

External Assessment 2022

PHYSICAL SCIENCES

PSC315118

Section **A**

| | |
|-------------------|----|
| Pages | 12 |
| Questions | 5 |
| 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.
 - 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 that you spend **approximately 36 minutes** in total answering the questions in this section.
- A TASC approved scientific calculator is allowed 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:
 - Criterion 4 apply concepts and processes of atomic properties and nuclear reactions.

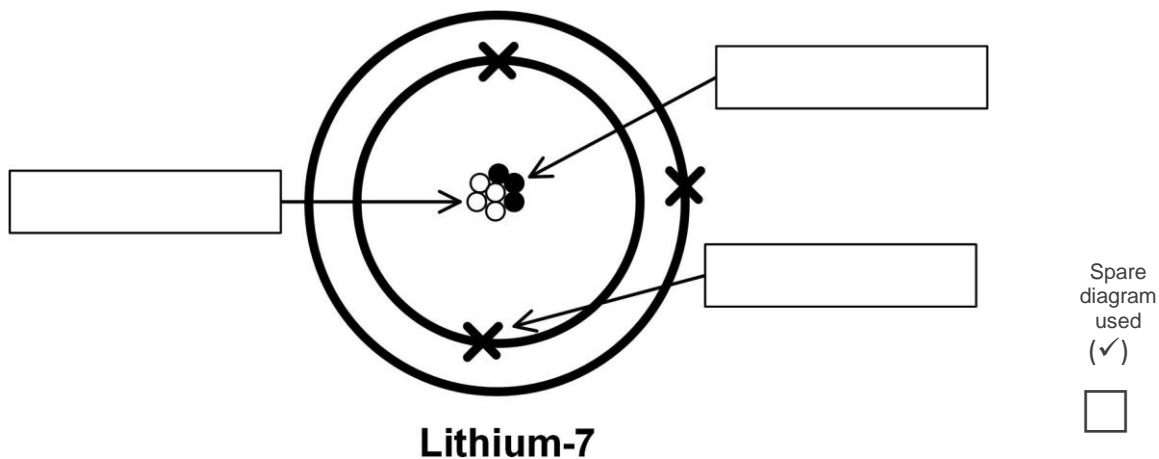
| Marker Use | |
|------------|------|
| C4 | / 36 |

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 |

Question 1

- a) The image below is that of the atom Lithium-7, (${}^7_3\text{Li}$). Label the subatomic particles present in Lithium-7.



- b) Lithium readily forms a stable Li^+ ion. Why is Li^+ the most stable ion?

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- c) Two other elements near lithium on the Periodic Table are beryllium and boron. Which of the three elements has the smallest radius? Justify your reasoning.

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- d) Give the electron configuration of beryllium.

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Marker use

2

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Total Q1

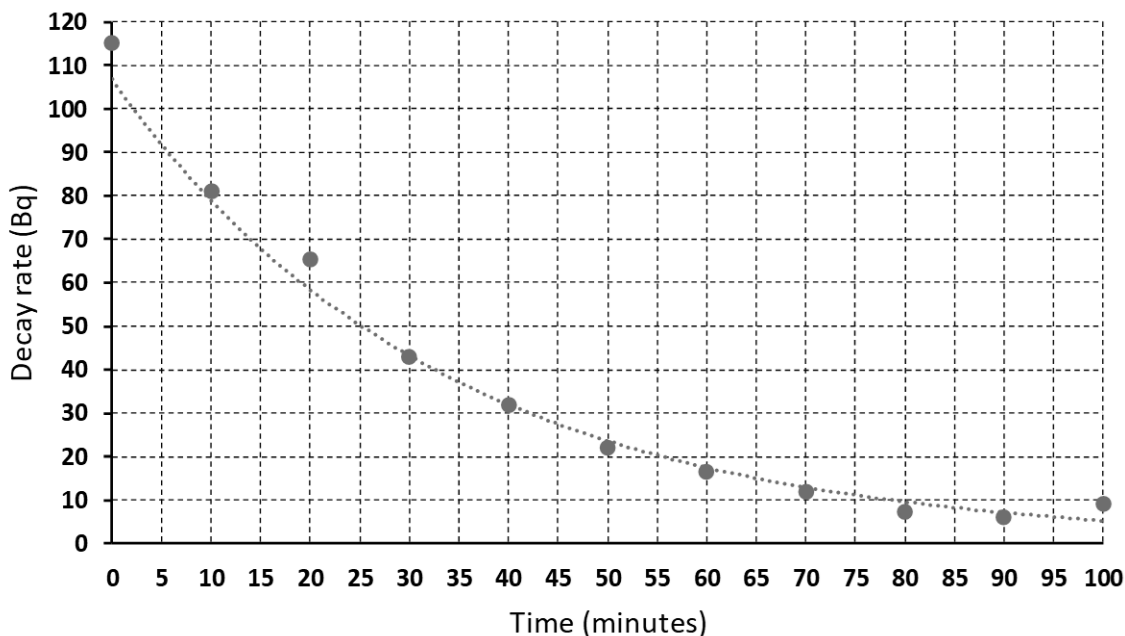
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Question 2

The element francium is found in nature, but in extremely small quantities. It is estimated that only 20 – 30 g exists at any one time in the Earth’s crust.

