Tasmanian Certificate of Education

PHYSICAL SCIENCES

Senior Secondary

Subject Code: PSC315109

External Assessment

2013

Part 1

Time: approximately 45 minutes

On the basis of your performance in this examination, the examiners will provide a result on the following criterion taken from the course statement:

**Criterion 5** Demonstrate knowledge and understanding of the principles of force and motion.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>/40</td>
</tr>
</tbody>
</table>

Pages: 12
Questions: 6

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CANDIDATE INSTRUCTIONS

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Answer **ALL** questions. Answers must be written in the spaces provided on the examination paper.

The 2013 External Examination Information Sheet for Physical Sciences can be used throughout the examination.

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This examination is 3 hours in length.

It is recommended that you spend approximately 45 minutes in total answering the questions in this booklet.

Show all working in your answers to numerical questions. Some credit will be given for unsimplified answers but no credit will be given for an incorrect answer, unless it is accompanied by details of the working. Appropriate units must be included.

All written responses must be in English.
Question 1

(a) Aristotle (about 300 BC) was one of the first people to propose ideas about forces and motion. He believed that objects moved only as long as they were pushed. Much later Newton’s Laws of Motion overturned Aristotle’s ideas.

(i) State Newton’s Law of Motion that replaced Aristotle’s idea ‘that objects move only as long as they are pushed’. (2 marks)

(ii) Name a relevant force that Aristotle did not take into account when he proposed his ideas. (1 mark)

(b) (i) Explain, with reference to Newton’s Third Law why a person of mass 75 kg who tries to jump from a floating canoe of similar mass to a riverbank may end up falling into the water. (2 marks)

(ii) Is the person likely to experience the same problem if the person tries to jump from a 1000 kg motor boat? Explaining using one or more of Newton’s Laws. (2 marks)
Question 2

(a) Distinguish between the terms mass and weight, indicating which is a scalar and which is a vector. (2 marks)

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A person said ‘I weigh 70 kilograms’.

(b) What might a physicist object to about this statement? (1 mark)

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Question 3

A baseball is pitched horizontally straight at a wall 15.0 m away. By the time it hits the wall it has dropped 1.00 m.

(a) Show that the time of flight of the baseball is 0.452 s. (1 mark)

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(b) What is the horizontal velocity of the baseball as it is pitched? (1 mark)

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(c) Determine the velocity of the baseball as it hits the wall. (3 marks)

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**Question 4**

On the Midlands Highway, near Epping Forest, there is a 4 km section of road that can be used as a section for a speedometer check. The road has markers accurately spaced at 1 km intervals. A driver wishes to check his speedometer and starts to drive with his speedometer at 110 km h\(^{-1}\) and asks a passenger to keep a log for each 1 km interval.

The log is given below.

<table>
<thead>
<tr>
<th>Kilometre section</th>
<th>Description</th>
<th>Time taken (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 1</td>
<td>Drives consistently with the speedometer at 110 km h(^{-1}).</td>
<td>34.0</td>
</tr>
<tr>
<td>1 – 2</td>
<td>Drives behind a slow moving farm truck.</td>
<td>42.4</td>
</tr>
<tr>
<td>2 – 3</td>
<td>200 m into this section there is an opportunity to overtake the truck. The overtaking takes about 300 m.</td>
<td>32.8</td>
</tr>
<tr>
<td>3 – 4</td>
<td>Drives consistently with the speedometer at 110 km h(^{-1}).</td>
<td>34.0</td>
</tr>
</tbody>
</table>

(a) Show that the time taken for a car travelling at exactly 110 km h\(^{-1}\) is 32.7 s for each kilometre. (1 mark)

(b) What was the actual speed of the car when the speedometer was consistently showing 110 km h\(^{-1}\)? (1 mark)

(c) Using the terms average speed and instantaneous speed, explain whether it is likely the driver broke the 110 km h\(^{-1}\) speed limit at any stage during the journey. (3 marks)
Question 5

A cricket ball of mass 200 g is travelling east at 20.0 m s\(^{-1}\). It is struck by a cricket bat of mass 2.50 kg moving west at 10.0 m s\(^{-1}\).

(a) What is the initial momentum of:

(i) the cricket ball?

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(ii) the cricket bat?

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After it is hit, the ball moves directly back with a speed of 30.0 m s\(^{-1}\) west.

(b) What is the velocity of the cricket bat after it strikes the ball? (3 marks)

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(c) What is the change in momentum of the bat? (1 mark)

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The duration of impact between the bat and ball is 5 ms.

