TASMANIAN ASSESSMENT, STANDARDS & CERTIFICATION

External Assessment 2025

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PHYSICAL SCIENCES

PSC315118

Section A

Pages: 12
Questions: 4
Information Sheet: 1

Preparation time for this exam: 15 minutes

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.
  - A spare diagram has been provided at the end of this section. Indicate in the box provided if you have used the spare diagram.
- The exam is **three (3) hours** in length. The suggested working time for this section is **approximately 36 minutes**.
- 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	
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.

Question 1

Marker use

As displayed in Table 1, particles A, B, C and D have the following subatomic structures.

Particle	Number of Protons	Number of Neutrons	Electron Configuration
A	7	7	2, 4
B	8	8	2, 6
C	8	10	2, 8
D	9	10	2, 8

Table 1

a) Which **two (2)** of the particles are isotopes?

.....

/1

b) What is the valency of particle B?

.....

/1

c) State the **group number** and **period number** of particle D.

Group number: .....

Period number: .....

/1

d)

i. Predict which **three (3)** of the particles are ions.

.....

/1

ii. Suggest, with reason, if any of these ions are chemically stable.

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/2

Total Q1

/6

Question 2

Marker use

The potential to build nuclear power stations in Australia has been debated over the past year. The fuel used in most nuclear reactors is uranium, specifically the naturally occurring uranium-235 ($^{235}_{92}U$) isotope.

a) Provide the number of subatomic particles in a neutral uranium-235 atom. /2

Number of Protons	
Number of Neutrons	
Number of Electrons	

Table 2

b) Name **one (1)** physical or chemical property that will differ between the two isotopes $^{235}_{92}U$ and $^{238}_{92}U$? /1

.....

.....

c) Complete the nuclear fission reaction of uranium-235, identifying the missing element, its atomic number and mass number. /2

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{92}_{36}Kr + \square\!\square\!\square + 3{}^{1}_{0}n$$

Spare diagram used (X) ☐

d) Nuclear reactions in powerplants are controlled fission chain reactions. In the context of nuclear reactors, what is meant by the following terms: /2

i. chain reaction

.....

.....

.....

ii. controlled reaction

.....

.....

Question 2 continues

Question 2 continued

Marker use

An unwanted byproduct of nuclear reactors is plutonium-239. Plutonium-239 has a half-life of 24 000 years.

e) If 160 kg of plutonium is formed in a nuclear reactor each year, how long would it take for there to be only 5 kg of plutonium remaining? /2

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Nuclear waste, including plutonium, krypton and other fission products, emit alpha, beta and gamma particles.

f) Which of the **three (3)** particles is the **least** penetrating? Explain your reasons. /2

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g) How might unwanted nuclear fission products be stored to ensure safety for nearby communities? /1

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Total Q2 /12

Question 3

Marker use

Technetium-99m ($^{99m}_{43}Tc$) accounts for 80% of all nuclear medicine procedures worldwide.

a) What does the **m** in $^{99m}_{43}Tc$ **represent** and what particles are **emitted** from its decay? /2

i. **m** meaning

.....

ii. particle emitted

.....

The activity of a small sample of $^{99m}_{43}Tc$ is displayed in Figure 1, with background radiation interference clearly present.

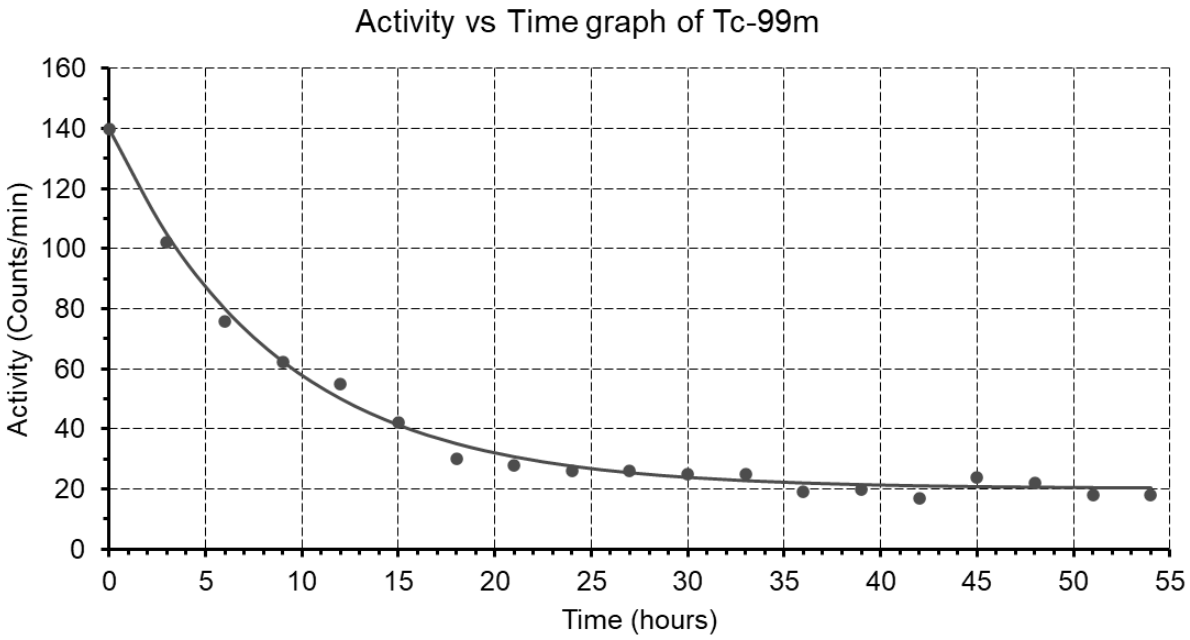

Figure 1

b) What is the difference between radiation from electrical devices like mobile phones and radiation from nuclear processes? /1

.....

.....

Question 3 continues

Marker use

c) From Figure 1, estimate the background radiation contribution.

/1

.....

.....

d) From Figure 1, estimate the half-life of $^{99m}_{43}Tc$.

/2

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Radioactive isotopes used in medicine are not without risk. For example, low doses of **beta-emitting** iodine-131 ($^{131}_{53}I$) used to treat thyroid tumours in children have been linked to thyroid cancer. Large doses are less likely to cause cancer.

e) Write a decay equation for $^{131}_{53}I$.