Its most stable isotope, Fr-223 ($^{223}_{87}\text{Fr}$), exists on Earth for only short periods. Below is a decay graph of the isotope Fr-223.

Decay Graph for Francium-223



a) From the chart determine the half-life of Fr-223.

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b) Account for the variation in the decay rate from the expected trend line.

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c) If Fr-223 decays so rapidly, how is it possible that any Fr-223 exists in the Earth’s crust at all?

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Question 2 continues

Question 2 continued

Marker use

- d) Fr-223 decays by beta decay. Write the decay equation for Fr-223, clearly indicating what isotope is formed from the beta decay.

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Total Q2

Section A continues

6

Question 3

Over the past two decades, radioimmunotherapy has been used to effectively treat many types of cancer. The treatment involves injecting cancer patients with a radioactive chemical that selectively attaches to tumour cells located throughout the body.

One method injects a radium-223 ($^{223}_{88}\text{Ra}$) chemical into the patient. Ra-223 is an **alpha** emitter.

a) Write a decay equation for Ra-223.

2

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Another method for treating different tumours involves injecting a beta emitter into the patient, forming the isotope osmium-188 ($^{188}_{76}\text{Os}$).

b) Write a decay equation for the formation of Os-188 via **beta** decay.

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c) Both alpha and beta radioimmunotherapy are very effective at killing tumours. Considering the ionisation and penetration of alpha and beta radiation, outline the advantages of each treatment.

4

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Question 3 continues

Question 3 continued

Marker use

- d) What dangers exist for a patient that has been injected with a radioactive isotope, be it an alpha or beta emitter?

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Beta decay events also often emit gamma radiation via a metastable intermediate.

- e) What use can be made of gamma radiation during radioimmunotherapy? Justify your reasoning from the properties of gamma radiation.

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Total Q3

Section A continues

11

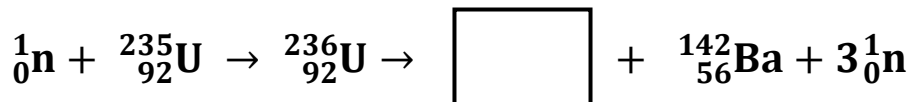
Section A continued

Marker use

Question 4

Nuclear reactors have been used to produce electrical energy around the world for over 50 years. The reaction involves the bombardment of U-235 with a neutron producing a **chain reaction** that is controlled to produce heat and, subsequently, electricity.

a) Complete the fission reaction by adding the correct isotope into the empty box below.



Spare diagram used (✓)

1

b) What is meant by a chain reaction?

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c) The isotope Ba-142 has a half-life of 10.5 minutes. If a sample has an activity of 1.28 MBq, what will the activity of the sample be after 63 minutes? Give your answer in kBq.

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d) If the activity of Ba-142 is 1.28 MBq, what was its activity 21 minutes earlier?

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Question 4 continues

Question 4 continued

Marker use

e) Suggest **two (2)** sources of natural background radiation.

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Total Q4

Section A continues

7

Question 5

A single carbon-12 atom has a mass of 1.993×10^{-23} g. It has a relative mass of exactly 12 atomic mass units.

- a) The weighted mass of a chlorine atom over its two isotopes is 5.888×10^{-23} g. Show that its relative atomic mass is 35.45 .

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- b) Chlorine has two isotopes, Cl-35 and Cl-37. From the relative atomic mass, calculate the percentage of each isotope present in naturally occurring chlorine.

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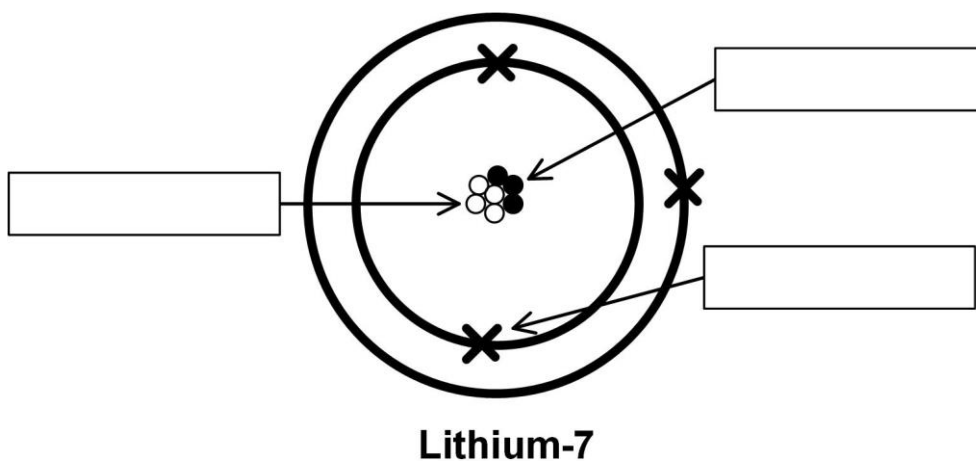
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Total Q5