(d) Calculate the force with which the bat strikes the ball. (2 marks)

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(e) What is the force of the ball on the bat? (1 mark)

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Question 6

A 75.0 kg skydiver jumps from a stationary helicopter at a height of 1000 m. She falls with a constant acceleration of 6.00 m s\(^{-2}\) down (since there is air resistance) to a height of 400 m, at which time she opens her parachute.

(a) Show that her velocity at the time she opens her parachute is 84.9 m s\(^{-1}\) down. (2 marks)

As the parachute opens, the skydiver experiences even greater air resistance and slows to a constant downward velocity of 2.00 m s\(^{-1}\). This part of her descent takes 8.00 s.

(b) What was her average deceleration in the 8.00 s taken to reach constant velocity? (2 marks)

(c) How high was she above the ground when she reached constant velocity? (3 marks)

Question 6 continues opposite.
Question 6 (continued)

(d) What was the net force acting on the skydiver while she was: (2 marks)

(i) reaching constant velocity.
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(ii) travelling at constant velocity.
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(e) On the axes below, sketch a graph of velocity against time for the descent of the skydiver. Show only the general shape of the graph. There is no need to include any values. (2 marks)

[Graph axes: Velocity on y-axis, Time on x-axis]
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Tasmanian Certificate of Education

PHYSICAL SCIENCES

Senior Secondary

Subject Code: PSC315109

External Assessment

2013

Part 2

Time: approximately 45 minutes

On the basis of your performance in this examination, the examiners will provide a result on the following criterion taken from the course statement:

Criterion 6 Demonstrate knowledge and understanding of the principles of structures and properties of materials.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>/40</td>
</tr>
</tbody>
</table>

Pages: 12
Questions: 8

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All written responses must be in English.
**Question 7**

Complete the following table. The first line has been completed as an example. (3 marks)

<table>
<thead>
<tr>
<th>Name</th>
<th>Chemical formula</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>sodium iodide</td>
<td>NaI</td>
<td>ionic</td>
</tr>
<tr>
<td>PbCl₂</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dinitrogen tetrafluoride</td>
<td>PCl₅</td>
<td></td>
</tr>
</tbody>
</table>

**Question 8**

(a) X and Y are elements that combine to form the ionic compound XY₂. The ions X²⁺ and Y⁻ both have the same electronic configuration as the argon atom. Use the Periodic Table on the information sheet to identify X and Y. (1 mark)

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(b) Explain the following properties of metals by referring to metallic structure.

(i) Metals are conductors of heat and electricity. (2 marks)

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(ii) Metals have high density. (1 mark)

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(c) Covalent molecular substances occur as soft solids, liquids or gases. Explain why this is so with reference to the covalent molecular bonding model. (2 marks)

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### Question 9

Complete the following table. (6 marks)

<table>
<thead>
<tr>
<th>Structure</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Structure 1" /></td>
<td>4-ethyl-3-iodo-3-methylhex-1-yne</td>
</tr>
<tr>
<td><img src="image2.png" alt="Structure 2" /></td>
<td></td>
</tr>
</tbody>
</table>
Question 10

(a) Explain the meaning of the following terms: (3 marks)

(i) monomer

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(ii) polymer

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(iii) polymerisation

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(b) Illustrate the formation of polypropene (commonly called polypropylene) from its monomer. (2 marks)
Question 11

(a) A student claims that ‘a molecule of silicon dioxide contains one atom of silicon and two atoms of oxygen’.

Comment on this claim. (2 marks)

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(b) Draw an electron dot diagram to show the covalent bonding in hydrogen sulfide (H₂S). (1 mark)
**Question 12**

Below is an outline of part of the Periodic Table, in which only hydrogen and helium have their correct symbols.

| H | A | D | G | J | L | M | Q | R | He |

Use the symbols in the table to answer the following questions.

(a) Write the chemical formula for the compound formed by reacting elements D and E. (1 mark)

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(b) What type of bonding would you expect to find in a sample of element G? (1 mark)

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(c) What type of bonding would you expect in a compound formed by reacting elements A and Q? (1 mark)

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(d) (i) How many valence electrons would you find in an atom of element M? (1 mark)

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(ii) What is the ion formed by element M? (1 mark)

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(e) Write the formula for a compound of R combined with another element in Period 3 of the table that would form covalent bonds. (1 mark)

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Question 13

(a) Explain the meaning of the term *isomer*. (1 mark)

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(b) Explain the meaning of the terms *saturated* and *unsaturated*. (1 mark)

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Hex-1-ene and cyclohexane are both *isomers*. One is *saturated* and the other is *unsaturated*.

(c) Both hex-1-ene and cyclohexane are colourless liquids. Describe an experiment to distinguish between the two compounds, giving an equation to illustrate your answer. (2 marks)

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(d) Under suitable conditions cyclohexane will react with chlorine gas.