/2

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.....

f) Justify why large doses of iodine-131, rather than low doses, are used to treat thyroid tumours.

/3

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Total Q3

/11

Question 4

Marker use

Consider the neutral elements sodium, chlorine and magnesium. All three of these elements are in period 3 of the periodic table.

a) What aspect of their electron configurations is similar?

.....

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/1

b) Sketch the electron shell diagram of a neutral chlorine **atom.**

/1

c) By referencing their atomic structure, explain why chlorine has the smallest radius of the three elements.

/2

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d) Outline why chlorine forms a Cl^- ion.

/1

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Question 4 continues

Marker use

The mass spectrum of chlorine is displayed in Figure 2, showing **count, not abundances**.

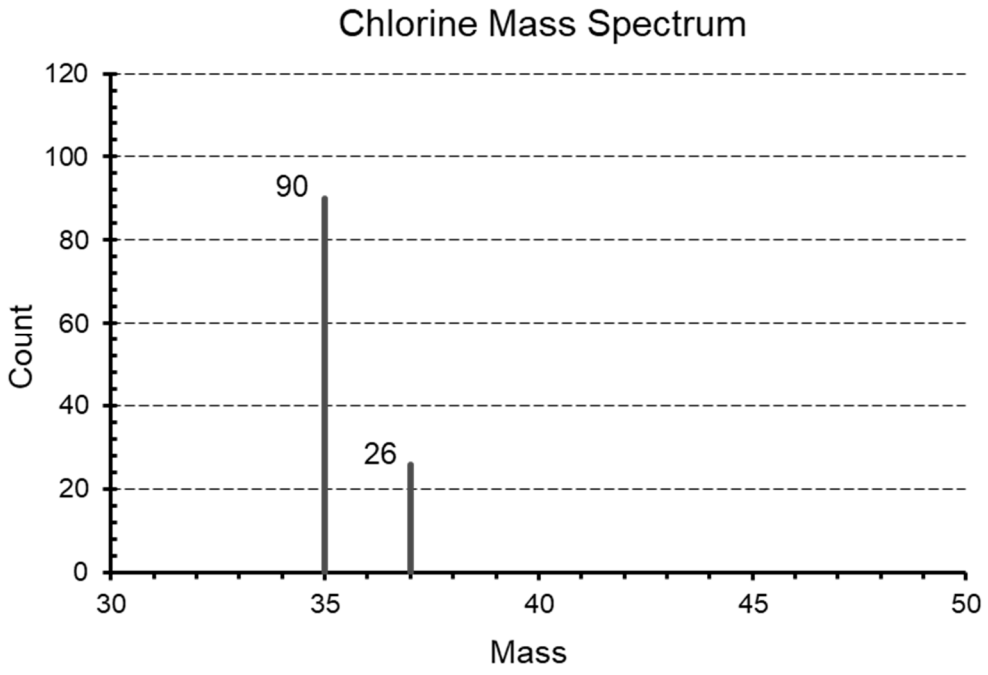

Figure 2

e) By considering the total count displayed in Figure 2, calculate the relative atomic mass of chlorine.

/2

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Total Q4

/7

Spare Diagrams

Marker use

Question 2 c)

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{92}_{36}Kr + \square\!\square\!\square + 3{}^{1}_{0}n$$

End of Section A

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PHYSICAL SCIENCES

PSC315118

Section B

Pages: 16
Questions: 5
Information Sheet: 1

Suggested working time: 36 minutes

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Marker use	
C5	/ 36

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Criterion

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

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

Question 5

Marker use

Modern highways often include signs that indicate driving times to important locations.

A sign is located **13 km** from an airport and it suggests a drive time of 7 min.

a) Show that the average speed needed to reach the airport 13 km away in 7.0 min is about 30 m s^{-1}. /1

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b) Calculate the speed in km hr^{-1}. /1

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c) For the first 4 minutes of the journey a car travels at 25 m s^{-1}. What new speed in m s^{-1}, will be needed to reach the airport in the original 7 minutes? /3

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Question 5 continues

Marker use

Figure 3 is the display from an ambulance travelling the same 13 km journey to the airport.

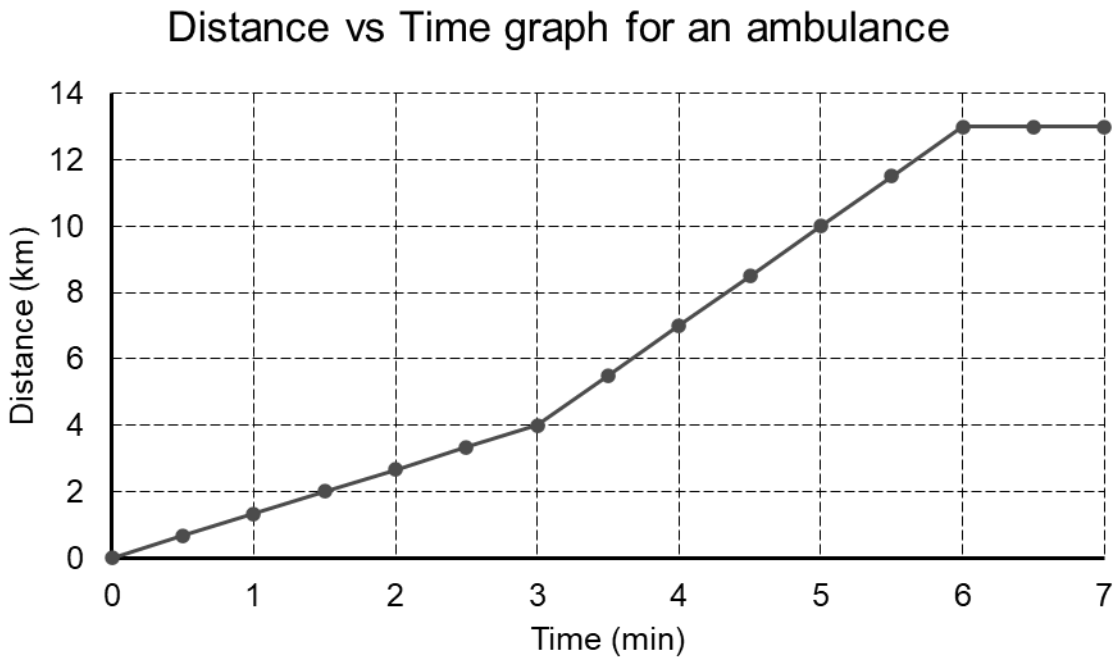

Figure 3

d) From Figure 3, how far had the ambulance travelled after 3 minutes?