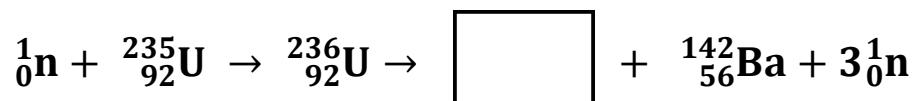
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Spare Diagrams

Question 1 a)



Question 4 a)



End of Section A



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External Assessment 2022

PHYSICAL SCIENCES

PSC315118

Section **B**

| | |
|-------------------|----|
| Pages | 12 |
| Questions | 5 |
| Information Sheet | 1 |

Suggested working time: 36 minutes

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

| Marker Use | |
|------------|------|
| C5 | / 36 |

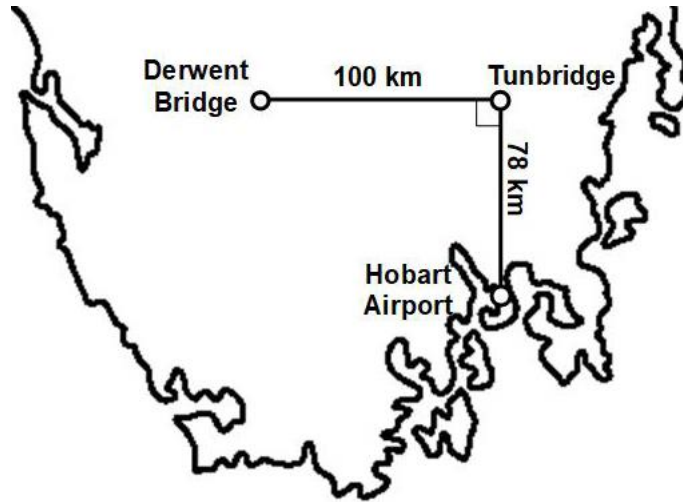
Guide to Exam Structure

| | 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 |

Question 6

Marker use

A helicopter was dispatched from the Hobart Airport and travelled directly North to Tunbridge, a distance of 78 km, in a time of 36 minutes. It then turned directly West, travelling 100 km to the town of Derwent Bridge, taking a further 40 minutes.



a) What distance was travelled by the helicopter?

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b) What is the helicopter's displacement for the whole journey?

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c) What velocity would the helicopter need if it was to return to Hobart in 30 minutes.

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Total Q6

Section B continues

6

Question 7

Cross-country skiing is a form of skiing where skiers rely on their own locomotion to move across a snow-covered field.

A cross-country skier at the recent winter Beijing Olympics completed the 15.0 km course in 0.632 hours.

- a) Calculate the average speed of the skier for the race in km h^{-1} .

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- b) Calculate the average speed of the skier in m s^{-1} .

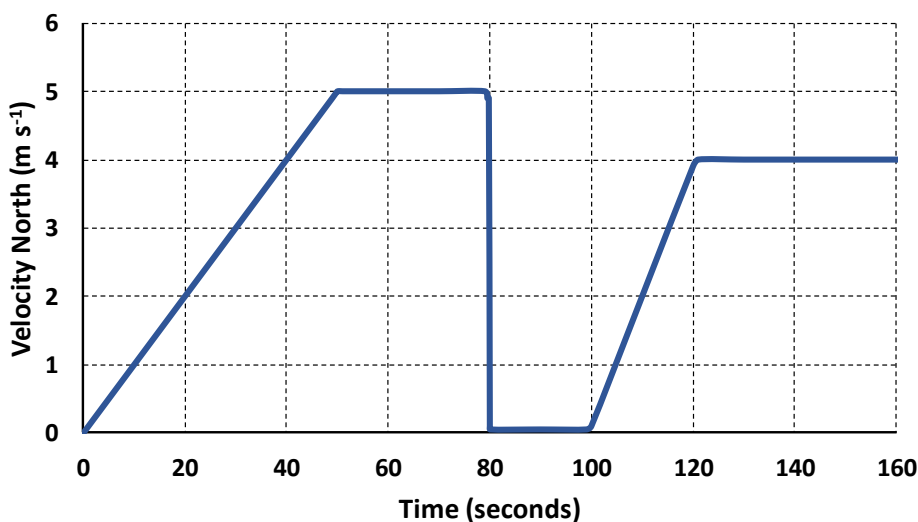
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A graph showing the velocity of the skier for a short period of time is displayed below.

Cross-country Skier Velocity vs Time Recording



- c) At what time interval(s) was the skier stationary?

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- d) What was the total distance covered by the skier in the 160 second recording?

/ 2

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Question 7 continues

Question 7 continued

Marker use

e) What is the acceleration of the skier in the first 40 seconds?

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Total Q7

6

Section B continues

Section B continued

Marker use

Question 8

An electric car with a mass of 1850 kg is travelling at 10 m s^{-1} North. It accelerates at 2.5 m s^{-2} North for 10 seconds.

a) Calculate the final velocity of the car.