(i) What type of reaction is this? (1 mark)

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(ii) Write a balanced equation for this reaction. (1 mark)

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**Question 14**

Bunsen burners are used as a heat source in many laboratories. They operate by burning butane (C₄H₁₀). The air supply provided for the combustion can be varied by opening and closing airholes at the base of the Bunsen burner, which enables temperature to be regulated.

In the diagram below, the flame on the right is produced when the air supply is fully open, whereas the one on the left is produced when the air supply is very limited. A white tile held above the right flame remains clean, but one placed above the left flame develops a black, sooty deposit.

![Diagram of Bunsen burners with flames]

(a) Write a balanced molecular equation to show the main chemical reaction for the flame on the right. (2 marks)

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(b) Write a balanced molecular equation to show the production of the sooty deposit for the flame on the left. (2 marks)

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(c) Name and give the chemical formula of another product that can be produced in the combustion of butane. No equation is required. (1 mark)

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Tasmanian Certificate of Education

PHYSICAL SCIENCES

Senior Secondary

Subject Code: PSC315109

External Assessment

2013

Part 3

Time: approximately 45 minutes

On the basis of your performance in this examination, the examiners will provide a result on the following criterion taken from the course statement:

**Criterion 7** Demonstrate knowledge and understanding of the principles of sources and properties of energy.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Mark</th>
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<tbody>
<tr>
<td>7</td>
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</tr>
</tbody>
</table>

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Questions: 7

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All written responses must be in English.
<table>
<thead>
<tr>
<th>Question 15</th>
<th>For Marker Use Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) (i) Carefully explain the meaning of the term electrical current. (1 mark)</td>
<td></td>
</tr>
<tr>
<td>(ii) Carefully explain the meaning of the term voltage (potential difference). (1 mark)</td>
<td></td>
</tr>
<tr>
<td>(b) (i) Calculate the electrical charge passing a point in a circuit when a current of 2.0 A flows for 2.0 minutes. (1 mark)</td>
<td></td>
</tr>
<tr>
<td>(ii) How many electrons does this charge represent? (2 marks)</td>
<td></td>
</tr>
</tbody>
</table>
Question 16

A 40 W electric light globe is powered by a 240 V supply.

(a) What current does the globe draw? (1 mark)

(b) What is the resistance of the globe? (1 mark)

A bill gave the price of electric power as 0.27758 dollars per kilowatt hour.

(c) What is the cost of running the globe for 8 hours per day for a year? Give your answer to the nearest dollar. (2 marks)

(d) What mass of water falling through a height of 200 m is required to provide enough electrical energy to run the globe for an hour, assuming 100% efficiency in the conversion? (2 marks)
Question 17

A 35.0 kg child slides down a long straight slide and reaches a speed of 3.0 m s\(^{-1}\). The vertical height of the slide is 10.0 m.

(a) What is the change in potential energy of the child? (1 mark)

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(b) The slide has length 20.0 m. Calculate the average frictional force acting on the child during the descent. (3 marks)

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At the bottom of the slide there is a horizontal extension in which the child comes to rest over a distance of 2.00 m.

(c) Calculate the average frictional force that brings the child to rest. (1 mark)

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Question 18

The diagram below shows an arrangement used to measure the voltage across a device with a varying current.

(a) On the diagram, show: (1 mark)

(i) the positive and negative terminals of the battery

(ii) the direction of conventional current flow.

(b) The graph below shows the results obtained when the device is an Ohmic resistor.

Voltage vs Current for the Ohmic Resistor

Calculate the value of the resistance of the Ohmic resistor. (1 mark)

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Question 18 continues opposite.
Question 18 (continued)

(c) The graph below shows the results obtained when the device is a light globe (a non-Ohmic resistor).

Describe what happens to the resistance of the globe as the voltage across it increases.

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(1 mark)

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Question 19

Polonium (Po) is a rare and highly radioactive element with no stable isotopes.

(a) Explain the meaning of the term isotope. (1 mark)

Polonium-210 has a half life of 134.8 days. It can be produced by bombarding bismuth-209 with protons. Gamma radiation is emitted as a by-product.

(b) Write the equation to show the production of polonium-210 from bismuth-209. (1 mark)

Polonium decays by the emission of alpha particles.

(c) Write the equation for polonium decay. (1 mark)

(d) How do the alpha particles change after emission? (2 marks)

Question 19 continues opposite.
In 2006, Alexander Litvinenko, a former Russian agent, died three weeks after falling ill in London. He suffered severe organ failure. It has been suggested that he was delivered a dose of polonium-210 in a cup of tea that he drank.