/1

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e) How many minutes did it take to reach the airport?

/1

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.....

f) Determine the fastest speed of the ambulance?

/1

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Total Q5

/8

Question 6

Marker use

A run in baseball is when a player, after hitting the ball, runs in a **square** from Home Base to Bases 1, 2, 3 and back to Home Base. Figure 4 outlines the pitch setup; Base 2 is directly north of Home Base.

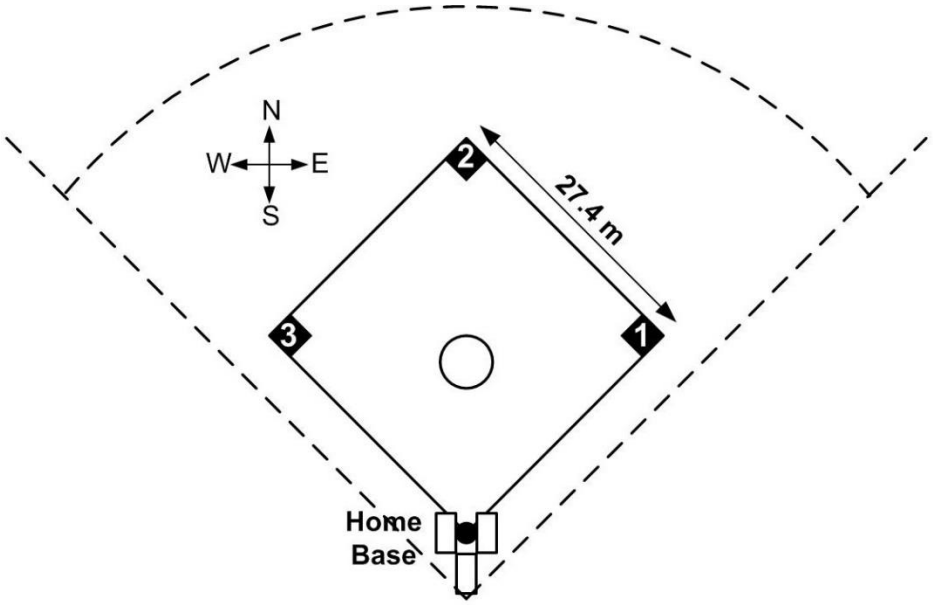

Figure 4

a) What is the **distance** travelled running from Home Base through Bases 1 and 2 to Base 3? /1

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.....

b) What is the **displacement** running from Home Base through Bases 1 and 2 to Base 3? /1

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.....

c) If it took 13.5 s to run from Home to Base 3, calculate the runner's average velocity. /2

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Question 6 continues

Marker use

d) On one occasion a runner fell **midway** between Base **2 and 3**. What was the runner's displacement when they fell?

/3

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Total Q6

/7

Question 7

Marker use

Figure 5 illustrates a 21.0 kg child happily bouncing up and down on a trampoline.
The figure has the child placed **above the trampoline in midair**.

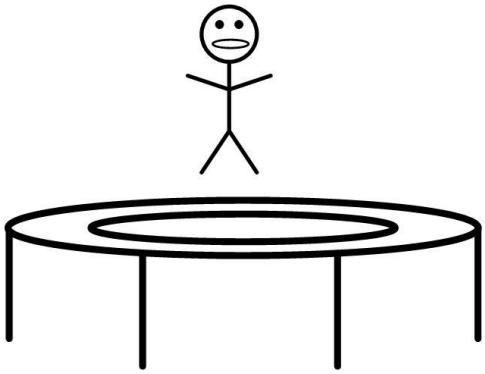

Figure 5

a) Calculate the weight of the child.

/1

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b) Newton's Third Law applies to the child's weight. Identify the **reaction force** to the child's weight force.

/1

.....

.....

Question 7 continues

Marker use

c) Add labelled force vectors to the **centre of the child** depicted below in Table 3 for the three situations: moving down, stationary at the lowest point and moving up.

/3

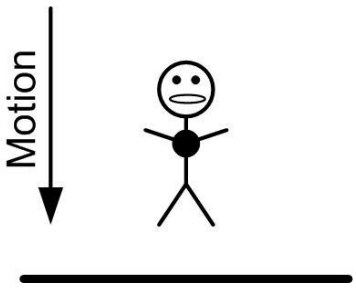
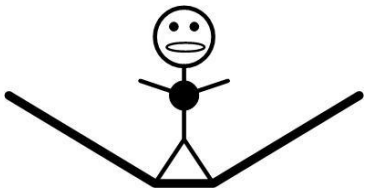
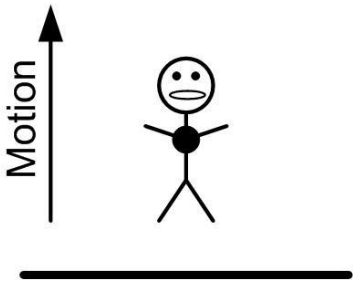
Moving **down** before hitting the trampoline	**Stationary** at the lowest point on trampoline	Moving **up** after leaving the trampoline
		

Table 3

Spare diagram used (X) ☐

d) The child bounces off the trampoline onto the ground, landing in an upright position. Explain in terms of Newton's Laws why the child bends their legs on landing.

/2

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Total Q7

/7

Question 8

Marker use

A mountain bike rider competing in a Hardline action race in Tasmania needed to clear a small pond with a horizontal take-off as illustrated in Figure 6.

The take-off platform was 3.20 m high and 10.0 m horizontally from the landing position.