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b) What displacement did the car travel during this time?

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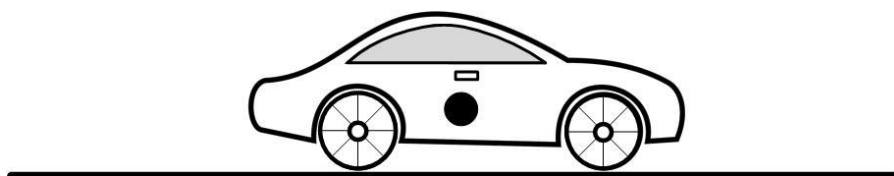
c) What is the weight of the car?

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d) On the diagram below, sketch the forces on the car during the acceleration. Assume no friction exists.

3



Spare diagram used (✓)

Question 8 continues

Question 8 continued

Marker use

- e) During the acceleration, the driver of the car noticed she felt pushed back in her seat. Use one of Newton's laws to explain this phenomenon.

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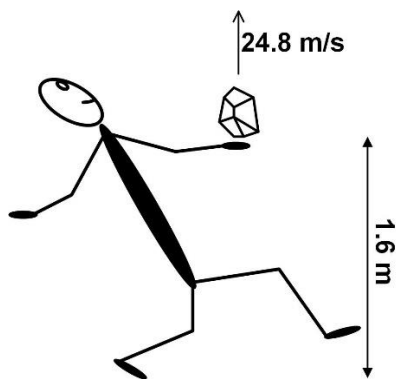
Total Q8

10

Section B continues

Question 9

A rock is thrown vertically into the air from a height of 1.60 m above the ground with a velocity of 24.8 m s⁻¹ upwards.



a) Calculate the maximum height above the ground reached by the rock.

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b) Calculate the time until the rock impacts the ground after being thrown into the air.

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Question 9 continues

Question 9 continued

Marker use

In a similar experiment, the rock is replaced with a light ball of the same size. The ball rises a smaller distance before falling and quickly reaching its terminal velocity.

c) What is meant by terminal velocity?

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d) In this situation, why does the ball reach terminal velocity so rapidly, yet the rock appears to be affected by gravity alone?

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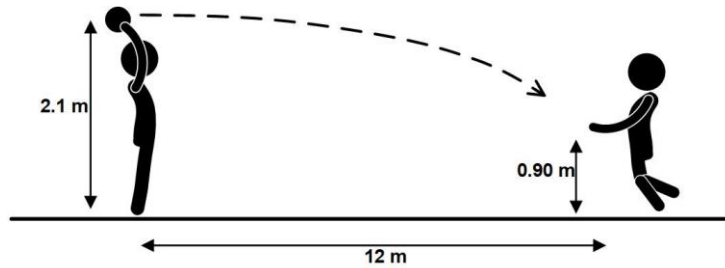
Total Q9

Section B continues

7

Question 10

A netball player throws a ball horizontally towards a teammate standing 12 m away. The ball is thrown from a height of 2.1 m. The teammate catches the ball at waist height of 0.90 m.



a) Show that the ball was in the air for about 0.5 seconds.

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b) Calculate the initial horizontal velocity of the ball.

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c) What final velocity did the ball have when caught by the teammate?

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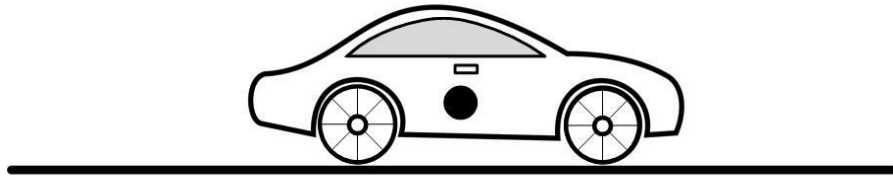
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Total Q10

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Spare Diagram

Question 8 d)



End of Section B



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External Assessment 2022

PHYSICAL SCIENCES

PSC315118

Section **C**

| | |
|-------------------|----|
| Pages | 12 |
| Questions | 5 |
| Information Sheet | 1 |

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

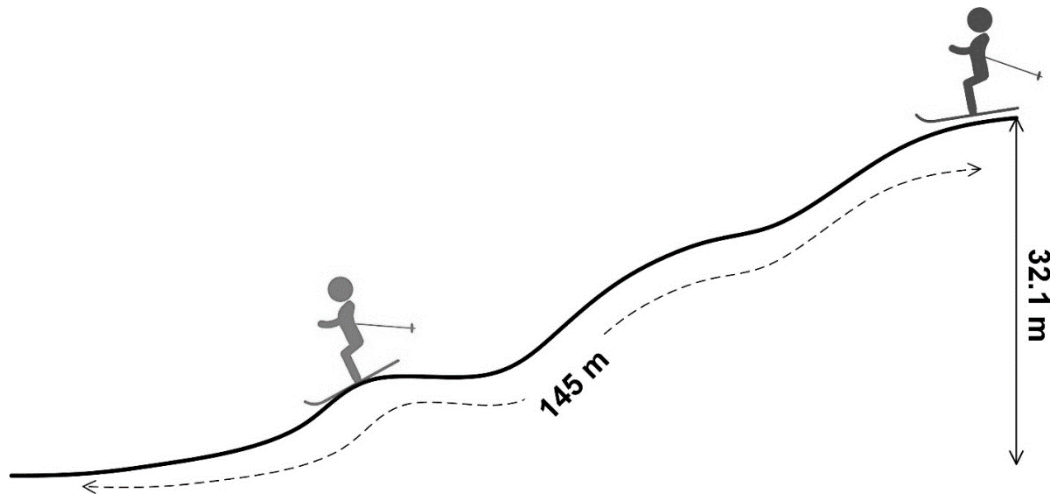
| Marker Use | |
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| C6 | / 36 |