(e) What particular feature of the radioactive decay of polonium-210 makes it highly toxic when ingested? Explain. (2 marks)

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(f) It was also suggested that the dose of polonium-210 was brought by air to London in a small glass bottle.

What particular feature of the radioactive decay of polonium-210 would make it safe to transport in this way, even for the person carrying it? Explain. (1 mark)

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Question 20

Iodine-128 is a radioactive nuclide often used in medicine as a tracer to measure the rate at which iodine is absorbed by the thyroid. The table below shows some measurements for the decay rate of iodine-128.

<table>
<thead>
<tr>
<th>Time (mins)</th>
<th>4</th>
<th>36</th>
<th>68</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity (Bq)</td>
<td>392</td>
<td>161</td>
<td>65</td>
<td>27</td>
</tr>
</tbody>
</table>

(a) Plot a graph of activity against time for this decay of iodine-128. 

(b) From the graph, determine the half life of iodine-128 to the nearest minute.
Question 21

A stone of mass 0.50 kg is thrown from point A with a speed of 22.0 m s⁻¹ as shown in the diagram opposite. (Ignore any effects due to air resistance.)

(a) Find the kinetic energy of the stone just as it leaves point A. (1 mark)

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(b) Show that the stone’s total energy just as it leaves point A is about 180 J. (1 mark)

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(c) Calculate the stone’s potential energy at the highest point B. (1 mark)

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(d) What is the stone’s total energy at ground level C just before impact? (1 mark)

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(e) Use energy principles to show that the stone’s speed at point B is about 20.0 m s⁻¹. (3 marks)

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(f) Determine the angle to the horizontal at which the stone was projected. (Hint: the horizontal component of the velocity remains constant.) (2 marks)

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Tasmanian Certificate of Education

PHYSICAL SCIENCES
Senior Secondary

Subject Code: PSC315109

External Assessment

2013

Part 4

Time: approximately 45 minutes

On the basis of your performance in this examination, the examiners will provide a result on the following criterion taken from the course statement:

Criterion 8 Demonstrate knowledge and understanding of the principles of chemical reactions and change.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Mark</th>
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</thead>
<tbody>
<tr>
<td>8</td>
<td>/40</td>
</tr>
</tbody>
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Question 22

Balance the following chemical equations and name the product(s).

(a) \[ \text{H}_2(g) + \text{N}_2(g) \rightarrow \text{NH}_3(g) \]  
   Name of product: 

(b) \[ \text{Fe}(s) + \text{Cl}_2(g) \rightarrow \text{FeCl}_3(s) \]  
   Name of product: 

(c) \[ \text{Ca(OH)}_2(aq) + \text{H}_3\text{PO}_4(aq) \rightarrow \text{Ca}_3(\text{PO}_4)_2(aq) + \text{H}_2\text{O}(l) \]  
   Name of products: 

Question 23

The average human body is said to contain approximately 0.40 mg of gold.

(a) Show that the average human body contains \( 2.03 \times 10^{-6} \) moles of gold.  
   (1 mark)

(b) How many atoms of gold does the average human body contain?  
   (1 mark)

(c) The quoted cost of gold is about $1500 per ounce, where 1 ounce is approximately 28.3 g. 
   What is the value of the gold in the average human body? Give your answer to the nearest whole number of cents.  
   (2 marks)
Question 24

A teacher wishes to demonstrate the concept of solubility to her class. She places a sample of ammonium carbonate solution in each of two test tubes. To one she adds a solution of sodium chloride and to the other a solution of copper II chloride.

(a) In which test tube will a precipitate form? (1 mark)
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   .................................................................

(b) (i) Write the formula equation for the precipitation you have identified in part (a) above. (2 marks)
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(ii) Write the balanced net ionic equation for this reaction. (1 mark)
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(c) Explain the meaning of the term ‘spectator ion’. (1 mark)
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(d) Identify the spectator ions in the precipitation reaction. (1 mark)
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(e) The precipitate is then filtered and the remaining solution heated to evaporate the water. Describe what will happen to the solution and name any substance which remains after the evaporation. (2 marks)
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Question 25

The reaction between potassium hydroxide and hydrochloric acid is as shown below.

\[
\text{KOH}(aq) + \text{HCl}(aq) \rightarrow \text{KCl}(aq) + \text{H}_2\text{O}(l)
\]

A 10.0 mL sample of approximately 1 mol L\(^{-1}\) KOH is added to a volumetric flask and diluted to exactly 100.0 mL.

In a titration, 0.105 mol L\(^{-1}\) standard HCl solution is used to determine the concentration of the diluted KOH solution. The average volume of HCl needed to neutralise a 25.0 mL sample of KOH solution was determined to be 21.1 mL.

