

External Assessment 2023

PHYSICAL SCIENCES

PSC315118

Section **A**

Pages: 16

Questions: 5

Information Sheet: 1

Preparation time for this exam: 15 minutes

Suggested working time: 36 minutes

Instructions:

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 - Spare diagrams have been provided at the end of each section. Indicate in the box provided if you have used the spare diagrams.
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- The Physical Sciences Information Sheet can be used throughout the exam.
- All answers must be written in **English**.
- You **must** make sure your answers address the listed criterion.

Marker use	
C4	/ 36

Additional Instructions

- Note: When you are asked to “**show that**”:
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Section E	5	5	36 minutes	36 marks
Totals	25	25	180 minutes (3 hours)	180 marks

Criterion

You **must** make sure your answers address:

- Criterion 4 apply concepts and processes of atomic properties and nuclear reactions.

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Question 1

A simplified model of an atom is given in Figure 1.

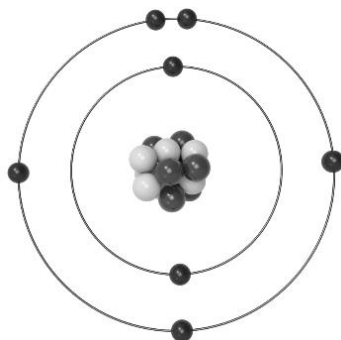


Figure 1: Simplified model of an atom, highlighting the central nucleus and orbiting electrons.

This atomic model shows protons and neutrons in a central nucleus with electrons orbiting in distinct shells.

a) Complete Table 1.

Subatomic particle	Charge
Proton	
Neutron	
Electron	

Table 1

Spare table used (X)

The number of electrons that can exist in each electron shell increases with distance from the nucleus.

b) Complete Table 2.

Electron shell	Maximum number of electrons
1	
2	

Table 2

Spare table used (X)

Question 1 continues

/1

/2

Question 1 continued

Marker use

Electrons orbiting an atomic nucleus travel at very high speeds.

c) Explain why electrons orbit atomic nuclei rather than move away from the nucleus.

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Sulfur is found in group 16 (VI) and period 3 of the periodic table.

d) Give the electron configuration of a neutral sulfur atom.

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Sulfur readily forms the sulfide ion, S²⁻.

e) Give the electron configuration of a sulfide ion.

/1

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f) Identify **two (2)** other ions with the same electron configuration as the sulfide ion, S²⁻.

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g) Explain why atomic radii decrease across period 3.

/2

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**Total
Q1
/10**

Question 2

Gamma radiography is an industrial technique commonly used to analyse **thick** pieces of metal to reveal any internal defects or inconsistencies in thickness.

It works by passing the gamma rays through the metal onto a detector.

The level of exposure is proportional to the number of gamma rays which reach the detector.

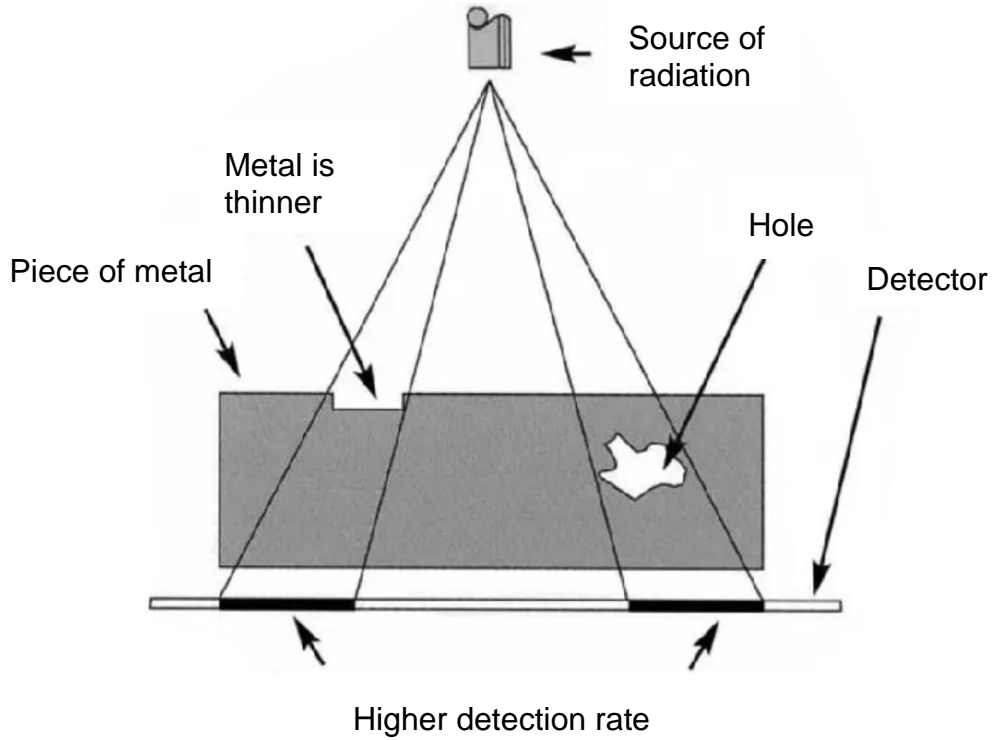


Figure 2: Diagram of the gamma radiography process.

Metastable cobalt-60 is commonly used as an isotope for this process.

a) Write a decay equation for the decay of metastable cobalt-60.

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Question 2 continues

Question 2 continued

Marker use

b) Explain why a proportion of gamma rays are able to pass through thick pieces of metal whilst beta-particles cannot.

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Beta-particles are also emitted by cobalt-60. Their presence does not affect the analysis, but must be considered to provide a safe work environment when conducting this analysis.

c) Outline **two (2)** methods of minimising harm for workers who conduct gamma radiography analysis using cobalt-60.

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The half-life of cobalt-60 is approximately 5.25 years. Sources are effective for gamma radiography if their activity is above 25.0 MBq.

d) A cobalt-60 source has an initial activity of 100.0 MBq. For how many years can it be used?

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Total
Q2
/9

Question 3

Marker use

a) Define the term **isotope**.

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Antimony has two (2) isotopes with abundances as shown in the mass spectrum in Figure 3:

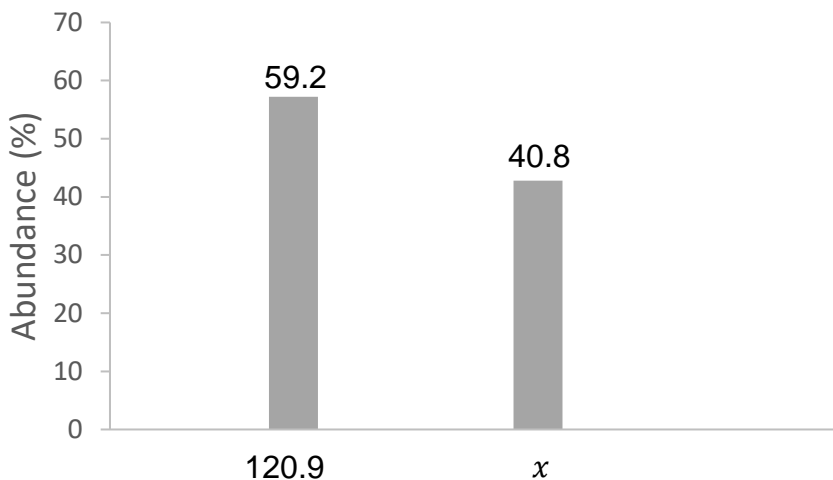


Figure 3: Mass spectrum of isotopes of antimony.

One of the isotopes above, ^{121}Sb , has a relative isotopic mass of 120.9 units.

The relative atomic mass of antimony is 121.8 units.

b) From the information in Figure 3, calculate the relative isotopic mass of the second isotope of antimony to one (1) decimal place.

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Total
Q3
/4

Question 4

Marker use

Plutonium-239 is an artificial radioisotope with a half-life of approximately 24 000 years that decays via alpha emission.

a) Write a decay equation for the alpha decay of plutonium-239.