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 |

Question 11

A 74.5 kg skier is stationary at the top of a 145 m long ski run that has a vertical height of 32.1 m.



a) Calculate the skier's potential energy at the top of the ski run.

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b) If the slope was frictionless, what is the skier's kinetic energy at the bottom of the run?

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The slope is not frictionless and the skier's speed was measured at the bottom of the run to be only 18.0 m s⁻¹.

c) Calculate the work done by friction on the skier .

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d) Calculate the magnitude of the average frictional force on the skier.

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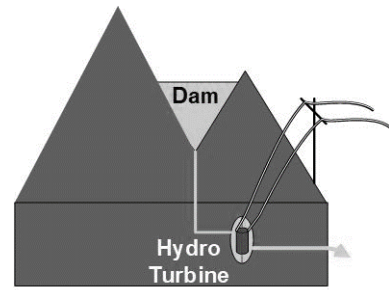
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Total Q11

/ 6

Question 12

One method used to generate energy is hydroelectric power, where water is collected in high elevation dams and run through low lying electrical generators or turbines.



Marker use

A dam in Tasmania stores 1.8×10^9 kg water every **24 hours**. This is released into a turbine 180 m below the dam.

a) What is the theoretical amount of electrical energy that can be generated in 24 hours.

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b) When the 1.8×10^9 kg of water drops the 180 m to the generator, it is found to create 1.43 TJ of electrical energy. Calculate the percentage of gravitational potential energy changed to electrical energy.

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c) Calculate the power output from the turbine.

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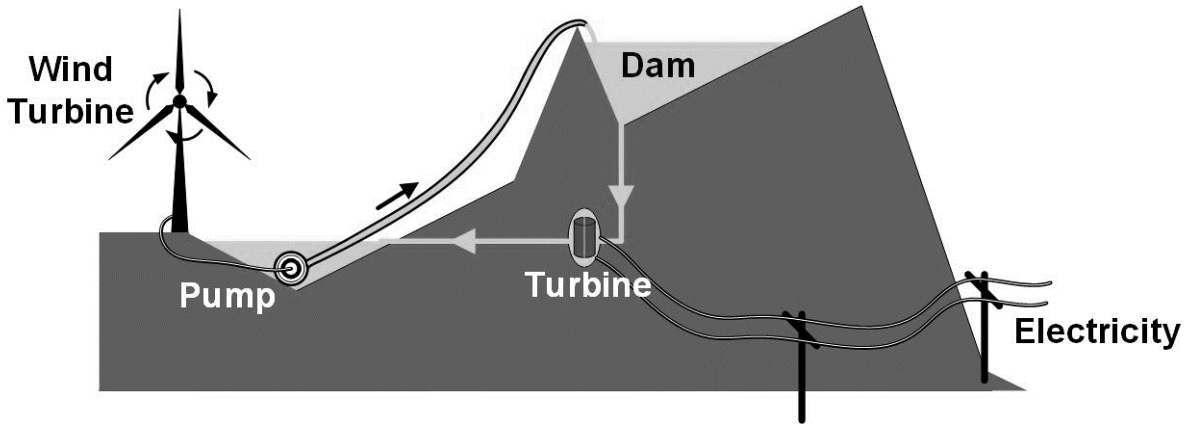
Question 12 continues

Question 12 continued

Marker use

Another method of generating reliable energy is wind turbines combined with pumped hydroelectric storage.

The image below outlines the process where a wind turbine powers a water pump, which is used to fill an elevated dam.



d) What energy changes are occurring in this pumped hydroelectric system.

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Total Q12

Section C continues

7

Question 13

a) Using circuit notation, sketch a circuit showing a battery connected to a resistor. A current flows through the resistor. Include a voltmeter and ammeter in the circuit to correctly read the voltage across, and current through, the resistor.