(a) Show that the 21.1 mL standard HCl solution contains \(2.22 \times 10^{-3}\) mol. (1 mark)

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(b) Determine the concentration of the diluted KOH solution. (1 mark)

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(c) What was the concentration of the original KOH solution before dilution? (2 marks)

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(d) Suggest why the original solution was diluted to perform this standardisation. (1 mark)

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**Question 26**

‘Hard’ water is water that contains ions such as calcium and magnesium, which prevent soap from lathering. This effect can be counteracted by the addition of washing soda, which consists mostly of sodium carbonate together with other substances that do not react with hydrochloric acid.

The reaction between sodium carbonate and hydrochloric acid is shown.

\[
\text{Na}_2\text{CO}_3(aq) + 2\text{HCl}(aq) \rightarrow 2\text{NaCl}(aq) + \text{CO}_2(g) + \text{H}_2\text{O}(l)
\]

A 0.30 g sample of washing soda completely reacts with 19.6 mL of 0.25 mol L\(^{-1}\) HCl.

(a) Show that the molar mass of sodium carbonate is 106.0 g mol\(^{-1}\). (1 mark)

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(b) Show that the number of moles of HCl in the 19.6 mL sample is \(4.9 \times 10^{-3}\). (1 mark)

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(c) How many moles of sodium carbonate are there in the sample of washing soda? (1 mark)

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(d) Determine the percentage of sodium carbonate in the washing soda sample. (3 marks)

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Question 27

On analysis, glucose was found to contain the following elemental percentages by mass:

- 40.00% C
- 6.72% H
- 53.29% O

(a) Find the empirical formula of glucose. (2 marks)

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(b) Further analysis found the molar mass of glucose to be 180 g mol\(^{-1}\).

What is the molecular formula of glucose? (1 mark)

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.............................................................................................................................................
Question 28

One of the main ingredients of garden lime is calcium hydroxide. It is used in agriculture as a slow release conditioner to alter the pH of soil to make it more suitable for plants, such as onions, that require a non-acidic soil for maximum production. It is applied to the damp soil as a solid that will dissolve if the soil is moist.

(a) Why is calcium hydroxide effective in reducing the acidity of the soil? Support your answer with an ionic equation.

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(b) What happens to the value of the pH of the soil with the addition of garden lime?

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.............................................................................................................................................
Question 29

A teacher wishes to demonstrate a **precipitation reaction** to students.

The teacher has available **solid** samples of the following four compounds:

- barium sulfate, $\text{BaSO}_4$
- barium nitrate, $\text{Ba(NO}_3\text{)}_2$
- sodium carbonate, $\text{Na}_2\text{CO}_3$
- sodium chloride, $\text{NaCl}$

(a) Which two of the above compounds should the teacher select to demonstrate a precipitation reaction? Give reasons for your answer, by referring to the suitability or unsuitability of each of the compounds. (4 marks)

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(b) Write a balanced net ionic equation for the precipitation reaction. (1 mark)

.............................................................................................................................................
This question paper and any materials associated with this examination (including answer booklets, cover sheets, rough note paper, or information sheets) remain the property of the Tasmanian Qualifications Authority.
 CONSTANTS

Acceleration due to gravity: \( g = 9.80 \text{ m s}^{-2} \) down
Charge on an electron: \( e = -1.6 \times 10^{-19} \text{ C} \)

 EQUATIONS OF MOTION

\[
\begin{align*}
    v_{av} &= \frac{s}{t} \\
    v &= u + at \\
    v^2 &= u^2 + 2as \\
    s &= ut + \frac{1}{2}at^2
\end{align*}
\]

Moments, Energy & Power

\[
\begin{align*}
    p &= mv \\
    F_{net} &= \frac{\Delta p}{t} = \frac{m(v-u)}{t} \\
    F_{net} &= ma \\
    F_w &= mg \\
    E_k &= \frac{1}{2}mv^2 \\
    E_p &= mgh \\
    P &= \frac{W}{t} \\
    P &= \frac{\Delta E}{t} \\
    W &= Fs \\
    W &= \Delta E
\end{align*}
\]

Electricity

\[
\begin{align*}
    I &= \frac{Q}{t} \\
    V &= \frac{W}{Q} \\
    V &= \frac{\Delta E}{Q} \\
    V &= IR \\
    P &= VI = I^2R = \frac{V^2}{R}
\end{align*}
\]