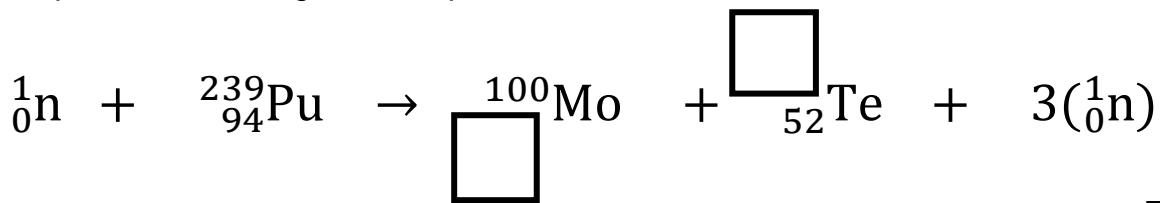
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Plutonium-239 is a radioisotope commonly used in nuclear weapons. When a plutonium-239 nucleus absorbs a neutron it will undergo fission and release a huge amount of energy.

b) Complete the following fission equation:

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Spare equation used (X)

Plutonium-239 also releases energy when it undergoes alpha decay, however, this decay process is not able to create a weapon.

c) Explain why alpha decay of plutonium-239 will not release a huge amount of energy whilst fission of plutonium-239 does.

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**Total
Q4
/6**

Question 5

Marker use

A Geiger counter is used to see how the activity of a sample of iridium-192 changes with time. The count rate vs time is shown in Figure 4.

The half-life of iridium-192 is approximately 73 days and it decays through beta emission.

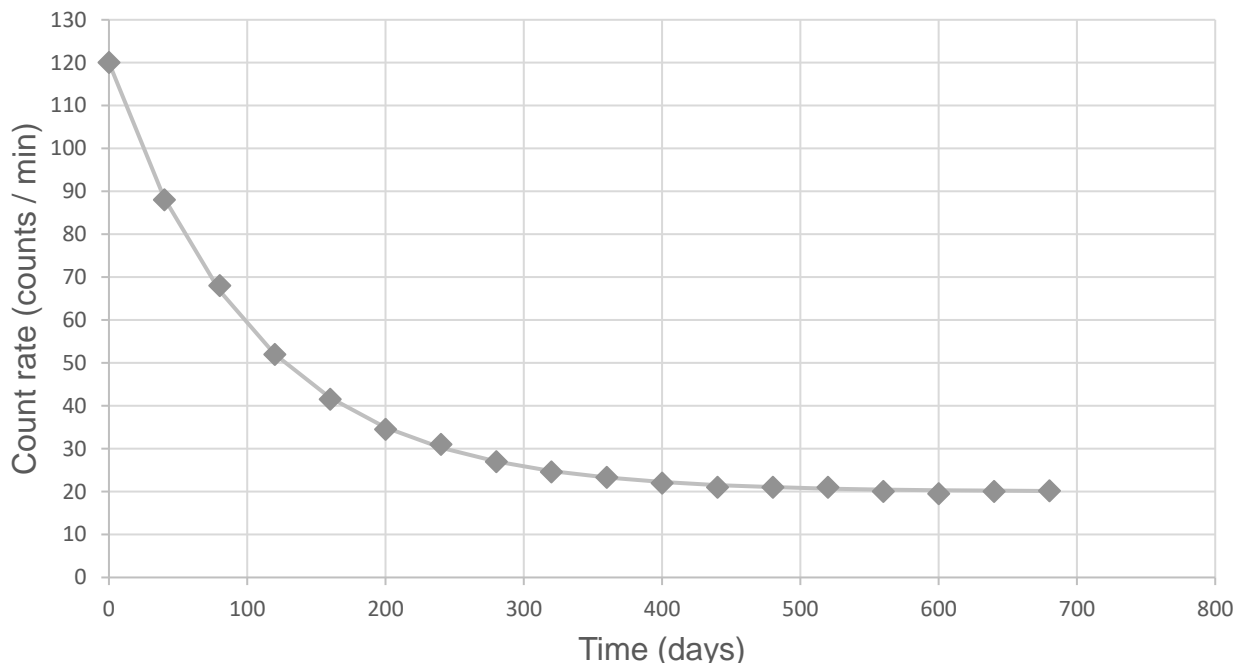


Figure 4: Graph showing decay of iridium-192.

- a) From Figure 4, estimate the amount of background radiation present during the analysis.

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- b) Write a decay equation for the beta decay of iridium-192.

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This graph of count rate vs time was measured from a sample of iridium of mass 24.0 ng.

- c) What was the mass of the sample when it was weighed after the 700 days?

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Question 5 continues

Question 5 continued

Another sample of iridium-192 was analysed at the same location. This sample had a mass of 12.0 ng.

d) On the axes (Figure 5) plot a decay curve for this sample over the same timeframe.

Space is provided below for calculations.

/3

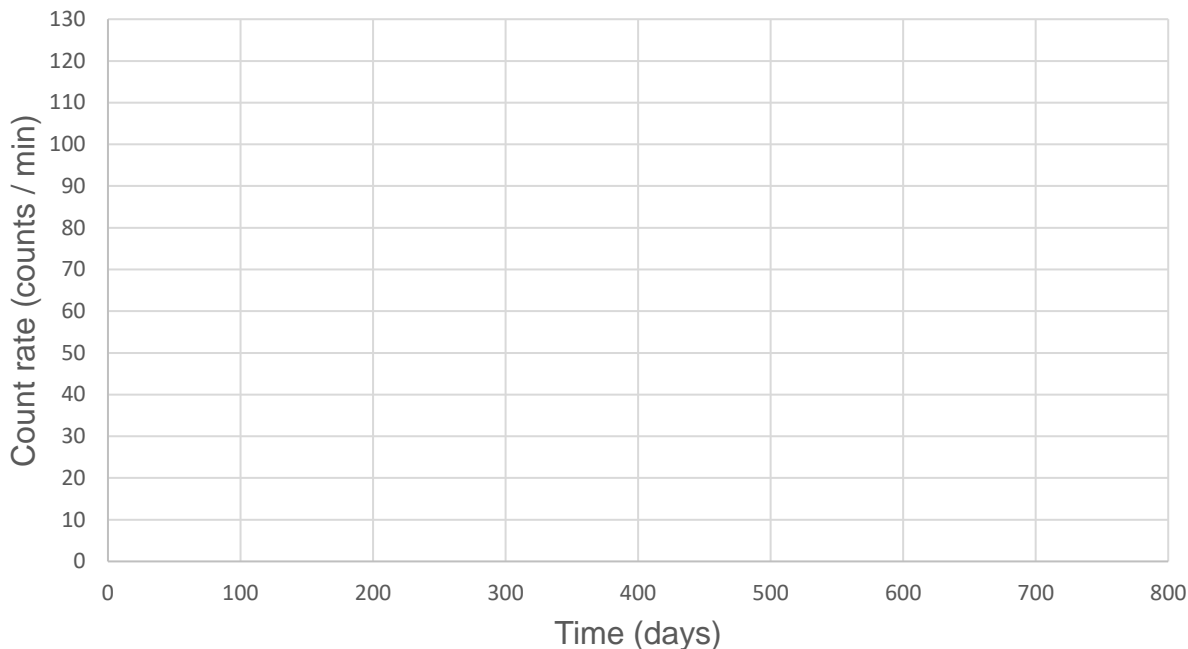


Figure 5: Graph for completion to answer Question 5 d).

Spare diagram used (X)

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Total
Q5
/7

Spare Diagrams

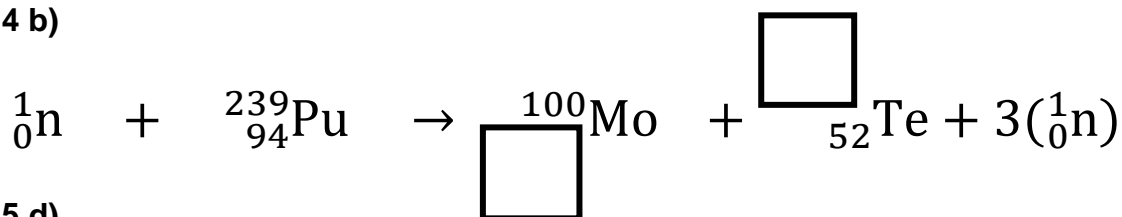
Question 1 a)