2

b) In the circuit you have designed, if you used a 1.5 V battery and a 6.0 ohm resistor, what is the reading on the:

2

i. Voltmeter:

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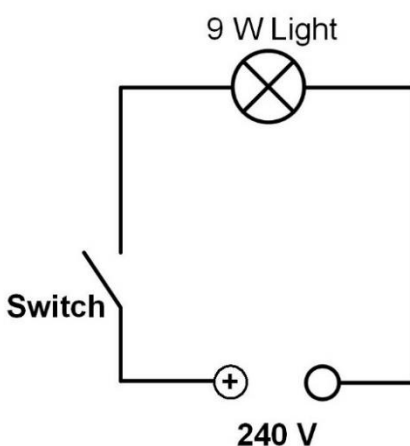
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ii. Ammeter:

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The circuit design for room lighting in a house is displayed below. A 9.0 watt light bulb is used.



c) If the power supply in Australia is 240 V, calculate the resistance of the 9.0 W light bulb.

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Question 13 continues

Question 13 continued

Marker use

The homeowner wants to add a second light bulb in parallel to make the total light power output 20 W.

d) Calculate the resistance of the second light bulb.

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e) If electrical energy costs 24.697 c per kWh, calculate the cost of running the 20 W light system for one full day. Give your answer to the nearest cent.

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Total Q13

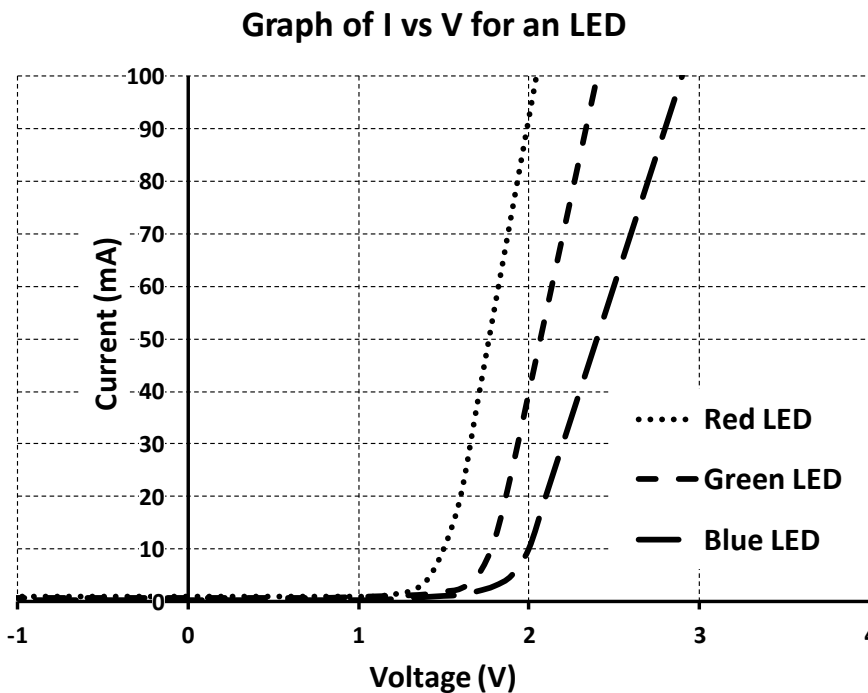
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Section C continues

Question 14

There are many different types of diodes that are placed in circuits. One common type is the LED, Light Emitting Diode.

These diodes come in a range of colours and their non-ohmic electrical behaviour is important in electronic devices. To illustrate this, a graph of I vs V for Red, Green and Blue LED's is displayed below.



a) At 2.0 volts, what current passes through the Red LED?

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b) Given your answer to (a), what charge passes through the Red diode at 2.0 V in 1.0 second?

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c) How many electrons does this represent?

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Question 14 continues

Question 14 continued

Marker use

d) LED's are non-ohmic resistors. What aspect of the graph suggests that the Red LED is non-ohmic?

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e) At a potential difference of 2.0 V, which of the three coloured diodes has the greatest resistance? Explain your reasoning.

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Total Q14

Section C continues

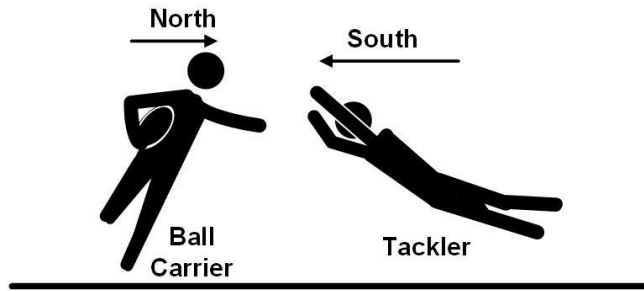
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Section C continued

Marker use

Question 15

During a game of rugby league, a 98 kg ball carrier running **northward** at 3.7 m s^{-1} is tackled by an 84 kg opponent tackler running **south** at 4.8 m s^{-1} . The pair collide and are held together during the encounter.



a) Calculate the momentum of each of the ball carrier and the tackler before the collision.

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i. Ball carrier:

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ii. Tackler:

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b) Calculate the velocity of the combined players after the collision.

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c)

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i. Calculate the total kinetic energy of the two players before the collision.

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ii. Calculate the kinetic energy of the combined players after the collision.

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iii. Is this an elastic collision? Justify your answer.