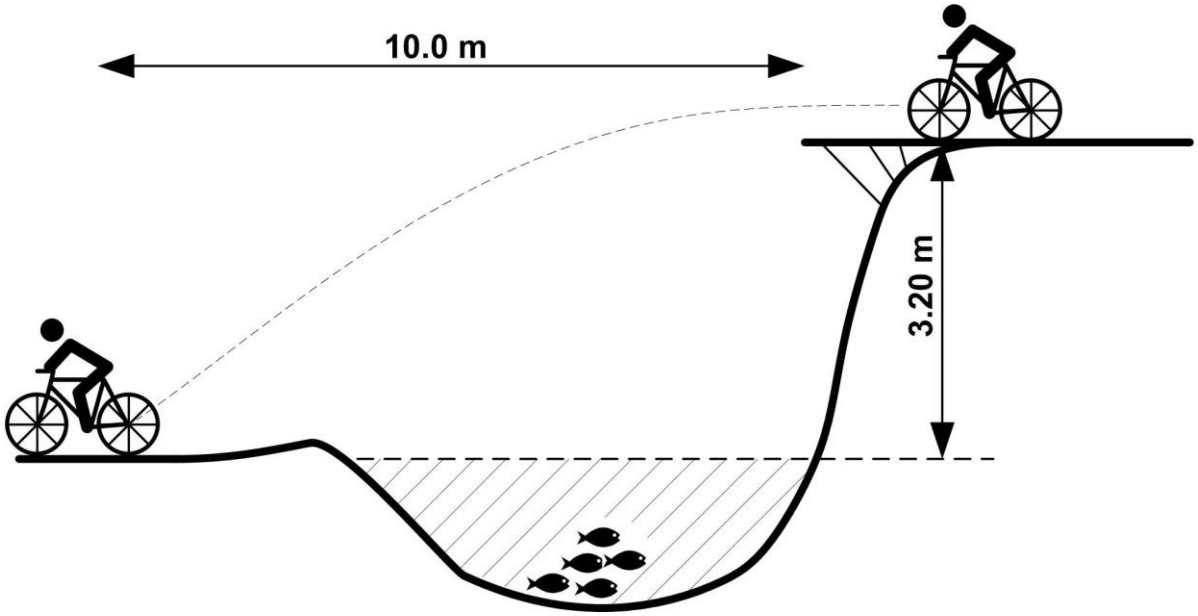

Figure 6

a) Show that the bike was in the air for about 0.8 seconds.

..... /1

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The experienced rider landed the bike exactly 10.0 m from the take-off platform.

b) Show that the velocity at takeoff was about 12 m s^{-1} forward.

..... /1

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c) Show that the vertical component of the velocity on landing was approximately 8 m s^{-1} downwards. /1

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Question 8 continues

Marker use

d) Calculate the final velocity on landing.

/3

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Total Q8

/6

Question 9

Marker use

Ignore frictional forces in this question.

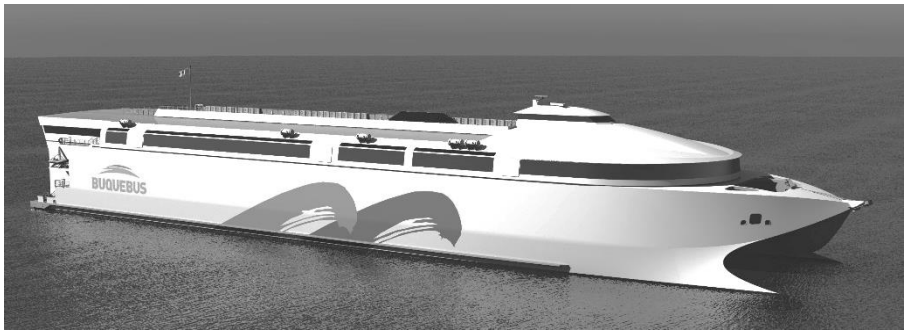

Figure 7

Source: https://incat.com.au/

A new battery powered ship built by Incat in Tasmania (Figure 7) is conducting sea trials. The trials are three successive acceleration tests carried out in a straight line.

The advanced navigation system onboard produced the following display of velocity vs time from the trials (Figure 8). Using Figure 8 as a guide, answer the following questions relating to the ship's motion.

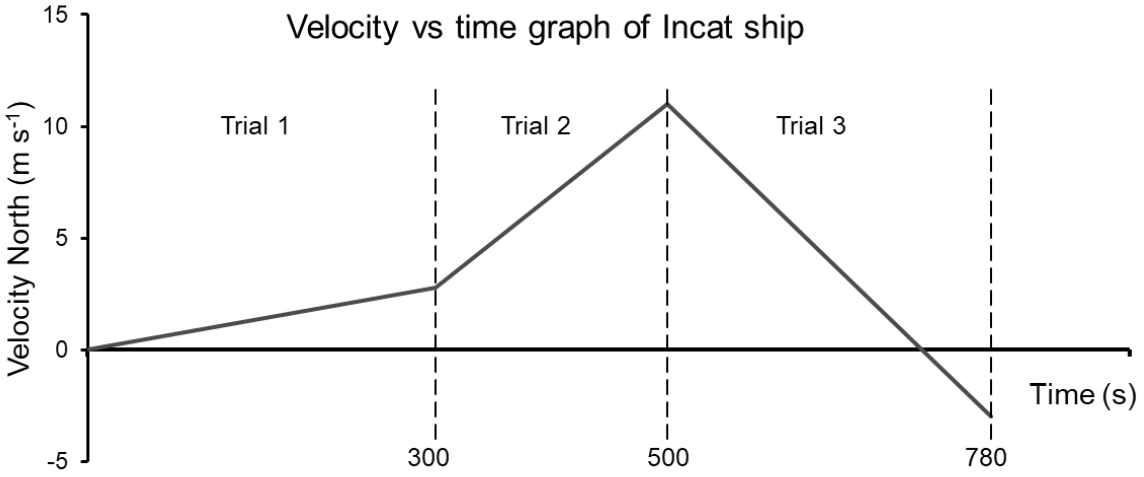

Figure 8

Trial 1: Slow acceleration north.

The ship started from stationary and reached a velocity of 2.79 m s^{-1} north in 300 s.

a) Determine the ship's **acceleration** after 150 s.

/1

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.....

Question 9 continues

Marker use

b) Determine the ship's **displacement** after 300 s.

/1

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.....

Trial 2: Moderate acceleration.

The ship increased its acceleration rate over the next 200 s, travelling an additional distance of 1.38 km north.

c) Calculate the **acceleration** of the ship during Trial 2.

/2

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d) Calculate the ship's **velocity** at the end of Trial 2, showing it is about 11 m s^{-1} north.

/1

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Trial 3: Emergency deceleration.

The emergency deceleration runs the motors in reverse. This creates an acceleration of 0.050 m s^{-2} south. After 280 s the ship has a velocity of 3.0 m s^{-1} south.

e) Calculate the total **distance** travelled by the ship over the **(3) three** trials.

