pressure ✓	1	1.1	ALLOW (high) gravitational field strength ALLOW hot (temperatures) / lots of heat IGNORE just heat
	(b)	(i)	Any one from: Both produce energy ✓ Both convert mass to energy / have a “loss” in mass ✓ Both produce neutrons ✓	1	1.1	
		(ii)	Any one from: In fusion nuclei join / in fission nuclei split/decay/break up / AW ✓ fusion occurs at higher temperatures or pressures / fission occurs at lower temperatures or pressures ✓ larger/heavier nucleus forms in fusion / smaller/lighter/daughter nuclei forms in fission ✓ more energy released in fusion / less energy released in fission ✓ fission causes a chain reaction / fusion does not cause a chain reaction ✓ fusion does not produce (radioactive) waste / fission does produce radioactive waste ✓	1	1.1	ALLOW atom IGNORE molecules / particles / ions ALLOW only fission reactors are used at present to produce electricity

Question	Answer	Marks	AO element	Guidance
(c)	Advantage - Any one from: no carbon dioxide produced / does not contribute to global warming/climate change/acid rain / no polluting gases ✓ small quantities of fuel needed / (idea of) more energy per unit mass ✓ fuel readily available ✓ will not run out as fast (as fossil fuels) ✓ to preserve fossil fuels ✓ Disadvantage - Any one from: Radioactive/nuclear waste produced ✓ security of transport of fuel / waste ✓ expensive to build ✓ danger of exposure to radiation ✓ decommissioning is expensive ✓ risk of accident (and after-effects)/uncontrollable (chain reaction) ✓ non-renewable ✓	2	2×1.1	ALLOW a named polluting gas IGNORE (idea of) ozone layer ALLOW (idea of) risk from terrorists ALLOW (idea of) explosion IGNORE just dangerous



19	(a)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 260 (s) award 4 marks (time =) distance ÷ speed ✓ distance = $(2.28 \times 10^{11} - 1.50 \times 10^{11}) = 7.8 \times 10^{10}$ (m) ✓ (time =) $7.8 \times 10^{10} \div 300\,000\,000$ ✓ (time =) 260 (s) ✓	4	1.2 3 × 2.1	ALLOW 0.8×10^{11} (m)
	(b)	(Mars is further from the Sun) so receives less energy/heat from the Sun/sunlight ✓ Temperature on Mars is lower ✓	2	2 × 3.2b	ALLOW other sensible explanation. e.g. Mars has a thin atmosphere / does not have an atmosphere so there is little/no greenhouse effect (AW) ALLOW it is difficult to know without knowing about the atmosphere on Mars



22	(a)	Any three from: (Speed is constant because) (resultant) force is perpendicular to direction of motion / (resultant) force is a centripetal force / there is no displacement in direction of force ✓ No work is done on the planet ✓ (Velocity is changing because) the direction is changing ✓ (Resultant force) provided by gravitational pull of the sun (causes the direction of motion to change) ✓ (So) planet is accelerating ✓	3	3 × 1.1	ALLOW (resultant) force is always towards the Sun/centre of circle ALLOW velocity is a vector and speed is a scalar ALLOW force provided by the gravity of the Sun
	(b) (i)	Smaller radius or closer to the Sun means larger (gravitational/centripetal) force/pull ✓ (smaller radius or closer to Sun or larger gravitational/centripetal force means) larger acceleration/speed ✓ OR Closer orbits have a lower GPE ✓ (closer orbits have) higher KE ✓	2	2 × 1.1	ALLOW ORA in each case ALLOW smaller radius means more gravity

Question	Answer	Marks	AO element	Guidance
22 (b) (ii)	Any two from: (A statement explaining that if proportional, you would expect:) e.g. $T = kr$ OR $T \div r = k$ OR $T_A \div r_A = T_B \div r_B$ OR $r_A \div T_A = r_B \div T_B$ OR $T_A \div T_B = r_A \div r_B$ OR $T_B \div T_A = r_B \div r_A$ / ORA ✓ Correct calculation of k or ratio of variables ✓ (Idea that) planet A is (approximately) double the radius of B but (approximately) triple the time (to orbit the Sun) ✓ BUT Statement (comparing two correctly calculated values) showing values are not equal or k is not constant ✓✓ Correct calculation of k from planet A (or B) and used to show that this k does not give correct value for the other planet ✓✓	2	2 × 3.1b	ALLOW all numbers substituted correctly in any version for 2 marks. e.g. $k = T_A \div r_A = 1.88 \div 2.28 \times 10^{11} = 8.25 \times 10^{-12}$ $k = T_B \div r_B = 0.62 \div 1.08 \times 10^{11} = 5.74 \times 10^{-12}$ e.g. $T_A \div r_A = 8.25 \times 10^{-12} \neq T_B \div r_B = 5.74 \times 10^{-12}$ $r_A \div T_A = 1.21 \times 10^{11} \neq T_B \div r_B = 1.74 \times 10^{11}$ $T_A \div T_B = 3.03 \neq r_A \div r_B = 2.11$ $T_B \div T_A = 0.330 \neq r_B \div r_A = 0.474$