Subatomic particle	Charge
Proton	
Neutron	
Electron	

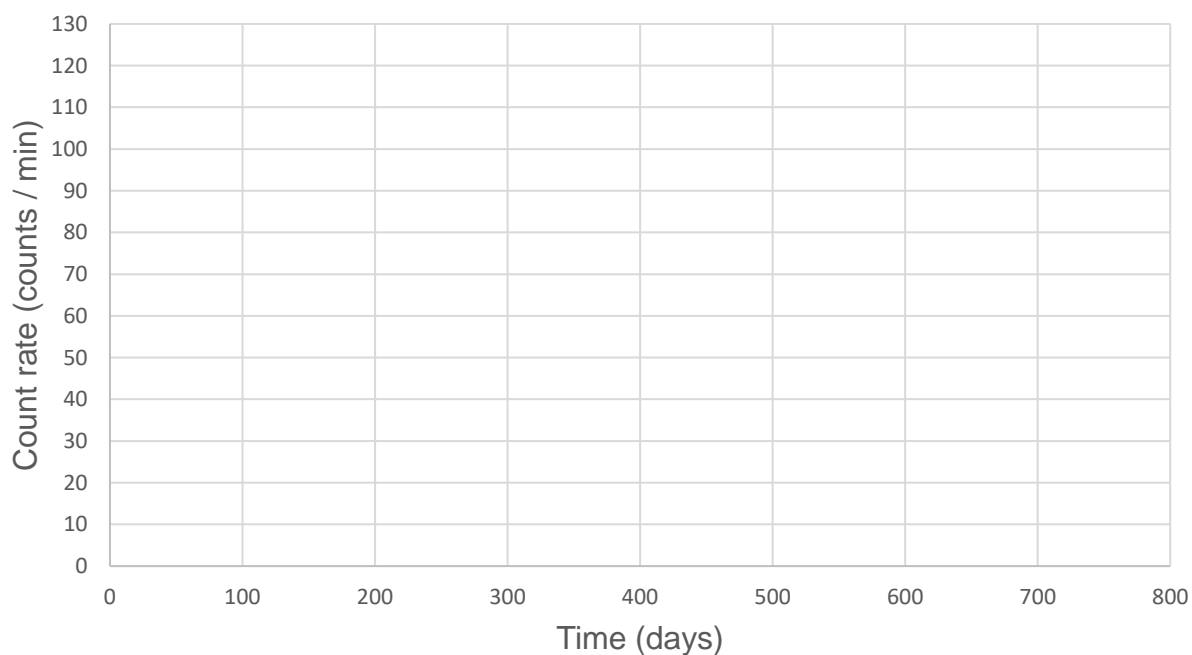
Question 1 b)

Electron shell	Maximum number of electrons
1	
2	

Question 4 b)



Question 5 d)



End of Section A
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External Assessment 2023

PHYSICAL SCIENCES

PSC315118

Section **B**

Pages: 16

Questions: 5

Information Sheet: 1

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Marker use	
C5	/ 36

Additional Instructions

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Criterion

You **must** make sure your answers address:

- Criterion 5 apply concepts and processes of motion and force.

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Question 6

Marker use

A boat, initially stationary, accelerates north to a velocity of 45.0 km h^{-1} . It travels 156.0 m during this period of constant acceleration.

a) Calculate this final velocity in SI units.

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b) Show that the magnitude of the acceleration was approximately 0.5 m s^{-2} .
Give your answer to the appropriate number of significant figures.

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c) Show that the boat took approximately 25 seconds to accelerate to 45.0 km h^{-1} .

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Once the boat reaches 45.0 km h^{-1} the driver changes the boat's direction to travel east. It then travels for 30.0 seconds at this speed before the driver turns the engine off.

d) Show that the boat had travelled 375 m east during this 30.0 seconds.

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Question 6 continues

Question 6 continued

Marker use

- e) Calculate the displacement of the boat over the 55.0 second journey.
You **must** include a labelled vector diagram as part of your answer.

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- f) Calculate the average velocity **and** average speed for the 55.0 second journey.

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**Total
Q6
/10**

Question 7

Marker use

In the future, an astronaut on the surface of Mars records the change in velocity of a ball as it is thrown upwards with an initial velocity of 11.1 m s^{-1} .

The ball was released from 1.50 m above the ground. It was then caught at the **same height** from which it was thrown.

The velocity vs time graph (Figure 6) is shown below.

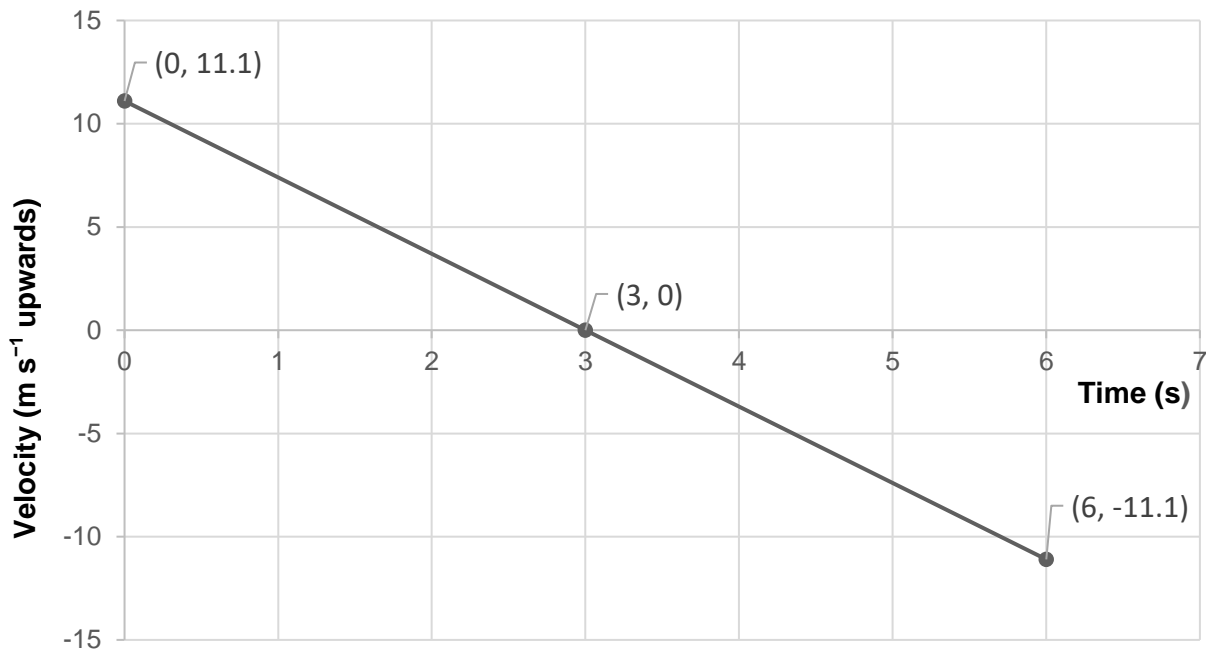


Figure 6: Graph of velocity vs time for a ball.

a) Show that the acceleration due to gravity on Mars is approximately 4 m s^{-2} downwards.

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b) At what time is the ball at maximum height?

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c) What maximum height did the ball reach above the surface of Mars?

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Question 7 continues

Question 7 continued

Marker use

- d) On the axes below (Figure 7), sketch a graph of height above surface vs time for the ball's motion.

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Label all axes and important points.

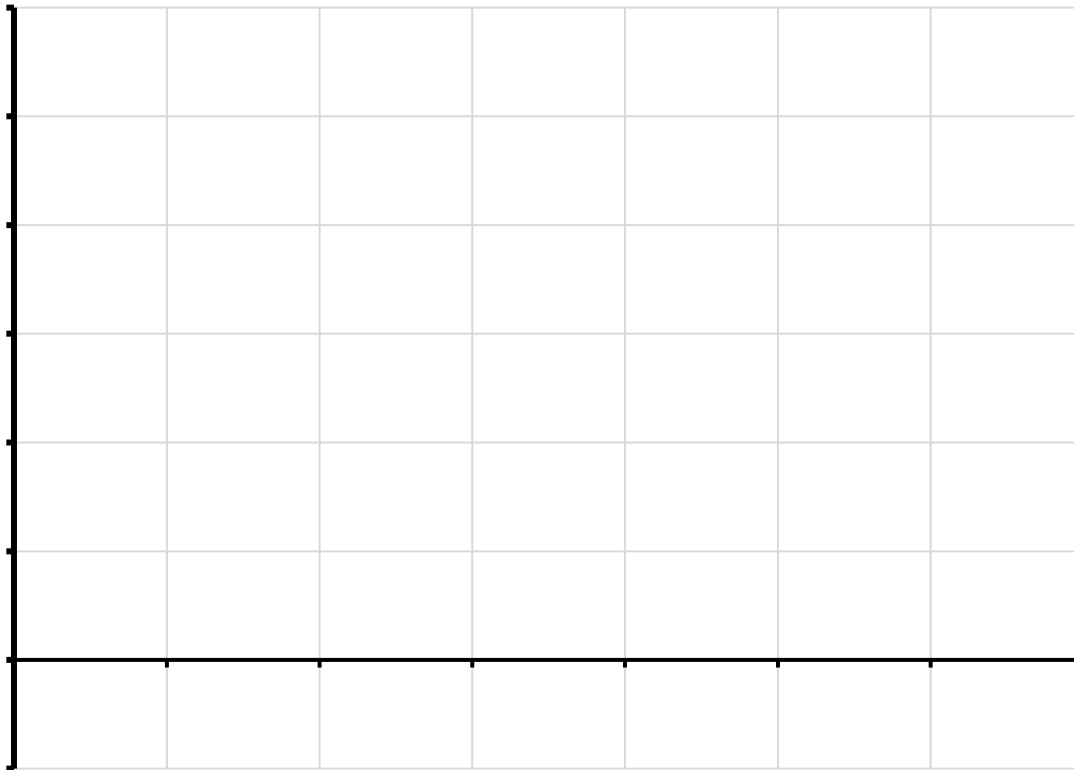


Figure 7: Graph for sketching answer to Question 7 d).