/3

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Total Q9

/8

Spare Diagrams

Question 7 c)

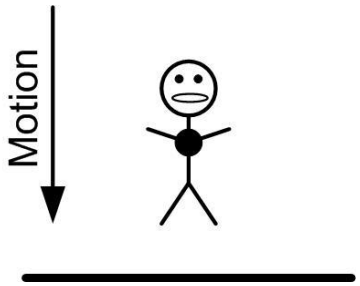
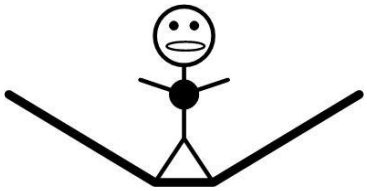
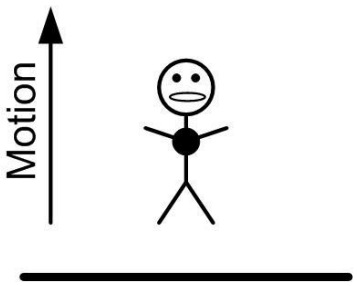
Moving **down** before hitting the trampoline	**Stationary** at the lowest point on trampoline	Moving **up** after leaving the trampoline
		

Table 3

End of Section B

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PHYSICAL SCIENCES

PSC315118

Section C

Pages: 16
Questions: 5
Information Sheet: 1

Suggested working time: 36 minutes

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Marker use	
C6	/ 36

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Marker use

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Criterion

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

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

Question 10

Marker use

A person receives a large amount of static electricity by touching a Van de Graaff generator. As seen in Figure 9, their hair stands on end.

Figure 9

Source: https://assets.fishersci.com/TFS-Assets/CCG/product-images/FS102482~p.eps-650.jpg

a) Explain why static electricity causes hair to stand like this.

/2

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b) The charge is estimated at −13.9 μC. How many electrons does this represent?

/2

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Total Q10

/4

Question 11

Marker use

A student investigated the properties of a conductor by measuring the current passing through it as the potential difference across it is varied. Figure 10 was produced from the test results.

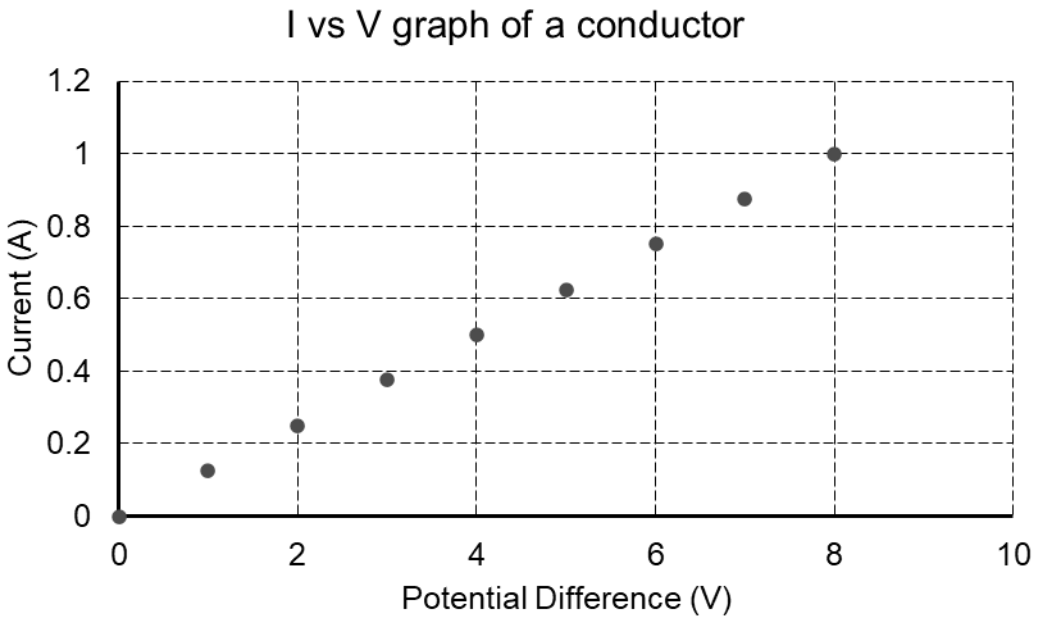

Figure 10

a)

i. Explain why the conductor is classified as ohmic.

/1

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ii. Calculate the resistance of the conductor.

/2

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Question 11 continues

Marker use

A series circuit is displayed in Figure 11.

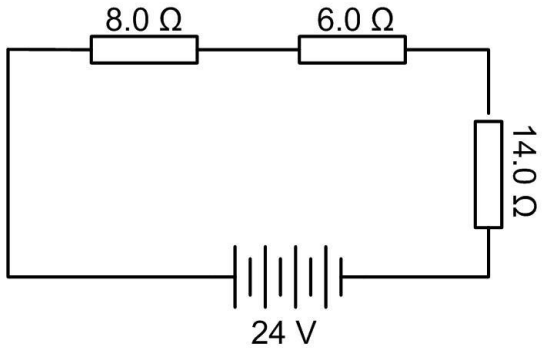

Figure 11

Spare diagram used (X) ☐

b) Place an **ammeter** and **voltmeter** in the Figure 11 circuit to measure the voltage across and current through the 8.0 Ω resistor. /1

c) Predict the current reading displayed by the ammeter. /2

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A parallel circuit is shown in Figure 12.

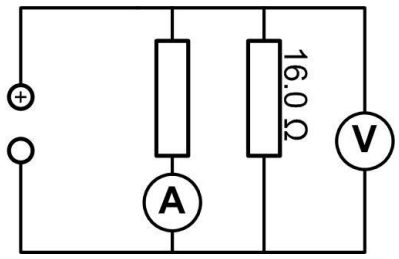

Figure 12

d) If the reading on the voltmeter is 14.0 V, and the reading on the ammeter is 0.636 A, show that the unknown resister is about 22 Ω. /1

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Question 11 continues

Marker use

e) Calculate the total resistance of the circuit in Figure 12.

/1

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f) Explain why the 16 Ω resistor has a greater power output than the 22 Ω resistor.

/2

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Total Q11

/10

Question 12

Marker use

Sales of electric vehicles in Australia have increased, with expectations being that virtually all car sales will be electric within 10 years. It is also expected that most homes in Australia will charge their cars with home solar panels.