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Total Q15

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End of Section C



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PHYSICAL SCIENCES

PSC315118

Section **D**

| | |
|-------------------|----|
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| Marker Use | |
|------------|------|
| C7 | / 36 |

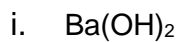
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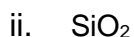
Question 16

Marker use

a) Give the systematic name of the following compounds:

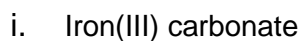


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b) Give the chemical formula of the following compounds:



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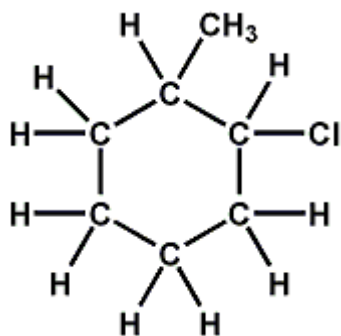


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c) Draw the structure of 3-bromopent-1-yne.

d) Give the systematic name for the following compound.

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Total Q16

Section D continues

Question 17

The elements hydrogen (H₂), nitrogen (N₂), oxygen (O₂), fluorine (F₂) and chlorine (Cl₂) are all diatomic gaseous elements at room temperature.

a) Which of the element(s) has similar chemical properties to sulfur?

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b) Which of the five diatomic elements are in the same group on the Periodic Table?

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c) Which of the above element(s) readily form -1 ions?

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d) Which of these gaseous elements can be identified using the pop test?

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Like many of these elements, combining them into molecular compounds changes their physical properties. For example, gaseous H₂ and O₂ combine chemically to form water H₂O.

e) Sketch the electron dot diagram for

i. H₂

ii. O₂

iii. H₂O

/ 3

Question 17 continues

Question 17 continued

Marker use

- f) The intramolecular bond strengths between atoms in each of H_2 , O_2 and H_2O are similar in strength. Yet water is a liquid at room temperature and H_2 and O_2 are both gases under the same conditions. With the aid of a diagram, explain this difference.

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Total Q17

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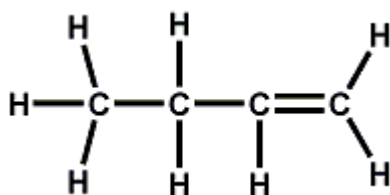
Section D continues

Section D continued

Marker use

Question 18

The chemical but-1-ene has the structure.



a) To which homologous group does but-1-ene belong?

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b) Sketch an isomer of but-1-ene that is saturated.

/ 1

c) But-1-ene readily decolours bromine via an addition reaction. Give a balanced equation using **structural formula**.

/ 2

d) But-1-ene is a highly flammable gas. Write a balanced combustion reaction with **insufficient** oxygen using **molecular formulae**.

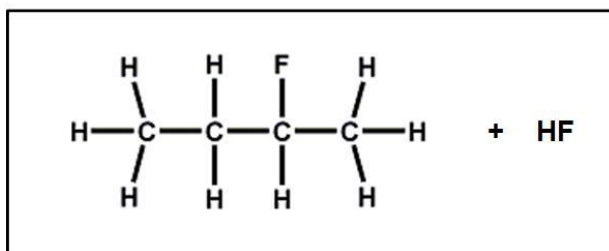
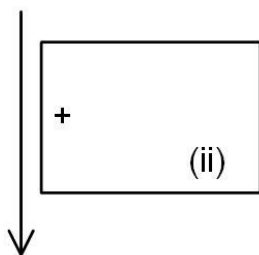
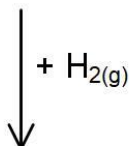
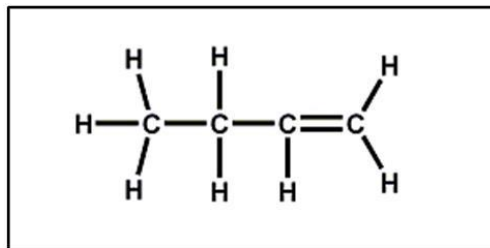
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Question 18 continues

Question 18 continued

- e) Complete the reaction sequence displayed below by sketching the structural formula for (i) and the reaction's conditions (ii).



Marker use

2

Spare diagram used (✓)

Total Q18

8

Section D continues

Question 19

Sodium is a malleable and electrically conductive metal.

- a) Describe the bonding in metallic sodium using a diagram to assist, that explains its properties of electrical conductivity and malleability .

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- b) With the aid of an electron shell diagram, describe how sodium chloride forms.

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Question 19 continues

Question 19 continues

Marker use

c) Solutions of NaCl (saltwater) are difficult to identify as they are colourless.

i. Outline a **chemical test** that can be used to identify the presence of Cl⁻ in saltwater.

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ii. **Name** a test that can be used to identify the presence of Na⁺ in saltwater.

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Total Q19

Section D continues

/ 9

Section D continued

Marker use

Question 20

Graphite is an allotrope of carbon. It is soft and does conduct electricity. With the aid of a diagram outline the structure of graphite and explain why it is **soft** and **conductive**.