19	(a)	(i)	Arrow with direction vertically upwards ✓ Arrow from lowest energy level to highest energy level ✓	2	2 × 2.1	ALLOW to above the highest energy level
		(ii)	Excited and absorbed ✓ Higher than ✓	2	2 × 1.1	BOTH required for first mark
	(b)		Any four from: (Both lines show) redshift ✓ Redshift for galaxy B > redshift for galaxy A / ORA ✓ (Redshift means that) galaxy/galaxies are moving away (from the Earth) ✓ Galaxy B is further away (from the Earth than galaxy A) / ORA ✓ Galaxy B is moving faster (than galaxy A) / ORA ✓ Galaxy B is moving away from galaxy A ✓	4	3.1a 3.1a 1.1 3.2b	ALLOW galaxy with longest wavelength for galaxy B throughout answer DO NOT ALLOW one galaxy moving towards (the Earth) ALLOW the more distant galaxy is moving faster / ORA ALLOW galaxy B is moving away faster (than galaxy A) / ORA for 2 marks (mp3 and mp5)

18	(a)	(i)	gravitational (force/pull) ✓	1	1.1	ALLOW gravity/weight IGNORE centripetal / gravitational potential
		(ii)	(Straight) arrow pointing from telescope to Sun ✓	1	2.1	
	(b)		Telescope constantly changes direction ✓ (so) velocity changes ✓	2	2.1 1.1	ALLOW acceleration/velocity is a vector / acceleration/velocity has magnitude and direction IGNORE velocity increases/decreases
	(c)		Any one from: (Idea of) remaining in contact with the (scientists on) Earth at all times (because signal is strong enough) ✓ (Idea of) short communication time between satellite and the Earth ✓ (Idea of) accessibility for maintenance of the satellite ✓	1	2.1	ALLOW (idea of) signal doesn't become (too) weak
	(d)		Radiation received by the satellite does not need to pass through the Earth's atmosphere / ORA ✓	1	1.1	ALLOW avoids interference from the Earth's atmosphere/other sources (of EM radiation) on the Earth ALLOW clearer signal ALLOW some wavelengths cannot pass through atmosphere / some wavelengths are absorbed by the atmosphere
	(e)		X has a faster speed / ORA ✓ Force (of gravity from Sun) stronger on X / ORA ✓	2	2 × 2.1	IGNORE reference to smaller radius/circumference.

21	(a)	First check the answer on the answer line If answer = 4.6×10^{20} award 2 marks (number =) $1.3 \times 10^9 \div 2.8 \times 10^{-12}$ ✓ evaluation: (number =) 4.6×10^{20} ✓	2	2 × 2.2	ALLOW $4.642857143 \times 10^{20}$ to at least 2 significant figures correctly rounded or truncated Alternative method: time/t (for 1 reaction) = $2.8 \times 10^{-12} \div 1.3 \times 10^9$ (= 2.15×10^{-21}) evaluation: (number = $1 \div$ time =) 4.6×10^{20}
	(b)*	Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) Detailed description of differences between fission and fusion reactions AND Detailed comparison of the benefits and difficulties of using fusion <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Clear description of differences between fission and fusion reactions AND Clear comparison of the benefits and difficulties of using fusion OR	6	3 × 1.1 1 × 3.1a 2 × 3.2b	AO1.1– Demonstrate knowledge and understanding of differences between fission and fusion reactions - fission is splitting (of nucleus) / produces lighter nuclei - fusion is combining (nuclei) / produces heavier/helium nuclei - fission is splitting heavy/uranium nucleus into lighter nuclei (and neutrons) - fusion is combining lighter/hydrogen nuclei into heavier/helium nuclei (description of) chain reactions occur in fission (and have to be controlled) - fusion requires high temperature and pressure AO3.1a– Analyse information from the table to suggest benefits of nuclear fusion - Nuclear fusion power station will (likely) output (1.3 times) more power / ORA

Question	Answer	Marks	AO element	Guidance
	Detailed description of differences between fission and fusion reactions AND Basic comparison of the benefits and difficulties of using fusion OR Basic description of differences between fission and fusion reactions AND Detailed comparison of the benefits and difficulties of using fusion <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) Basic description of a difference between fission and fusion reactions OR Basic comparison of the benefits and difficulties of using fusion from the table. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks No response or no response worthy of credit.			- Fission waste products are more radioactive / ORA - Fission waste products have a longer half-life / ORA AO3.2b– Analyse information from the table and from knowledge to draw conclusions about the benefits and difficulties of using fission and fusion (Fusion power station will (likely) output more power) so fewer needed / can be smaller / don't need to use other resources / ORA (Fission waste products have a longer half-life) so they stay dangerous for longer / have to be stored / ORA - Fission reactors pose a safety risk so reactions have to be controlled - Fusion needs high temperature and pressure (to maintain reactions), which is difficult to produce on the Earth - Uranium is non-renewable and hydrogen is renewable/more easily obtained