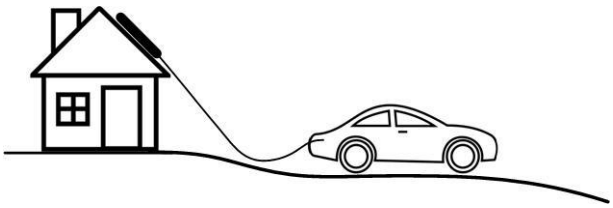

Figure 13

a) Describe the energy transformations that occur during the **charging** of an electric car using solar panels and its subsequent movement using an electric motor. /4

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One car has a battery pack energy rating of 60.5 kWh.

b) How many joules of energy does 60.5 kWh represent? /1

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Question 12 continues

Marker use

c) During optimal charging conditions, an array of home solar panels produces a current of 30.0 A at 240 V. How long will it take to fully charge the 60.5 kWh car battery pack from empty?

/2

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Total Q12

/7

Question 13

Marker use

A student, investigating momentum and energy conservation during a collision, set up two trolleys as outlined in Figure 14.

Trolley A has a mass of 0.103 kg and a velocity of 1.71 m s^{-1} right.

Trolley B has a mass of 0.39 kg and a velocity of 0.814 m s^{-1} right.

Note that both trolleys are travelling to the right.

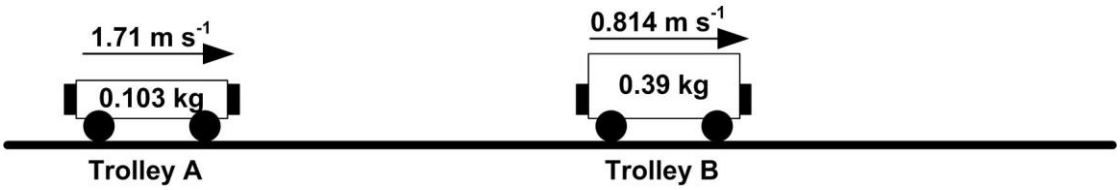

Figure 14

a) Show that the total momentum of Trolley A and Trolley B before the collision is about 0.5 kg m s^{-1} right**,** giving your answer to the correct number of significant figures. /3

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.....

After the trolleys collided, Trolley B was found to have a velocity of 1.41 m s^{-1} right.

b)

i. Show that the speed of Trolley A after the collision is about 0.5 m s^{-1}. /2

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Question 13 continues

Marker use

ii. In which direction is Trolley A moving after the collision?

/1

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The total kinetic energy before the collision is 0.280 J.

c) Is the collision elastic or inelastic? Justify your answer.

/3

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Total Q13

/9

Question 14

Marker use

The power output of an **1800 kg** vehicle is to be determined by measuring its speed going up a hill.

In one situation, shown in Figure 15, a vehicle moves from a **stationary** position up a slope for 90.0 m reaching a speed of 14.8 m s^{-1} at the top, 8.0 m above its original height.

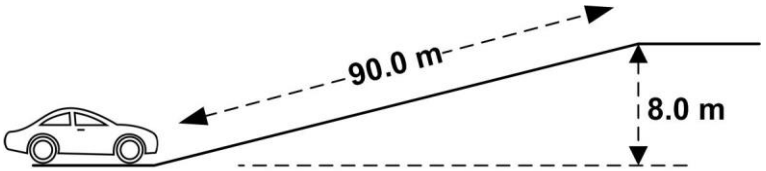

Figure 15

a) Calculate the **kinetic** and **gravitational potential** energy the car has at the top of the slope. /2

i. Kinetic energy

.....

.....

ii. Gravitational potential energy

.....

.....

b) **Ignoring friction**, show that the total **work done** on the vehicle travelling up the slope is about 340 kJ. /1

.....

.....

c) If the journey took 12.2 s, calculate the average **power** output of the car. /1

.....

.....

Question 14 continues

Marker use

As illustrated in Figure 16, the car now travels 50.0 m at a constant velocity down the other side of the 8.0 m high hill.

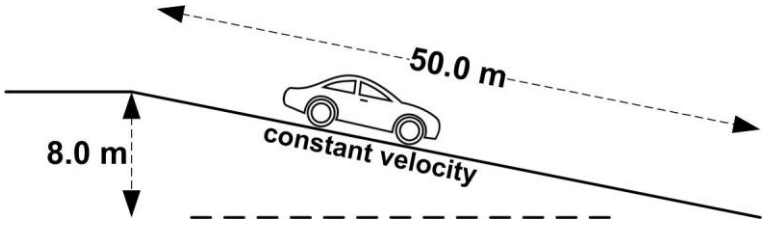

Figure 16

d) Calculate the **force** exerted on the car due to **friction**.

/2

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.....

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Total Q14

/6

Spare Diagram

Question 11 b)

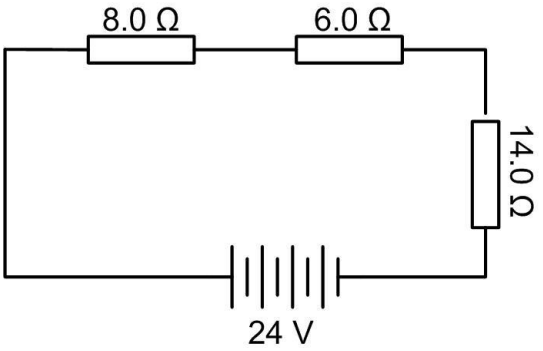

Figure 11

End of Section C

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PHYSICAL SCIENCES

PSC315118

Section D

Pages: 16
Questions: 6
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 this section. Indicate in the box provided if you have used the spare diagrams.
- The exam is **three (3) hours** in length. The suggested working time for this section is **approximately 36 minutes**.
- 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/criteria.

Marker use	
C7	/ 36

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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	4	4	36 minutes	36 marks
Section B	5	5	36 minutes	36 marks
Section C	5	5	36 minutes	36 marks
Section D	6	6	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.

Question 15

Marker use

The halogens fluorine, chlorine, bromine and iodine are all from group 17 of the periodic table.

a) Regarding **electron** configuration, what do all elements in group 17 have in common?

/1

.....

.....

b) Halogens are known to be reactive elements, with their reactivity decreasing down the group. Explain why halogens are so reactive **and** why the reactivity of halogens decreases down the group.

/3

i. Strong reactivity

.....