Physical Quantity Symbols (SI Units)

\[
\begin{align*}
    s &= \text{displacement} \quad (\text{m}) \\
    u &= \text{initial velocity} \quad (\text{m s}^{-1}) \\
    v &= \text{final velocity} \quad (\text{m s}^{-1}) \\
    a &= \text{acceleration} \quad (\text{m s}^{-2}) \\
    t &= \text{time} \quad (\text{s}) \\
    p &= \text{momentum} \quad (\text{kg m s}^{-1}) \\
    \Delta p &= \text{change in momentum} \quad (\text{kg m s}^{-1}) \\
    m &= \text{mass} \quad (\text{kg}) \\
    F &= \text{force} \quad (\text{N}) \\
    E_k &= \text{kinetic energy} \quad (\text{J}) \\
    E_p &= \text{potential energy} \quad (\text{J}) \\
    \Delta E &= \text{change in energy} \quad (\text{J}) \\
    g &= \text{acceleration due to gravity} \quad (\text{m s}^{-2}) \\
    h &= \text{change in vertical height} \quad (\text{m}) \\
    P &= \text{power} \quad (\text{W}) \\
    W &= \text{work done} \quad (\text{J}) \\
    Q &= \text{charge} \quad (\text{C}) \\
    I &= \text{current} \quad (\text{A}) \\
    V &= \text{potential difference} \quad (\text{V}) \\
    R &= \text{resistance} \quad (\text{\Omega})
\end{align*}
\]
PREFIXES

T — tera $10^{12}$
G — giga $10^9$
M — mega $10^6$
k — kilo $10^3$
c — centi $10^{-2}$
m — milli $10^{-3}$
$\mu$ — micro $10^{-6}$
n — nano $10^{-9}$

VECTORS AT RIGHT ANGLES

\[
\tan \theta = \frac{\text{opposite}}{\text{adjacent}} = \frac{b}{a}
\]
\[
\sin \theta = \frac{\text{opposite}}{\text{hypotenuse}} = \frac{b}{c}
\]
\[
\cos \theta = \frac{\text{adjacent}}{\text{hypotenuse}} = \frac{a}{c}
\]
\[c^2 = a^2 + b^2\]

IONISING RADIATION

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<th>$\alpha$ (alpha)</th>
<th>$\beta$ (beta)</th>
<th>$\gamma$ (gamma)</th>
<th>Neutron</th>
<th>Proton</th>
</tr>
</thead>
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<tr>
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<td>electron $^0_1$e</td>
<td>electromagnetic waves</td>
<td>neutron $^1_0$n</td>
<td>proton $^1_1$H</td>
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<td>−1</td>
<td>no charge</td>
<td>no charge</td>
<td>+1</td>
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<tr>
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<td>negligible</td>
<td>none</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Distance travelled in air</td>
<td>a few cm</td>
<td>20 – 30 cm</td>
<td>long distances</td>
<td>very long distances</td>
<td>20 – 30 cm</td>
</tr>
<tr>
<td>Stopped by</td>
<td>paper, skin</td>
<td>~1 mm of aluminium</td>
<td>several cm of lead</td>
<td>thick layer of concrete</td>
<td>~1 mm of aluminium</td>
</tr>
</tbody>
</table>
ORGANIC CHEMISTRY

Alkanes: \( C_nH_{2n+2} \)
Alkenes: \( C_nH_{2n} \)
Alkynes: \( C_nH_{2n-2} \)
Cyclic Alkanes: \( C_nH_{2n} \)

ORGANIC STEM NAMES

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<tr>
<th>Carbon Atoms in Chain</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
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<tbody>
<tr>
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<td>eth-</td>
<td>prop-</td>
<td>but-</td>
<td>pent-</td>
<td>hex-</td>
<td>hept-</td>
<td>oct-</td>
<td>non-</td>
<td>dec-</td>
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</table>

SIDE CHAINS AND SUBSTITUTES

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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>methyl</td>
<td>(-CH_3)</td>
<td>bromo</td>
<td>(-Br)</td>
<td></td>
</tr>
<tr>
<td>ethyl</td>
<td>(-C_2H_5)</td>
<td>chloro</td>
<td>(-Cl)</td>
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<tr>
<td>propyl</td>
<td>(-C_3H_7)</td>
<td>fluoro</td>
<td>(-F)</td>
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<tr>
<td></td>
<td>iodo</td>
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<td>(-I)</td>
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PREFIXES

<table>
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<tr>
<th>Atoms in molecule</th>
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<th>4</th>
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<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
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<tbody>
<tr>
<td>prefix</td>
<td>mono-</td>
<td>di-</td>
<td>tri-</td>
<td>tetra-</td>
<td>penta-</td>
<td>hexa-</td>
<td>hepta-</td>
<td>octa-</td>
<td>nona-</td>
<td>deca-</td>
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GENERAL CHARACTERISTICS OF DIFFERENT STRUCTURES