Spare diagram used (X)

Total
Q7
/7

Question 8

Block A, with mass 6.00 kg, is placed on a frictionless surface as shown in Figure 8.



Figure 8: Diagram of block A on a frictionless surface.

a) Calculate the weight of block A.

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b) The free body diagram (Figure 9) shows the forces acting on block A while it is not moving.

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Label the **two (2)** forces, including their magnitudes.

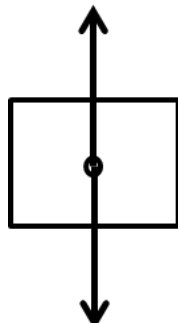


Figure 9: Free body diagram for annotation to answer Question 8 b).

Spare diagram used (X)

c) According to Newton's third law, identify the action/reaction pair to the weight force acting on block A.

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Question 8 continues

Question 8 continued

Marker use

A second block, B, with mass 12.0 kg, is positioned touching block A as shown in Figure 10. A person applies a force of 12.0 N on block A, pushing towards the right.

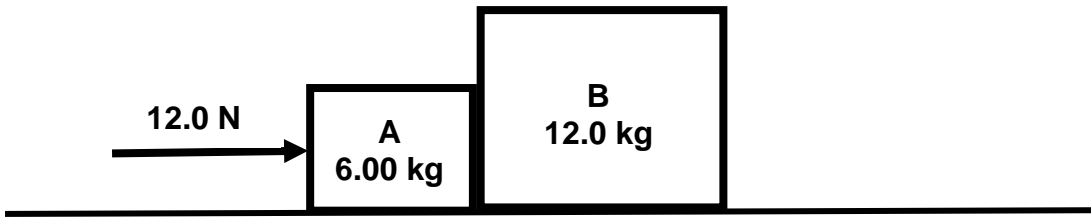


Figure 10: Diagram of blocks A and B, highlighting a person applying a force of 12.0 N to block A.

d) Calculate the acceleration of block A due to the applied force.

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e) Calculate the force block A applies to block B while the person is pushing.

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**Total
Q8
/8**

Question 9

Marker use

A person throws a dart horizontally at a dart board 2.37 m away.

The person throws the dart from in front of their eyes, 1.80 m above the ground.

The dart impacts the dart board 1.60 m above the ground.

The dart impacts the dart board at 11.9 m s^{-1} .

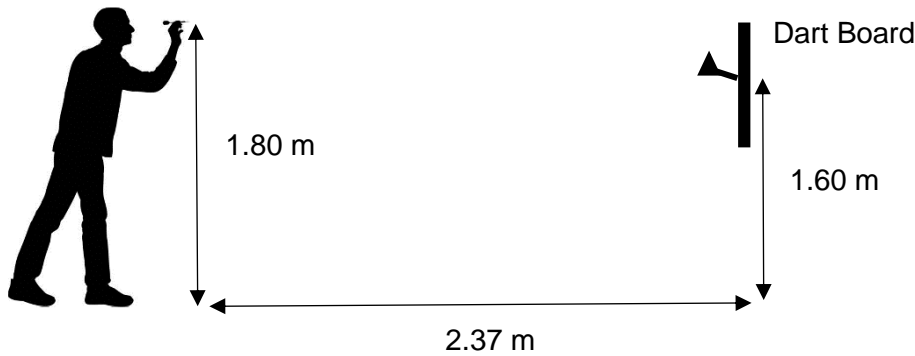


Figure 11: Diagram of a person throwing a dart at a dart board, highlighting distance and height measurements.

- a) Show that the vertical component of the velocity of the dart when it hit the board was 1.98 m s^{-1} .

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- b) Determine the initial horizontal velocity of the dart when it left the person's hand.

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Question 9 continues

Question 9 continued

Marker use

c) Determine the angle of impact between the dart and dart board.

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**Total
Q9
/5**

Question 10

Marker use

In April 2023, the European Space Agency launched the JUICE (Jupiter Icy Moons Explorer) spacecraft to travel to Jupiter. The spacecraft will arrive in 2031.

- a) With reference to one of Newton’s Laws, explain why the JUICE spacecraft will not need to continuously use its engine once it is travelling in space towards Jupiter.

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As it approaches Jupiter it will be travelling at 12.1 kilometres per second (km s^{-1}).

To enter orbit around Jupiter JUICE will need to slow down below 10.0 km s^{-1} .

To do this it will use its main engine in reverse. Its engine can produce 425 N of thrust and the average mass of the spacecraft during this slow-down procedure is 4 180 kg.

- b) If the spacecraft fires its engine for 350 minutes, show that it will provide a change in momentum of approximately $9 \times 10^6 \text{ kg m s}^{-1}$ in magnitude on the spacecraft.

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- c) Calculate the velocity of the spacecraft after this change in momentum to determine if it will slow down sufficiently.

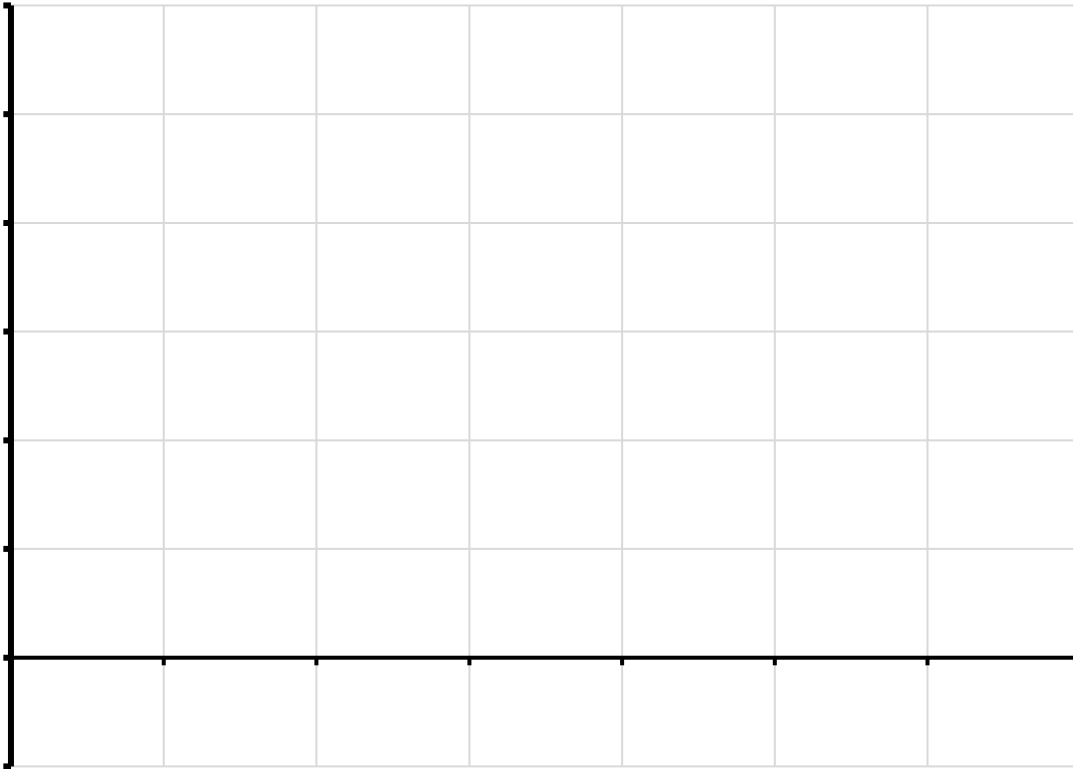
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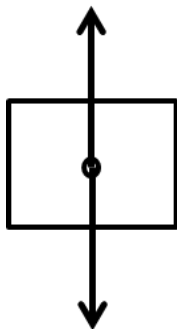
Total
Q10
/6

Spare Diagrams

Question 7 d)



Question 8 b)



End of Section B
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PHYSICAL SCIENCES

PSC315118

Section **C**

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Marker use	
C6	/ 36

Additional Instructions

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Criterion

You **must** make sure your answers address:

- Criterion 6 apply concepts and processes of conservation in physics.