.....

ii. Decreasing reactivity down group

.....

.....

.....

.....

Two commonly used halogen-containing compounds are the disinfectant chlorine, Cl_2 and the feed material for PVC, chloroethene (C_2H_3Cl – commonly called vinyl chloride).

c) In the space provided in Table 4, sketch the electron dot diagram for Cl_2 and C_2H_3Cl.

/2

Cl_2	C_2H_3Cl

Table 4

Spare diagram used (X) ☐

Total Q15

/6

Question 16

Marker use

/6

Complete Table 5 by adding the missing name, empirical formula or structural formula.

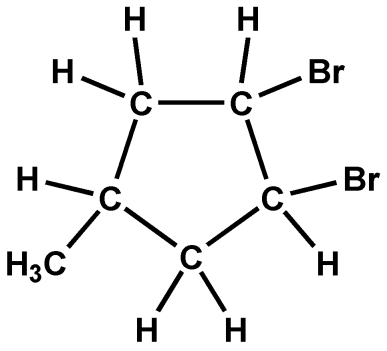
Systematic Name	Empirical Formula	Structural Formula
	CS_2	
Silver carbonate		
	$Sn(CrO_4)_2$	
4-chloro-but-1-ene	C_4H_7Cl	
		

Table 5

Spare diagram used (X) ☐

Total Q16

/6

Question 17

Marker use

For each of the following substances **state the bonding present** and **outline the reason** for the properties listed based on their structure. A structural diagram may assist in your answer.

a) **Iron (Fe) solid**

/2

Properties: A **hard** but **malleable** solid.

Bonding present: .....

Reason: .....

.....

.....

.....

b) **Lithium Chloride (LiCl)**

/2

Properties: Does **not conduct** electricity when solid but does **conduct** electricity in both **molten** and **aqueous** states.

Bonding present: .....

Reason: .....

.....

.....

.....

Question 17 continues

Marker use

c) **Water (H_20)**

/2

Properties: Is **chemically stable** and has a **higher** than expected boiling point.

Bonding present: .....

Reason: .....

.....

.....

.....

Total Q17

/6

Question 18

Marker use

Barium nitrate solution is a common analytical reagent that can be used to identify the difference between a sodium sulfate solution and a sodium hydroxide solution.

a) Write a full chemical equation **and** a net ionic equation for the reaction between barium nitrate solution and sodium sulfate solution.

i. Full chemical equation

/2

.....

.....

.....

ii. Net ionic equation

/1

.....

.....

b) Name (or provide symbols of) the spectator ions in this reaction.

/1

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.....

c) Explain why barium nitrate is used to identify between sodium sulfate and sodium hydroxide.

/1

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.....

.....

d) Nitrate chemicals such as barium nitrate and sodium nitrate are difficult to identify chemically due to their high solubility and low reactivity. Suggest a method that could be used to distinguish between barium nitrate and sodium nitrate.

/1

.....

.....

Total Q18

/6

Question 19

Marker use

Carbon forms many allotropes. One recently explored group of carbon allotropes are fullerenes. One example, a Buckminsterfullerene, is displayed in Figure 17.

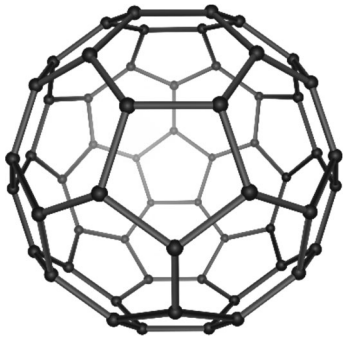

Figure 17

a) Explain why Buckminsterfullerenes do not conduct electricity.

/2

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.....

b) Explain why Buckminsterfullerenes are chemically stable.

/2

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Total Q19

/4

Question 20

Marker use

The carbon compound but-1-ene is an unsaturated hydrocarbon.

a) What does the term **unsaturated** mean in carbon chemistry?

/1

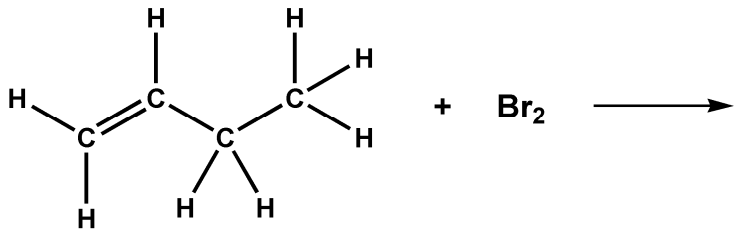
.....

.....

But-1-ene can be tested for unsaturation using bromine.

b) Complete the addition reaction below of bromine added to but-1-ene.

/1



Spare diagram used (X) ☐

c) What would be **observed** as bromine is added to but-1-ene?

/1

.....

.....

If the bromine in the reaction above was replaced with hydrogen bromide, two isomers form.

d) Draw the structural formula of the **two (2)** isomers in the space provided in Table 6.

/2

Isomer 1	Isomer 2

Table 6

Spare diagram used (X) ☐

Question 20 continues

Marker use

e) In a similar reaction bromine can be reacted with butane to form a range of different bromobutane isomers. What name is given to this type of reaction?

/1

.....

.....

f) But-1-ene (C_4H_8) is a highly combustible chemical. Complete and balance **one (1)** combustion reaction below, of but-1-ene (C_4H_8) with a **limited** supply of oxygen.

/2

$$C_4H_{8(l)} + O_{2(g)} \rightarrow$$

Spare diagram used (X) ☐

Total Q20

/8

Spare Diagrams

Question 15 c)

Cl_2	C_2H_3Cl

Table 4

Question 16

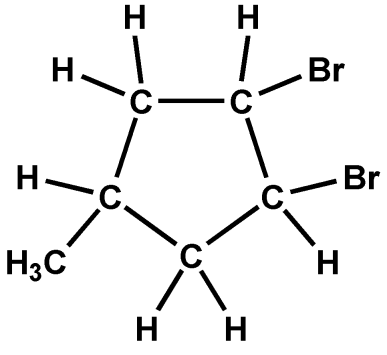
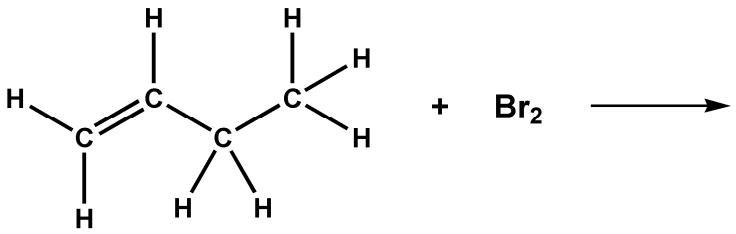
Systematic Name	Empirical Formula	Structural Formula
	CS_2	
Silver carbonate		
	$Sn(CrO_4)_2$	
4-chloro-but-1-ene	C_4H_7Cl	
		

Table 5

Spare Diagrams

Question 20 b)



Question 20 d)

Isomer 1	Isomer 2

Table 6

Question 20 f)

$C_4H_{8(l)} + O_{2(g)} \rightarrow$

End of Section D

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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. The suggested working time for this section is **approximately 36 minutes**.
- 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 D	6	6	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.

