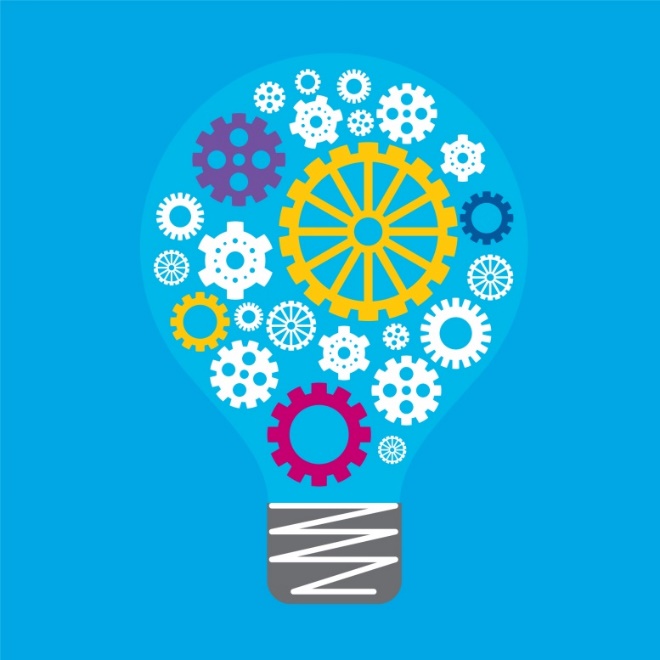
STEM – Film canister rockets

Levels 7 and 8



Disclaimer: It is the responsibility of the school to ensure that duty of care is exercised in relation to the health and safety of all students undertaking activities. In this unit of work, particular consideration should be given to ensuring adequate supervision of students for all practical activities.

Authorised and published by the Victorian Curriculum and Assessment Authority  
Level 7, 2 Lonsdale Street  
Melbourne VIC 3000

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Overview

**Unit of work:** Film canister rockets

**Levels:**  7 and 8

This learning sequence focuses on Level 8.

**Approximate time:** 20 × 1-hour sessions

This learning sequence is aimed at Levels 7 and 8 and addresses content from Design and Technologies, Science and Mathematics. The learning sequence explains how to teach students to investigate the best shape for fins when designing film canister rockets, and how to plan fair experiments, using chemical reactions, to test the creation of film canister rockets.

Rockets can have a variety of fin shapes and sizes to act as stabilisers during and after launching. These fins can be made from a range of materials and can have a variety of impacts on the flight of the rocket. Experimentation can help identify the most effective fin shape and size.

Most rockets are fuelled by chemical reactions, a process that requires specific ratios of reactants in order to be as effective as possible. Experimentation with different ratios of reactants can allow us to identify the combination that will achieve the longest flight distance.

As part of their investigation into film canister rockets, students need to investigate:

* What is the optimum fuel for a film canister rocket?
* What is the best shape for fins on a rocket?

**What makes this unit have a STEM focus?**

This unit of work incorporates content from:

* *Design and Technologies* – Creating Designed Solutions
* *Science* – Science Understanding, Chemical sciences; Science Inquiry Skills
* *Mathematics* – Measurement and Geometry, Using units of measurement, Geometric reasoning

Note: The teacher may also consider including a discussion of forms of energy (Science: Science Understanding, Physical sciences) in this learning sequence.

**Advice and considerations:**

* This learning sequence can be implemented in a number of ways. The sequence of lessons assumes an alignment or integration of learning time across Design and Technologies, Science and Mathematics classes for the students. As such, they have been ordered to accommodate the fact that students will have these classes spaced across each week. In some instances, lesson sequences could be rearranged to better suit the timetable structure. This would be a decision for the teachers involved. If this decision is made, care should be given to ensure a clear sequence of ideas is still present.
* Throughout practical activities, ensure enough time is allocated for safe and efficient pack-up and cleaning of learning spaces