Question 12

A person is riding an e-scooter to work. The combined mass of the scooter and rider is 78.0 kg.

Initially the scooter and rider are travelling along a flat road at 6.00 m s^{-1} .

- a) Calculate the kinetic energy of the scooter and rider as they ride along the flat road.

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The scooter and rider come to a hill with an angle of 5.00° to the horizontal. The scooter and rider travel 80.0 m up the hill as shown in Figure 12.

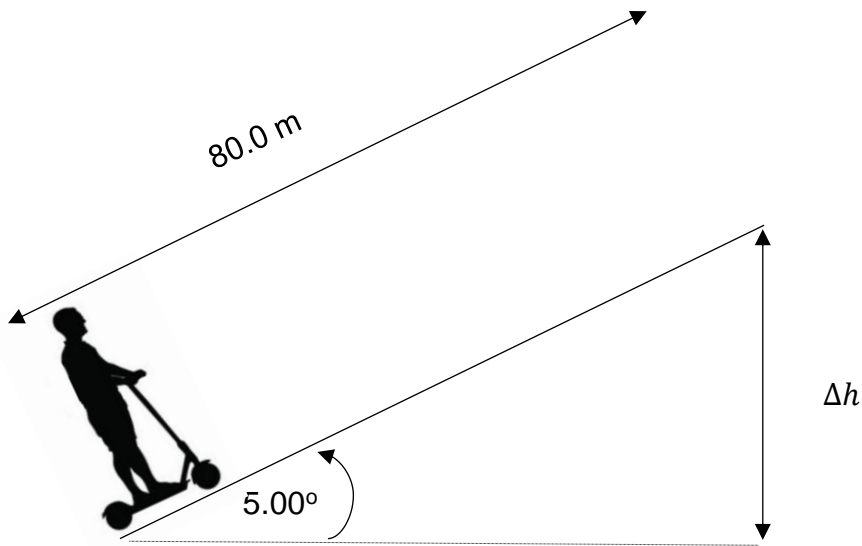


Figure 12: Diagram of a person riding an e-scooter up a hill, highlighting measurements.

- b) Show that the change in height, Δh , of the scooter and rider relative to the ground is approximately 7 m.

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- c) Hence, determine the change in potential energy of the scooter and rider as they travel up the slope.

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Question 12 continues

Question 12 continued

Marker use

At the top of the slope the speed had dropped to 3.00 m s^{-1} from 6.00 m s^{-1} at the bottom.

- d) Determine the change in kinetic energy of the scooter and rider as they travel up the slope.

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Whilst travelling up the slope, a constant frictional force of 6.10 N applies.

- e) Determine the work done against friction whilst travelling up the slope.

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It took the scooter and rider 18.0 seconds to travel up the hill.

A scooter is legal to own if its electric motor's power does not exceed 200 W .

- f) Calculate the power of the scooter's electric motor to determine if it is legal.

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**Total
Q12
/8**

Question 13

Marker use

Note: Ignore friction in this question.

A student is considering the changes in energy that occur when a pendulum swings back and forth.

The pendulum swings from point A to point C, passing through point B. Points A and C are 0.100 m higher than point B. The pendulum has a mass of 2.00 kg, and takes three (3) seconds to swing from point A to point C.

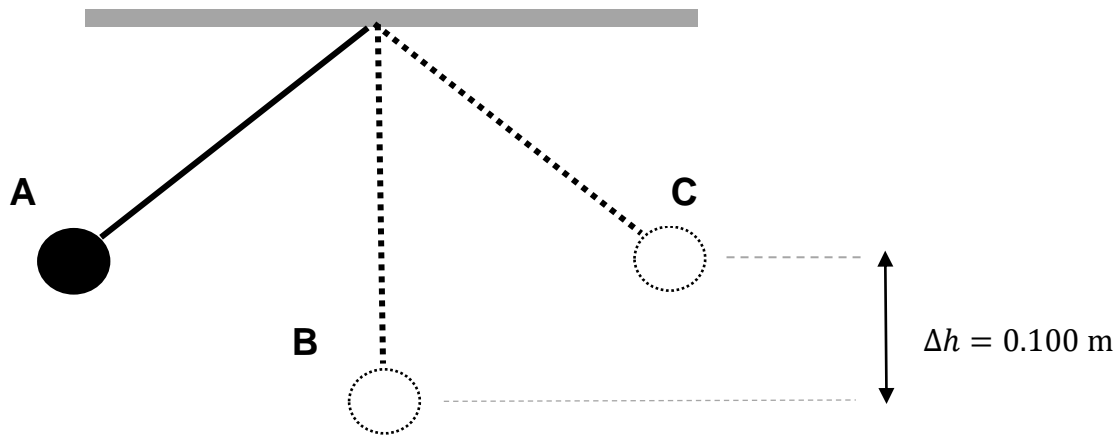


Figure 13: Diagram of a pendulum swing, highlighting the height difference of points A – C.

a) Calculate the gravitational potential energy of the pendulum at point A, relative to point B.

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b) Hence, determine the kinetic energy of the pendulum at point B.

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c) Calculate the velocity of the pendulum as it passes through point B.

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Question 13 continues

Question 13 continued

Marker use

Figure 14 shows how the gravitational potential energy of the pendulum changes with respect to position.

- d) On the same set of axes, sketch the change in kinetic energy as the pendulum swings from position A to position C.

/2

Label the y-intercept of the graph.

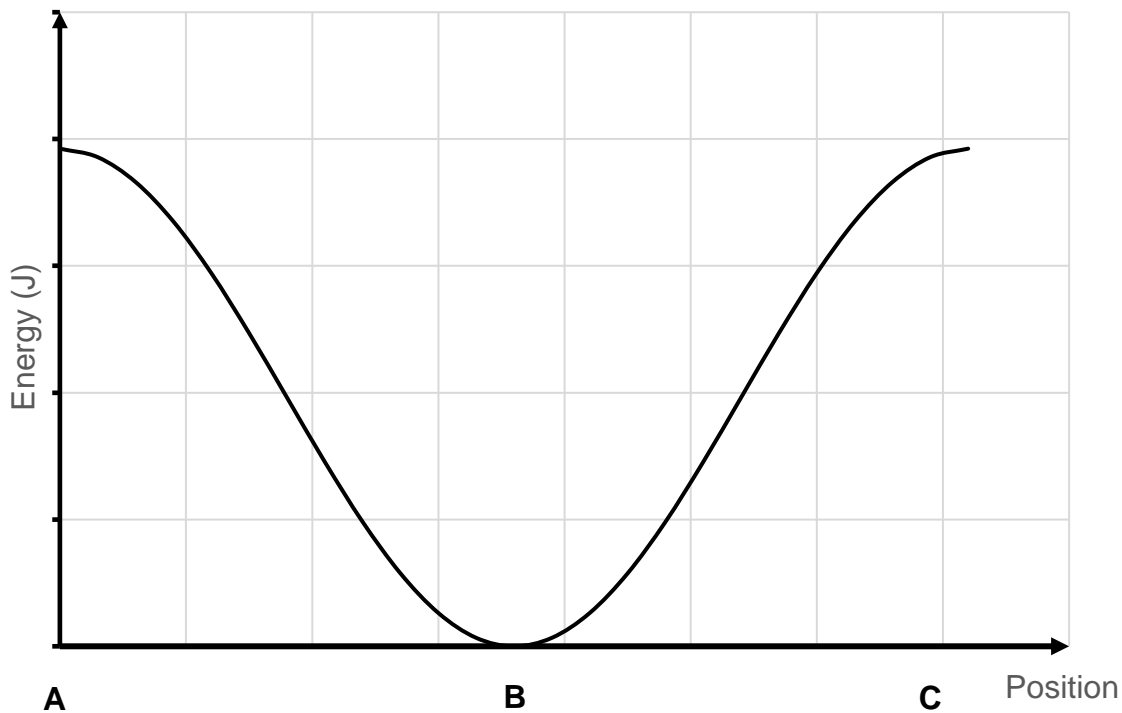


Figure 14: Graph for annotation to answer Question 13 d).