<table>
<thead>
<tr>
<th>Structure</th>
<th>Melting/boiling point</th>
<th>Electrical conductivity</th>
<th>Further physical properties</th>
<th>Particles present</th>
<th>Charge carriers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Solid</td>
<td>Molten</td>
<td>Aqueous</td>
<td></td>
</tr>
<tr>
<td>Metallic</td>
<td>high</td>
<td>conducts</td>
<td>conducts</td>
<td>insoluble</td>
<td>+ ions &amp; electrons</td>
</tr>
<tr>
<td>Ionic</td>
<td>high</td>
<td>non-conducting</td>
<td>conducts</td>
<td>conducts if soluble</td>
<td>+ &amp; - ions</td>
</tr>
<tr>
<td>Covalent molecular</td>
<td>low</td>
<td>non-conducting</td>
<td>non-conducting</td>
<td>non-conducting if soluble</td>
<td>soft solids, liquids or gases</td>
</tr>
<tr>
<td>Covalent network</td>
<td>very high</td>
<td>non-conducting</td>
<td>non-conducting</td>
<td>insoluble</td>
<td>hard, brittle</td>
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### COMMON POSITIVE IONS (CATIONS)

<table>
<thead>
<tr>
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<th>1+</th>
<th>2+</th>
<th>3+</th>
<th>4+</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>ammonium NH$_4^+$</td>
<td>barium Ba$_2^+$</td>
<td>aluminium Al$_3^+$</td>
<td>lead (IV) Pb$_4^+$</td>
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<tr>
<td></td>
<td>hydrogen H$^+$</td>
<td>calcium Ca$_2^+$</td>
<td>chromium (III) Cr$_3^+$</td>
<td>tin (IV) Sn$_4^+$</td>
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<tr>
<td></td>
<td>lithium Li$^+$</td>
<td>copper (II) Cu$_2^+$</td>
<td>iron (III) Fe$_3^+$</td>
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<tr>
<td></td>
<td>potassium K$^+$</td>
<td>iron (II) Fe$_2^+$</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>silver Ag$^+$</td>
<td>lead (II) Pb$_2^+$</td>
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<td></td>
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<tr>
<td></td>
<td>sodium Na$^+$</td>
<td>magnesium Mg$_2^+$</td>
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<tr>
<td></td>
<td></td>
<td>mercury (II) Hg$_2^+$</td>
<td>nickel (II) Ni$_2^+$</td>
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<td></td>
<td>strontium Sr$_2^+$</td>
<td>tin (II) Sn$_2^+$</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>tin (II) Sn$_2^+$</td>
<td>zinc Zn$_2^+$</td>
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</table>

### NAMES AND FORMULAE OF SOME COMMON NEGATIVE IONS (ANIONS)

<table>
<thead>
<tr>
<th></th>
<th>–1</th>
<th>–2</th>
<th>–3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>bromide Br$^-$</td>
<td>carbonate CO$_3^{2-}$</td>
<td>nitride N$^3-$</td>
</tr>
<tr>
<td></td>
<td>chloride Cl$^-$</td>
<td>chromate CrO$_4^{2-}$</td>
<td>phosphate PO$_4^{3-}$</td>
</tr>
<tr>
<td></td>
<td>ethanoate (acetate) CH$_3$COO$^-$</td>
<td>dichromate Cr$_2$O$_7^{2-}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>fluoride F$^-$</td>
<td>oxide O$_2^-$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>hydrogen carbonate HCO$_3$</td>
<td>sulfate SO$_4^{2-}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>hydrogen sulfate HSO$_4^-$</td>
<td>sulfide S$_2^{2-}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>hydrogen sulfite HSO$_3^-$</td>
<td>sulfite SO$_3^{2-}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>hydroxide OH$^-$</td>
<td>thiosulfate S$_2$O$_3^{2-}$</td>
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</tr>
<tr>
<td></td>
<td>iodide I$^-$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>nitrate NO$_3^-$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>nitrite NO$_2^-$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>permanganate MnO$_4^-$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### IMPORTANT REACTIONS OF ACIDS

- acid + base [hydroxide/ metal oxide] → salt + water
- acid + reactive metal → salt + hydrogen
- acid + carbonate → salt + water + carbon dioxide
- acid + hydrogen carbonate → salt + water + carbon dioxide
### SOLUBILITY TABLE FOR COMMON IONIC COMPOUNDS