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Learning area | Design and Technologies | Science | | Mathematics |
| Levels | 7–8 | 7–8 | 7–8 | 8 |
| Strand | Creating Designed Solutions | Science Understanding | Science Inquiry Skills | Measurement and Geometry |
| Sub-strand | Investigating  Generating  Producing  Evaluating  Planning and managing | Chemical sciences | Planning and conducting  Recording and processing  Analysing and evaluating  Communicating | Using units of measurement  Geometric reasoning |
| Content descriptions | Critique needs or opportunities for designing and investigate, analyse and select from a range of materials, components, tools, equipment and processes to develop design ideas [(VCDSCD049)](http://victoriancurriculum.vcaa.vic.edu.au/Curriculum/ContentDescription/VCDSCD049)  Generate, develop and test design ideas, plans and processes using appropriate technical terms and technologies including graphical representation techniques [(VCDSCD050)](http://victoriancurriculum.vcaa.vic.edu.au/Curriculum/ContentDescription/VCDSCD050)  Effectively and safely use a broad range of materials, components, tools, equipment and techniques to produce designed solutions [(VCDSCD051)](http://victoriancurriculum.vcaa.vic.edu.au/Curriculum/ContentDescription/VCDSCD051)  Independently develop criteria for success to evaluate design ideas, processes and solutions and their sustainability [(VCDSCD052)](http://victoriancurriculum.vcaa.vic.edu.au/Curriculum/ContentDescription/VCDSCD052)  Use project management processes to coordinate production of designed solutions [(VCDSCD053)](http://victoriancurriculum.vcaa.vic.edu.au/Curriculum/ContentDescription/VCDSCD053) | Chemical change involves substances reacting to form new substances [(VCSSU098)](http://victoriancurriculum.vcaa.vic.edu.au/Curriculum/ContentDescription/VCSSU098) | Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed [(VCSIS108)](http://victoriancurriculum.vcaa.vic.edu.au/Curriculum/ContentDescription/VCSIS108)  In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task [(VCSIS109)](http://victoriancurriculum.vcaa.vic.edu.au/Curriculum/ContentDescription/VCSIS109)  Construct and use a range of representations including graphs, keys and models to record and summarise data from students’ own investigations and secondary sources, and to represent and analyse patterns and relationships [(VCSIS110)](http://victoriancurriculum.vcaa.vic.edu.au/Curriculum/ContentDescription/VCSIS110)  Use scientific knowledge and findings from investigations to identify relationships, evaluate claims and draw conclusions [(VCSIS111)](http://victoriancurriculum.vcaa.vic.edu.au/Curriculum/ContentDescription/VCSIS111)  Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of the data collected, and identify improvements to the method [(VCSIS112)](http://victoriancurriculum.vcaa.vic.edu.au/Curriculum/ContentDescription/VCSIS112)  Communicate ideas, findings and solutions to problems including identifying impacts and limitations of conclusions and using appropriate scientific language and representations [(VCSIS113)](http://victoriancurriculum.vcaa.vic.edu.au/Curriculum/ContentDescription/VCSIS113) | Find perimeters and areas of parallelograms, trapeziums, rhombuses and kites [(VCMMG287)](http://victoriancurriculum.vcaa.vic.edu.au/Curriculum/ContentDescription/VCMMG287)  Establish properties of quadrilaterals using congruent triangles and angle properties, and solve related numerical problems using reasoning [(VCMMG293)](http://victoriancurriculum.vcaa.vic.edu.au/Curriculum/ContentDescription/VCMMG293) |
| Achievement Standards (relevant extracts) | By the end of Level 8 … Students create designed solutions for each of the prescribed technologies contexts based on an evaluation of needs or opportunities. They develop criteria for success, including sustainability considerations, and use these to judge the suitability of their ideas and designed solutions and processes. They create and adapt design ideas, make considered decisions and communicate to different audiences using appropriate technical terms and a range of technologies and graphical representation techniques. Students apply project management skills to document and use project plans to manage production processes. They independently and safely produce effective designed solutions for the intended purpose. | By the end of Level 8, students … use the particle model to predict, compare and explain the physical and chemical properties and behaviours of substances … They provide evidence for observed chemical changes in terms of … heat change, gas production …  They plan experiments, identifying variables to be changed, measured and controlled. They consider accuracy and ethics when planning investigations, including designing field or experimental methods. Students summarise data from different sources and construct representations of their data to reveal and analyse patterns and relationships, and use these when justifying their conclusions. They explain how modifications to methods could improve the quality of their data and apply their scientific knowledge and investigation findings to evaluate claims made by others. They use appropriate scientific language, representations and simple word equations to communicate science ideas, methods and findings. | | Students … find the perimeter and area of parallelograms, rhombuses and kites … Students identify conditions for the congruence of triangles and deduce the properties of quadrilaterals. They use tools, including digital technology, to construct congruent shapes. |

Equipment and resources

The equipment and resources required may vary depending on the design options selected. Quantities needed per student are indicative only.