Spare diagram used (X)

Total
Q13
/5

Question 14

A series circuit is shown in Figure 15.

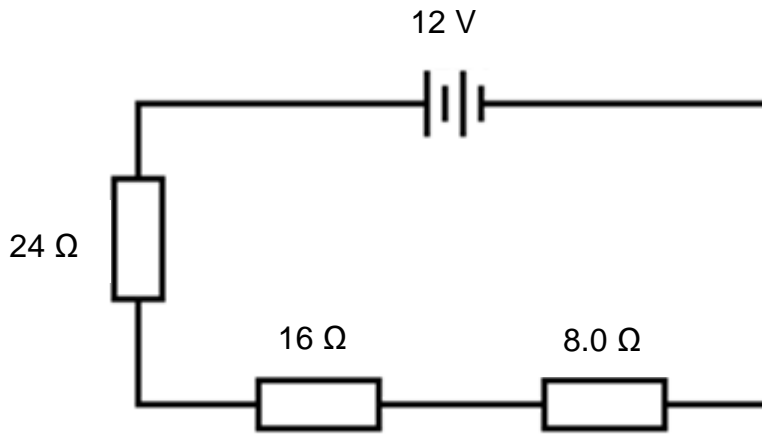


Figure 15: Diagram of a series circuit.

Spare diagram used (X)

a) Show that the total resistance in the circuit is 48 Ω.

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b) Calculate the current flowing through this circuit.

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c) On Figure 15 show:

- the direction of conventional current flow
- the polarity of the battery terminals.

/2

Question 14 continues

Question 14 continued

Marker use

A parallel circuit is shown in Figure 16. It contains two (2) resistors – one (1) of which has an unknown resistance.

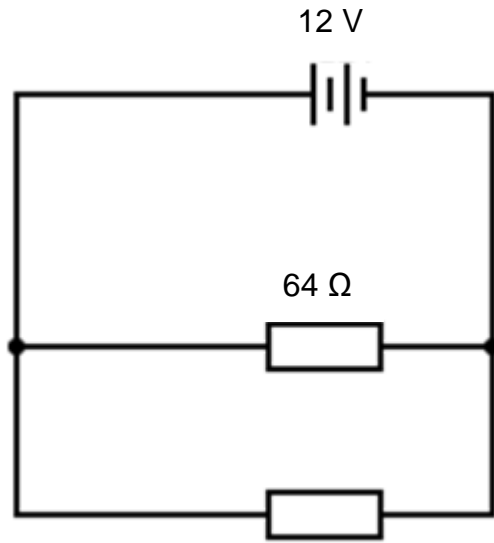


Figure 16: Diagram of a parallel circuit, highlighting an unknown resistance.

Spare diagram used (X)

d) If this parallel circuit has the same resistance as the series circuit (48 Ω), determine the resistance of the second resistor.

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e) On Figure 16 add:

- a voltmeter to read the voltage across the 64 Ω resistor
- an ammeter to determine the current flowing through the 64 Ω resistor.

/2

Total
Q14
/9

Question 15

A small solar panel is used to charge a phone's battery during the day. At night the phone is then used to play music and videos.



Figure 17: Photo of a solar panel charging a phone battery.

Marker use

- a) Describe the energy transformations that occur during the charging **and** use of the phone.

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A typical phone battery is labelled as 3 200 mAh. This is a measure of the maximum amount of charge it contains.

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- b) Show that 3 200 mAh is equivalent to 11 520 C.

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- c) How many electrons does this charge represent?

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Question 15 continues

Question 15 continued

Marker use

The phone's battery has a voltage of 3.83 V.

- d) Show that the battery has an energy storage capacity of approximately 12 watt hours (Wh).

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In optimum conditions, the solar panel can produce 7.0 W of power.

- e) How long would it take to fully charge the phone from empty, assuming optimum conditions.

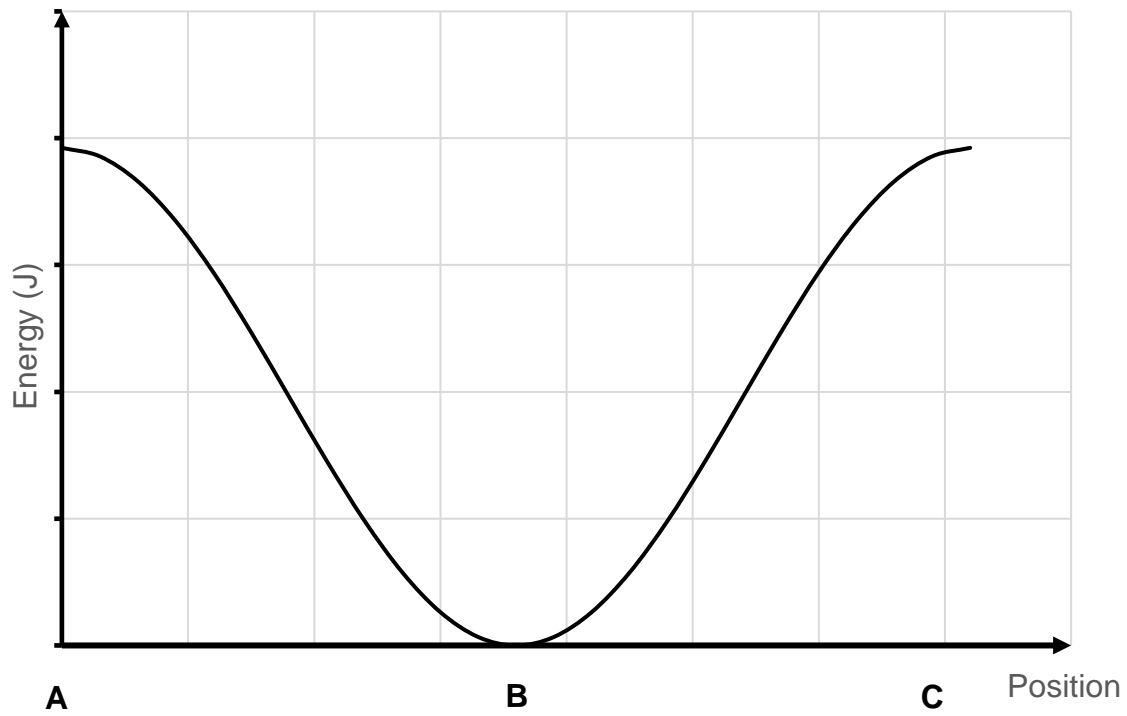
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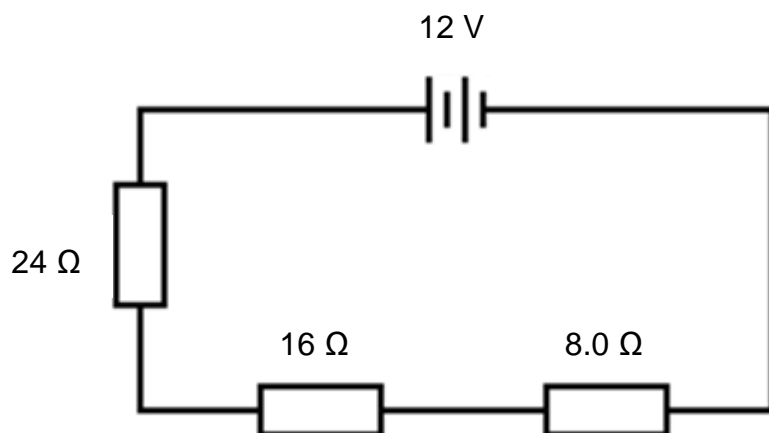
**Total
Q15
/8**

Spare Diagrams

Question 13 d)

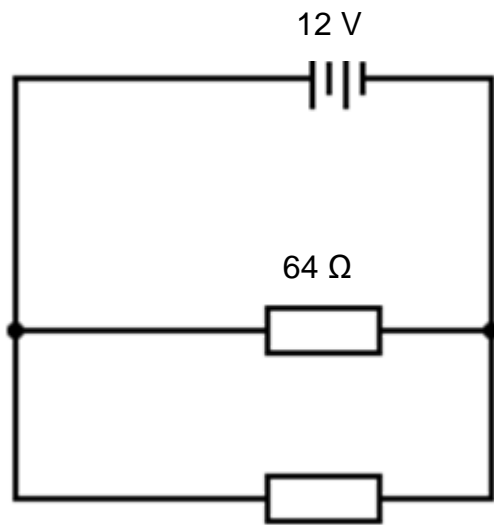


Question 14 c)



Spare Diagrams

Question 14 e)



End of Section C
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External Assessment 2023

PHYSICAL SCIENCES

PSC315118

Section **D**

Pages: 16

Questions: 5

Information Sheet: 1

Suggested working time: 36 minutes

Instructions:

- Answer all questions and all items within each question.
- Write your answers in the spaces provided in this exam paper.
 - Show working in answers to numerical questions and use appropriate units. Marks may not be given to answers without working.
 - Spare diagrams have been provided at the end of each section. Indicate in the box provided if you have used the spare diagrams.
- The exam is **three (3) hours** in length. It is suggested you spend **approximately 36 minutes** in total answering the questions in this section.
- TASC-approved scientific calculators can be used throughout the exam.
- The Physical Sciences Information Sheet can be used throughout the exam.
- All answers must be written in **English**.
- You **must** make sure your answers address the listed criterion.