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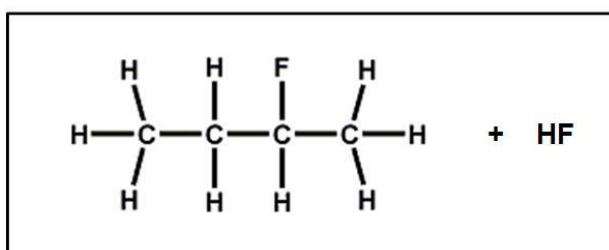
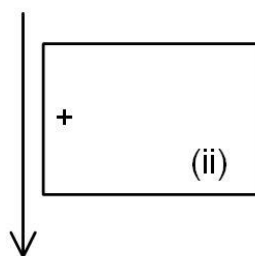
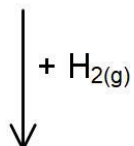
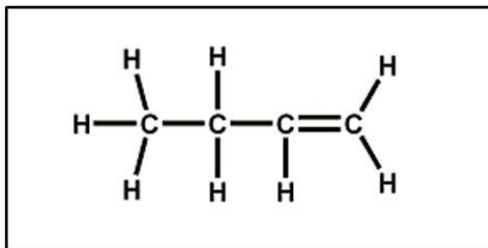
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Total Q20

3

Spare Diagram

Question 18 e)



End of Section D



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External Assessment 2022

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.
 - 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 that you spend **approximately 36 minutes** in total answering the questions in this section.
- A TASC approved scientific calculator is allowed 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:
 - Criterion 8 apply concepts and processes of chemical reactions and reacting quantities.

| Marker Use | |
|------------|------|
| C8 | / 36 |

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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 |

Question 21

Marker use

Ammonium chloride is a white crystalline compound with the formula NH_4Cl .

a) Show that the molar mass of NH_4Cl is 53.49 g mol^{-1} .

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b) Show that 22.1 g of NH_4Cl represents 0.413 moles.

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c) Find the number of **atoms** in 0.413 moles of NH_4Cl .

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d) What is the concentration of NH_4Cl solution if 0.413 moles of solid NH_4Cl is placed in a 50.0 mL volumetric flask and made up to the mark with water? Provide your answer in both **mol L⁻¹** and **g L⁻¹**.

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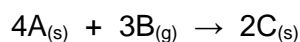
Total Q21

8

Section E continues

Question 22

A, B and C are hypothetical compounds. The following reaction takes place to form the solid C.



- a) When 25 g of A was reacted with B, 48 g of C was produced. What **mass** of B was reacted?

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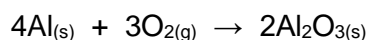
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- b) If 0.415 moles of A was reacted with B, how many **moles** of C will be produced?

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A real reaction, where aluminium is burnt in oxygen to form aluminium oxide is shown below.



- c) What mass of $Al_2O_{3(s)}$ will form from 89 g of $Al_{(s)}$?

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Total Q22

6

Section E continues

Question 23

A chemical found in the skin of green potatoes was analysed. The results were as follows:

Hydrogen = 2.24 %

Carbon = 26.7 %

Oxygen = 71.1 %.

- a) Use this information to **show** that the compound has an empirical formula, HCO_2 .

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- b) The compound was further analysed to find its molar mass, which is 90.03 g mol^{-1} . Use this information to **show** that the chemical compound is oxalic acid, $\text{H}_2\text{C}_2\text{O}_4$.

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- c) Oxalic acid is considered a weak acid.

- i. What is meant by 'a weak acid'?

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- ii. Suggest a pH of a dilute oxalic acid solution.

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Total Q23

Section E continues

/ 7

Question 24

The concentration of hydrochloric acid (HCl) is easily determined by titration against anhydrous sodium carbonate (Na_2CO_3 , $M_r = 105.99 \text{ g mol}^{-1}$).

- a) Write a balanced equation for the reaction of a dilute HCl solution with a solution of Na_2CO_3 .

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0.373 g of Na_2CO_3 was placed in a conical beaker and dissolved in water.

3 drops of acid-base indicator were added.

When titrated against an unknown HCl acid solution the Na_2CO_3 was exactly neutralised by 28.4 mL of the acid.

- b) Show that the concentration of the unknown HCl is about 0.25 mol L^{-1} .

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- c) Calculate the volume of water needed to be added to 1.0 L of 0.25 mol L^{-1} HCl to create a 0.20 mol L^{-1} solution.

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Total Q24

Section E continues

7

Question 25

The strong acid, hydrobromic acid ($\text{HBr}_{(\text{aq})}$) was reacted with sodium hydroxide (NaOH) and magnesium metal (Mg).

- a) $\text{HBr}_{(\text{aq})}$ was added to $\text{NaOH}_{(\text{aq})}$. Write a chemical equation that could represent the reaction occurring.

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- b) By referring to the Brønsted-Lowry model of acids and bases, explain the relationship that exists between an acid like HBr when reacted with a base like NaOH .

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- c) A 1.0 mol L^{-1} solution of HBr was also added to a strip of magnesium metal.

- i. Write a chemical equation that would represent the reaction.

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- ii. From your equation, outline **two (2)** observations from the reaction.

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Total Q25

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End of Section E

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