Question 21

Marker use

Nitric acid is commonly used to dissolve metals such as chromium. The reaction occurring is described by the equation

$$6HNO_{3(aq)} + 2Cr_{(s)} \rightarrow 2Cr(NO_3)_{3(aq)} + 3H_{2(g)}$$

In one reaction, 145 mL of 8.10 mol L^{-1} HNO_3 is reacted with a large quantity of chromium.

a) Show that about 1.20 moles of HNO_3 are present. /1

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b) How many moles of chromium metal will react with the nitric acid? /1

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.....

c) Calculate the mass of chromium that reacted with the nitric acid. /1

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d) Explain why HNO_3 is acting as a Bronsted-Lowry acid in this equation. /1

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.....

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Total Q21 /4

Question 22

Marker use

The latest drug used for weight loss (although initially developed as an antidiabetic drug) is called semaglutide. It has a large structure with a molecular formula of $C_{187}H_{291}N_{45}O_{59}$.

a) Show that it has a molar mass of 4113.6 g mol^{-1}.

..... /2

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.....

.....

b) Show that 1.00 kg of semaglutide represents 0.243 moles.

..... /1

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c) How many **nitrogen atoms** are present in the 1.00 kg sample of semaglutide?

..... /2

.....

.....

.....

Question 22 continues

Marker use

/3

d) Another weight loss drug, developed over 60 years ago, is phentermine. Analysis of this compound suggests it has the following composition:

- Carbon 80.48%
- Hydrogen 10.13%
- Nitrogen 9.388%.

Determine an empirical formula for this compound.

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Total Q22

/8

Question 23

Marker use

Sulfuric acid, a strong **diprotic** acid, is used extensively in our society in areas such as fertiliser production, pharmaceutical production and even in its concentrated form in some car batteries.

a) What is meant by **diprotic**?

.....

.....

/1

Acids readily react with carbonate and hydrogen carbonates as shown in the ionic equations below:

Equation 1. Carbonate $2H^+_{(aq)} + CO_3^{2-}{}_{(aq)} \rightarrow H_2O_{(l)} + CO_{2(g)}$

Equation 2. Hydrogen Carbonate $H^+_{(aq)} + HCO_3^-{}_{(aq)} \rightarrow H_2O_{(l)} + CO_{2(g)}$

b) If the carbonate in equation 1 was solid sodium carbonate (Na_2CO_3) and the acid was sulfuric acid solution, write a full balanced chemical equation of the reaction.

.....

.....

/1

c) If the hydrogen carbonate in equation 2 was solid sodium hydrogen carbonate ($NaHCO_3$) and the acid was sulfuric acid solution, write a full balanced chemical equation of the reaction.

.....

.....

/1

d) Consider **100 g** of both **sodium carbonate** and **sodium hydrogen carbonate.**

i. Calculate the number of moles of Na_2CO_3.

.....

.....

/1

ii. Calculate the number of moles of $NaHCO_3$.

.....

.....

/1

Question 23 continues

Marker use

iii. Which will produce the most CO_2 if added to excess sulfuric acid. Justify your answer.

/2

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iv. Which of the 100 g samples of sodium carbonate and sodium hydrogen carbonate will better neutralise excess sulfuric acid? Justify your answer.

/2

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e) A laboratory technician decided to use the hydrated form of sodium carbonate $Na_2CO_3.10H_2O$ to neutralise a sulfuric acid spill. Would this compound be as effective as Na_2CO_3 or $NaHCO_3$ at neutralising sulfuric acid? Explain.

/2

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Total Q23

/11

Question 24

Marker use

The hydrochloric acid (HCl) concentration of stomach fluid was analysed by titration against a sodium hydroxide (NaOH) solution of known concentration.

In the titration, 12.1 ml of stomach fluid was needed to exactly neutralise 25.0 ml of 0.0852 mol L^{-1} sodium hydroxide solution.

a) Write a balanced chemical equation for the reaction of aqueous hydrochloric acid with a solution of sodium hydroxide. /1

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b) Calculate the number of moles of NaOH present in 25.0 mL of a 0.0852 mol L^{-1} solution. /1

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c) Therefore, determine the number of moles of HCl present in the acid solution. /1

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d) Calculate the concentration of the acid solution in mol L^{-1}. /1

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e) Convert this concentration of HCl to g L^{-1} units. /1

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Question 24 continues

Marker use

f) Hydrochloric acid in the stomach is considered a ‘dilute strong acid’. What is meant by a ‘dilute strong acid’?

/2

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g) At the concentration calculated in part e) above, suggest a pH for stomach acid.

/1

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Total Q24

/8

Question 25

Marker use

A mineral rock sample is known to contain only calcium carbonate ($CaCO_3$) and calcium oxide (CaO). The percentage by mass of $CaCO_3$ can be calculated by measuring the sample's reduction in mass after strong heating due to the evolution of CO_2 gas from the solid $CaCO_3$.

$$CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$$

Useful Information

$Mr(CaCO_3) = 100.1$

$Mr(CO_2) = 44.01$

A sample of the mineral rock was heated strongly, cooled and reweighed to a constant mass. The mass of the solid sample reduced from 5.000 g to 3.191 g.

a) Calculate the **mass** of CO_2 liberated by the heating. /1

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b) Hence, calculate the mass of $CaCO_3$ present in the initial sample. /3

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c) Calculate the percentage of $CaCO_3$ in the original mineral rock sample. /1

.....

.....

Total Q25 /5

End of Exam

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