Marker use	
C7	/ 36

Additional Instructions

- Note: When you are asked to “**show that**”:
 - You should calculate your own answer to the appropriate number of significant figures and then use this value to answer the following item(s) of the question.
 - If you are unable to determine the required value, you should use the value given in the following items of the question.

Guide to Exam Structure

	Questions available	Questions to answer	Suggested working time	Marks available
Section A	5	5	36 minutes	36 marks
Section B	5	5	36 minutes	36 marks
Section C	5	5	36 minutes	36 marks
Section D	5	5	36 minutes	36 marks
Section E	5	5	36 minutes	36 marks
Totals	25	25	180 minutes (3 hours)	180 marks

Criterion

You **must** make sure your answers address:

- Criterion 7 apply concepts and processes of chemical structures and properties.

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Question 16

Marker use

The formula of three (3) ionic compounds are given in Table 3.

a) Complete Table 3.

Formula	Name
BaCl ₂	Barium chloride
Sr(OH) ₂	
Sn(NO ₃) ₂	

Table 3

Spare table used (X)

b) Write a full, balanced equation for a precipitation reaction using solutions of **two (2)** of the three (3) compounds listed in Table 3.

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c) Write a net ionic equation for your precipitation reaction in item b).

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/2

/2

/1

Question 16 continues

Question 16 continued

Marker use

Barium chloride is a brittle white crystalline substance, with a melting point of 962°C.

d) Explain, with reference to its structure, each of the following:

Its high melting point:

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Why it is brittle:

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/ 3

**Total
Q16
/ 8**

Question 17

Marker use

Aluminium, magnesium and sodium are all metals from the third period of the periodic table.

a) What do all elements in period 3 have in common?

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/1

All three (3) of these metals react vigorously with acids.

b) Order these metals from most reactive to least reactive.

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Most reactive

→

Least reactive

/1

c) Explain the trend in reactivity for the period 3 metals.

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/3

Question 17 continues

Question 17 continued

Marker use

Aluminium is commonly used in cookware because, like all metals, it has the ability to conduct heat quickly.

d) With reference to the structure of metals, explain why aluminium will conduct heat quickly.

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Total
Q17
/7

Question 18 continued

Marker use

c) Define the term **isomer**.

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d) Reaction B will also form a second isomer not shown in Figure 19. Draw the structural formula and name this product.

/2

Structure:

Name:

e) Which reaction, A or B, would occur more rapidly? Circle the correct answer.

/1

Reaction A

Reaction B

**Total
Q18
/8**

Question 19

Marker use

Dimethyl ether is a covalent molecular compound with the following structure:

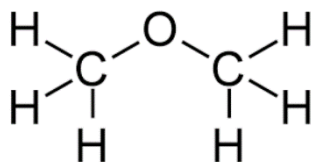


Figure 20: Diagram of dimethyl ether's molecular structure.

It has a melting point of -141°C and a boiling point of -24°C .

- a) When dimethyl ether boils at -24°C , describe the changes that occur (if any) in both its intermolecular and intramolecular bonding.

/2

Intermolecular:

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Intramolecular:

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- b) Draw the electron dot diagram of dimethyl ether.

/2

Question 19 continues

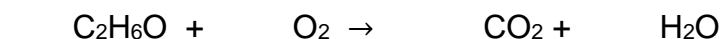
Question 19 continued

Marker use

Dimethyl ether is highly flammable.

c)

i. Balance the complete combustion equation below.



ii. Describe a test to identify **one (1)** of the gaseous products of the above reaction.

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Water is also a covalent molecular compound with a similar structure to dimethyl ether.

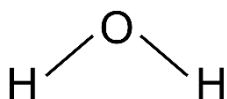


Figure 21: Diagram of water's molecular structure.

It has a melting point of 0°C and a boiling point of 100°C (at sea level).

d) With reference to the structure of water, explain why its melting and boiling points are significantly higher than dimethyl ether.

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/2

Total
Q19
/8

Question 20

Marker use

Lonsdaleite is an allotrope of carbon with a hexagonal lattice in which each carbon atom is bonded to four (4) others as shown in the abbreviated macromolecular structure in Figure 22:

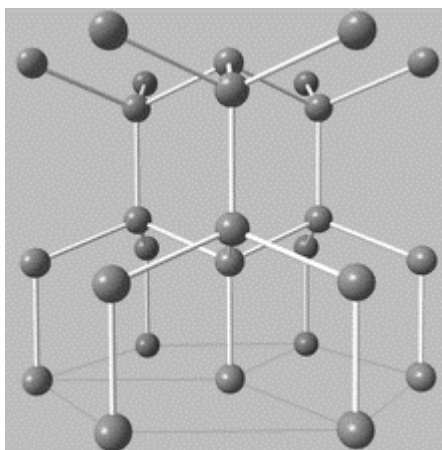


Figure 22: Diagram of the macromolecular structure of Lonsdaleite.

a) Define the term **allotrope**.

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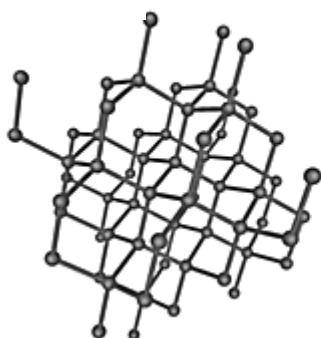
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/1

Two (2) other allotropes of carbon are shown in Figure 23:

Diamond:



Graphite:

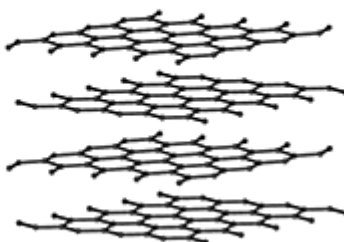


Figure 23: Diagram of the macromolecular structures of diamond and graphite.

Lonsdaleite is harder and stronger than diamond.

b) By considering these properties, suggest **one (1)** possible application of Lonsdaleite.

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/1

Question 20 continues

Question 20 continued

Marker use

- c) Would you expect Lonsdaleite to be able to conduct electricity?
Explain with reference to the structures of diamond and graphite.

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**Total
Q20
/5**

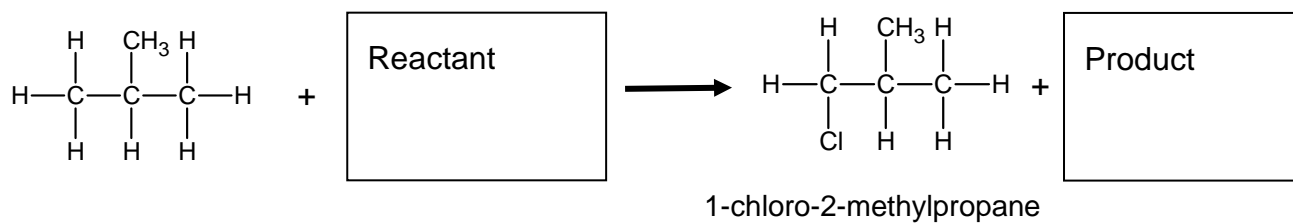
Spare Diagrams

Question 16 a)