20	(a)	Any three from: (Formed by clouds of) dust/gas ✓ Drawn together by gravitational force ✓ Gravitational potential energy transferred to kinetic energy ✓ The core becomes very hot/dense ✓ A protostar forms ✓ (Nuclear) fusion began ✓	3	3 × 1.1	ALLOW nebula / formed from hydrogen ALLOW gravity for gravitational force ALLOW nuclei start to fuse
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Question	Answer	Marks	AO element	Guidance
20 (b) *	Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) Detailed descriptions of fission and fusion AND Detailed explanation of why power stations use nuclear fission <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Detailed description of fission or fusion AND Clear explanation of why power stations use nuclear fission OR Clear description of fission and fusion AND Clear explanation of why power stations use nuclear fission OR Clear description of fission or fusion AND Detailed explanation of why power stations use nuclear fission <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i>	6	4 × 1.1 2 × 3.2a	AO1.1 – Demonstrates knowledge and understanding of nuclear fission and fusion reactions. - fusion involves joining two lighter/smaller nuclei together into a heavier nucleus to release large amounts of energy - fission involves splitting a heavier/larger nucleus, when hit by a neutron, into two lighter/smaller nuclei to release large amounts of energy - fission releases (2 or 3) neutrons - fusion releases more much energy than fission - fission produces dangerous waste / fusion would not - fission can lead to an uncontrolled chain reaction AO3.2a – Analyses information and ideas to make judgements about nuclear fusion power stations. - there is a range of temperatures over which fusion can occur - the probability of fusion happening is very low at low temperatures/temperatures less than 10 million °C - fusion requires very high temperatures/pressures to occur / ORA for fission - the highest probability of fusion happening is at approximately 1000 million °C - difficult to contain gases/plasma at very high temperatures for fusion
	Level 1 (1–2 marks) Basic description of fission and fusion OR Basic description of fission AND basic explanation of why power stations use nuclear fission OR Basic description of fusion AND basic explanation of why power stations use nuclear fission <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks <i>No response or no response worthy of credit.</i>			- hard to achieve the high temperatures/pressures needed for fusion on the Earth - more energy is required to make fusion work than is produced at present - more expensive to make fusion work - fusion reactors would be safer



22	(a)	(All galaxies) showed <u>red-shift</u> ✓ (Hubble measured the) wavelength/frequency of <u>light</u> (from the galaxy) ✓	2	2 × 1.1	ALLOW (all galaxies) showed <u>light</u> with a longer wavelength/lower frequency for 2 marks
	(b)	(i) Readings of speed taken for two different values of distance ✓ Working to show that the factor increase in speed is the same as distance ✓	2	2 × 3.1a	ALLOW +/- ½ a small square ALLOW a statement for the second mark e.g. as the distance doubles so does the speed. <u>Example:</u> At 20 Mpc, speed = 1400 km/s At 40 Mpc, speed = 2800 km/s $40/20 = 2 = 2800/1400$ ALLOW 1 mark maximum for it is a (straight) line of best fit through the origin (therefore it is proportional)
		(ii) Any one from: The more distant galaxies are travelling faster ✓ The evidence suggests the universe is expanding ✓ The universe was smaller in the past ✓	1	1.1	ALLOW galaxies are moving away from each other

Question	Answer	Marks	AO element	Guidance
(c)	To ensure results are reproducible / check the work is of high enough quality / claims are not false / for new theories to be accepted / to develop theories / AW ✓	1	1.1	ALLOW check validity / for mistakes/anomalies / AW ALLOW check that it's not biased / AW
(d)	(i) FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 5 800 000 (m/s) award 2 marks (Reads off speed from graph =) 5800 (km/s) ✓ Speed = $5800 \times 1000 = 5\,800\,000$ (m/s) ✓	2	2.2 1.2	ALLOW 5.8×10^6 (m/s) ALLOW ecf for their speed from graph x 1000
	(ii) FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 4.36×10^{17} (s) award 3 marks time = distance / speed ✓ (time =) $2.53 \times 10^{24} / 5\,800\,000$ ✓ (time =) 4.36×10^{17} (s) ✓	3	1.2 2.1 2.1	ALLOW ecf from (d)(i) ALLOW 4.4×10^{17} (s) ALLOW equation in any form