<table>
<thead>
<tr>
<th>Negative Ions (anions)</th>
<th>Solubility of Compounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>ethanoates (acetates) (CH₃COO⁻)</td>
<td>All soluble</td>
</tr>
<tr>
<td>nitrates (NO₃⁻)</td>
<td>All soluble</td>
</tr>
<tr>
<td>chlorides (Cl⁻)</td>
<td>All soluble except AgCl, PbCl₂, HgCl₂</td>
</tr>
<tr>
<td>bromides (Br⁻)</td>
<td>All soluble except AgBr, PbBr₂, HgBr₂</td>
</tr>
<tr>
<td>iodides (I⁻)</td>
<td>All soluble except AgI, PbI₂, HgI₂</td>
</tr>
<tr>
<td>sulfates (SO₄²⁻)</td>
<td>All soluble except BaSO₄, CaSO₄, SrSO₄, PbSO₄, Ag₂SO₄, SnSO₄</td>
</tr>
<tr>
<td>hydroxides (OH⁻)</td>
<td>Insoluble except LiOH, NaOH, KOH, RbOH, NH₄OH, Sr(OH)₂, Ba(OH)₂</td>
</tr>
<tr>
<td>sulfides (S²⁻)</td>
<td>Insoluble except Li₂S, Na₂S, K₂S, Rb₂S, (NH₄)₂S, MgS, CaS, SrS, BaS</td>
</tr>
<tr>
<td>carbonates (CO₃²⁻)</td>
<td>Insoluble except Li₂CO₃, Na₂CO₃, K₂CO₃, Rb₂CO₃, (NH₄)₂CO₃</td>
</tr>
<tr>
<td>phosphates (PO₄³⁻)</td>
<td>Insoluble except Li₃PO₄, Na₃PO₄, K₃PO₄, Rb₃PO₄, (NH₄)₃PO₄</td>
</tr>
<tr>
<td>sulfites (SO₃²⁻)</td>
<td>Insoluble except Li₂SO₃, Na₂SO₃, K₂SO₃, Rb₂SO₃</td>
</tr>
</tbody>
</table>

### QUANTITATIVE CHEMISTRY

Avogadro’s Number: \[ N_A = 6.02 \times 10^{23} \text{ mol}^{-1} \]

\[
N = n \times N_A
\]

\[
c = \frac{n}{V}
\]

\[
n = \frac{m}{M}
\]

- \( N \) = number of particles, etc
- \( n \) = amount of substance (mol)
- \( m \) = mass (g)
- \( M \) = molar mass (g mol⁻¹)
- \( c \) = concentration (mol L⁻¹)
- \( V \) = volume (L)
<table>
<thead>
<tr>
<th>Name</th>
<th>Symbol</th>
<th>Atomic Number</th>
<th>Relative Atomic Mass</th>
<th>Name</th>
<th>Symbol</th>
<th>Atomic Number</th>
<th>Relative Atomic Mass</th>
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<td>Hg</td>
<td>80</td>
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<td>molybdenum</td>
<td>Mo</td>
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<td>95.94</td>
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<td>americium</td>
<td>Am</td>
<td>95</td>
<td>-</td>
<td>neodymium</td>
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<td>Ne</td>
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<td>20.18</td>
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<td>9.012</td>
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<td>Os</td>
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<td>bismuth</td>
<td>Bi</td>
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<td>209.0</td>
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<td>O</td>
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<td>16.00</td>
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**Atomic number**

**Symbol**

**Name**

**Relative atomic mass**

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### Elements of the Periodic Table

- **Alkaline Earth Metals**: Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn
- **Actinides**: Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No, Lr
- **Groups**: 1A (alkali metals), 2A (alkaline earth metals), 3A–12A, 13A–18A

### Notable Elements

- **Boron (B)**: Relative atomic mass 10.81
- **Helium (He)**: Relative atomic mass 4.002
- **Lithium (Li)**: Relative atomic mass 6.941
- **Strontium (Sr)**: Relative atomic mass 87.62

### Periods

- **1st Period**: H, He
- **2nd Period**: Li, Be, B, C, N, O, F, Ne
- **3rd Period**: Na, Mg, Al, Si, P, S, Cl, Ar
- **4th Period**: K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn
- **5th Period**: Rb, Sr, Y, Zr, Nb, Mo, Tc, Ru, Rh, Pd, Ag, Cd
- **6th Period**: Cs, Ba, La, Hf, Ta, W, Re, Os, Ir, Pt, Au, Hg
- **7th Period**: Fr, Ra, Ac, Rf, Db, Sg, Bh, Hs, Mt, Uun, Uub

### Databases

- **Relative Atomic Mass**: Displayed for each element
- **Symbol**: Shown for each element
- **Name**: Clearly indicated for each element

### Additional Details

- **Actinide Series**: Elements from Lr to No
- **Lanthide Series**: Elements from La to Lr