Formula	Name
BaCl ₂	Barium chloride
Sr(OH) ₂	
Sn(NO ₃) ₂	

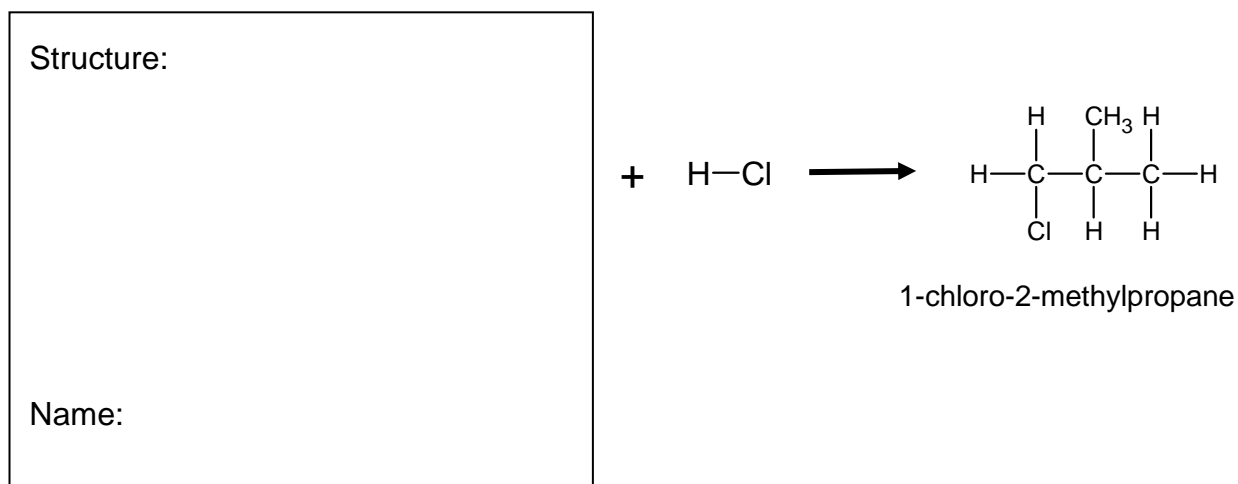
Question 18 a)

Reaction A



Question 18 b)

Reaction B



End of Section D

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External Assessment 2023

PHYSICAL SCIENCES

PSC315118

Section **E**

Pages: 12

Questions: 5

Information Sheet: 1

Suggested working time: 36 minutes

Instructions:

- Answer all questions and all items within each question.
- Write your answers in the spaces provided in this exam paper.
 - Show working in answers to numerical questions and use appropriate units. Marks may not be given to answers without working.
- The exam is **three (3) hours** in length. It is suggested you spend **approximately 36 minutes** in total answering the questions in this section.
- TASC-approved scientific calculators can be used throughout the exam.
- The Physical Sciences Information Sheet can be used throughout the exam.
- All answers must be written in **English**.
- You **must** make sure your answers address the listed criterion.

Marker use	
C8	/ 36

Additional Instructions

- Note: When you are asked to “**show that**”:
 - You should calculate your own answer to the appropriate number of significant figures and then use this value to answer the following item(s) of the question.
 - If you are unable to determine the required value, you should use the value given in the following items of the question.

Guide to Exam Structure

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Section B	5	5	36 minutes	36 marks
Section C	5	5	36 minutes	36 marks
Section D	5	5	36 minutes	36 marks
Section E	5	5	36 minutes	36 marks
Totals	25	25	180 minutes (3 hours)	180 marks

Criterion

You **must** make sure your answers address:

- Criterion 8 apply concepts and processes of chemical reactions and reacting quantities.

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Question 21

Marker use

Glucose is a compound with the formula $C_6H_{12}O_6$.

a) Show that the molar mass of glucose is 180.2 g mol^{-1} .

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b) Determine the mass of 1 molecule of glucose in grams.

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c) Determine the mass of 0.0277 mol of glucose.

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d) Show that the concentration of glucose is approximately 0.1 mol L^{-1} when 0.0277 mol is dissolved to make 275 mL of solution.

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Question 21 continues

Question 21 continued

Marker use

People with low blood sugar levels (hypoglycaemia) can receive an intravenous (IV) injection of glucose solution to fix their blood sugar level.

If the concentration of glucose in the bloodstream is below $3.90 \times 10^{-3} \text{ mol L}^{-1}$ they are considered hypoglycaemic.

If the concentration of glucose in the bloodstream is above $6.90 \times 10^{-3} \text{ mol L}^{-1}$ they are considered hyperglycaemic.

Blood sugar concentration should be between these two (2) values in a healthy person.

e) A patient suffering hypoglycaemia has **5.00 L** of blood in their body with a blood glucose concentration of $2.00 \times 10^{-3} \text{ mol L}^{-1}$.

To treat the condition they are given an IV injection containing the **275 mL** of 0.1 mol L^{-1} glucose as made up in 21 d).

Will this injection return their blood sugar concentration to a healthy level? Use mole calculations to support your answer.

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**Total
Q21
/9**

Question 22

Marker use

Copper sulfate is commonly found in its hydrated form, copper sulfate pentahydrate $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$.

$$M_r(\text{CuSO}_4) = 159.61$$

$$M_r(\text{CuSO}_4 \cdot 5\text{H}_2\text{O}) = 249.69$$

- a) Show that the percentage by mass of water in $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ is approximately 35%.

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- b) What is the maximum mass of water that could be driven off when 5.00 g of the pentahydrate is heated to remove the water from the compound.

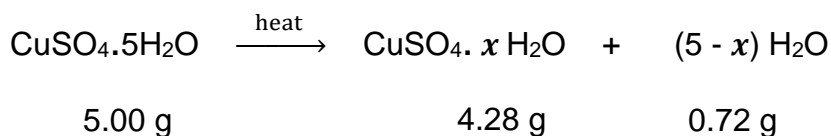
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A student heated a 5.00 g sample of copper sulfate pentahydrate for two (2) minutes. They found that the mass remaining was 4.28 g.



- c) Determine the new value of x , the water of hydration, after this partial evaporation of water.

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Total
Q22

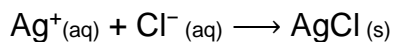
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Question 23

Marker use

The extraction of natural gas from underground produces wastewater which is contaminated with a high concentration of sodium chloride. This wastewater must be tested for chloride ion concentration before being released into the environment.

A scientist is testing a 10.0 L wastewater sample for chloride ion concentration by precipitation reaction with silver nitrate solution. The reaction occurring is:



The scientist requires 856 mL of 0.500 mol L⁻¹ silver nitrate to precipitate **all** the chloride ions present in the 10.0 L wastewater sample.

a) Show that approximately 0.4 mol of silver nitrate was added.

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Environmental regulations state that the wastewater cannot be discharged into the environment unless its chloride ion concentration is lower than 1400 mg L⁻¹.

b) Show that this sample cannot legally be discharged into the environment.

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**Total
Q23
/4**

Question 24

Marker use

Thiosulfuric acid, $\text{H}_2\text{S}_2\text{O}_3$, is a **weak, diprotic** acid.

a) Define the term **diprotic**.

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b) Would you expect the pH of a 0.1 mol L^{-1} solution of thiosulfuric acid to be higher or lower than a 0.1 mol L^{-1} solution of sulfuric acid, H_2SO_4 ? Explain your answer.

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c) A solution of thiosulfuric acid is added to sodium hydrogen carbonate solution. A gas is produced in this reaction.

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Write a chemical equation that would represent the reaction.

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Question 24 continues

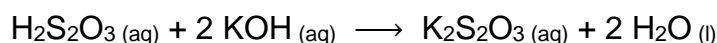
Question 24 continued

Marker use

A chemist has found a bottle of thiosulfuric acid solution of unknown concentration. To determine the concentration of the solution they perform a titration using the following procedure:

- A 10.00 mL sample of the thiosulfuric acid from the bottle is diluted to 100.0 mL using a volumetric flask.
- 20.00 mL samples of the diluted thiosulfuric acid are titrated against 0.4153 mol L⁻¹ potassium hydroxide.
- The average titre volume is 21.2 mL.

The reaction occurring is:



- d) Show that the concentration of thiosulfuric acid solution in the **diluted solution** is approximately 0.2 mol L⁻¹.

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Give your answer to the appropriate number of significant figures.

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- e) Calculate the concentration of the thiosulfuric acid in the bottle.

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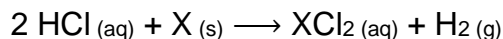
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**Total
Q24
/11**

Question 25

Marker use

Metal X reacts with hydrochloric acid according to the following equation:



a) Does metal X react as a Brønsted-Lowry base in this reaction? Explain your answer.

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b) If 0.249 g of hydrogen gas is produced from the reaction of 3.00 g of metal X with excess hydrochloric acid, determine the identity of element X.

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$M(\text{H}_2) = 2.016 \text{ g mol}^{-1}$

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c) Calculate the mass of XCl_2 produced in this reaction.

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**Total
Q25**

/7

End of Section E
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