* six identical film canisters per student. Teachers should test these in the manner described in the appendices.(**Tip:** You may be able to source film canisters from a local photography store, or you can buy empty film canisters via online shopping websites such as Amazon.com.)
* safety equipment, including safety glasses
* approximately 50 millilitres white vinegar per student
* 200 grams sodium bicarbonate (bicarbonate of soda) per student
* paper towel: pre-cutting this into approximately 10 centimetre × 10 centimetre squares will save students time. Each student will need approximately 20 sheets
* hot glue gun and glue
* a variety of suitable materials for students to construct their fins, such as high-impact polystyrene and thick card or cardboard (supply a variety of thicknesses and types, if possible). Ideally, these should be easy to cut in order to avoid the need for access to a workshop and/or potentially hazardous cutting instruments.
* scissors
* chalk
* mass balances capable of measuring to an accuracy of 0.1 gram
* 10 millilitre and 25 millilitre measuring cylinders (preferably plastic)
* measuring tapes and/or trundle wheels
* ‘Assessment rubric’ [(Appendix 1)](#Appendix1)
* ‘Custom-made launcher suggested design and set-up’ ([Appendix 2](#Appendix2))
* ‘Launch procedure’[(Appendix 3)](#Appendix3)
* ‘Testing fuel mixtures’ sheet [(Appendix 4)](#Appendix4)
* ‘Fin shapes’graphic [(Appendix 5)](#Appendix5)
* ‘Particles: states of matter’graphic [(Appendix 6)](#Appendix6)
* ‘Fin design template’[(Appendix 7)](#Appendix7)(six copies of template can be put together in a design booklet. An example of this can be found in the [FUSE resource package B9XQ2X](https://victoriancurriculum.vcaa.vic.edu.au/level8?layout=1&d=M&d=PSC))
* ‘Chemical change experiment’sheet [(Appendix 8)](#Appendix8)
* ‘Fin attachment procedure’[(Appendix 9)](#Appendix9)
* ‘Rocket testing record’ sheet [(Appendix 10)](#Appendix10)
* ‘Scientific report features’ [(Appendix 11)](#Appendix11)
* ‘Scientific report template’ ([FUSE resource package B9XQ2X](http://fuse.education.vic.gov.au/ResourcePackage/ByPin?pin=B9XQ2X))
* [Mathematics Curriculum Companion](http://fuse.education.vic.gov.au/?N7NDQC)

Preparation

Before commencing this unit of work:

* Review the full learning sequence and the associated [FUSE resource package B9XQ2X](http://fuse.education.vic.gov.au/ResourcePackage/ByPin?pin=B9XQ2X).
* Source 1 millimetre-thick high-impact polystyrene and varied thicknesses of cardboard.
* Source film canisters. These can typically be purchased from online retailers or teaching aid providers.
* Build multiple ‘­Custom-made launchers’[(Appendix 2)](#Appendix2). These can be constructed with two pieces of wood – your Design and Technology teacher may be of assistance.
* Test the procedure for launching the film canister rockets (see [Appendix 3](#Appendix3)).
* Print or provide digital copies of Assessment rubric [(Appendix 1)](#Appendix1), Fin design template [(Appendix 7)](#Appendix7), Testing fuel mixtures [(Appendix 4)](#Appendix4), Chemical change experiment [(Appendix 8)](#Appendix8), Fin attachment procedure [(Appendix 9)](#Appendix9) and Rocket testing record [(Appendix 10)](#Appendix10).

Occupational health and safety

Teachers should be familiar with the Victorian Department of Education and Training [Risk Management](http://www.education.vic.gov.au/school/principals/spag/governance/pages/risk.aspx) policy and related references, which provide tools and links to resources that assist in identifying and mitigating against risk in schools.

In this unit of work, particular consideration should be given to the following:

* Material safety data sheets should be made available for all chemicals used.
* Caution should be exercised when students are using hot glue guns. Ensure students are adequately supervised throughout.
* Students should stand well back and safety glasses should be worn when firing rockets.

Key concepts and vocabulary

**Congruence:** Two plane figures are called congruent if one can be moved by a sequence of translations, rotations and reflections so that it fits exactly on top of the other figure.

**Variable that is controlled:** A variable that is kept constant (or changed in constant ways) during an investigation. *Variables that are controlled* in this learning sequence include: the amount of fuel used in each rocket; the angle at which each rocket is fired; the size (area) of fins; the number of fins; and the material from which the fins are constructed.

**Variable that is measured:** A variable that changes in response to changes to the independent variable in an investigation. The *variable that is measured* in this learning sequence is the distance the rocket travels.

**Variable that is changed:** The variable that is changed in an investigation to see what effect it has on the dependent variable. The variable that is changed in this learning sequence is the fin shape.

**Particle model:** A model which accounts for the physical properties of matter. It states that all matter is made of discrete particles that are in constant motion. The motion of these particles depends on the state of matter in question.

Learning sequence summary

|  |  |  |
| --- | --- | --- |
| Lesson | Lesson focus | Main lesson activity |
| 1 | Science | Chemical change and initial rocket testing |
| 2 | Science | Variables and optimum fuel investigation |
| 3 | Mathematics | Area of quadrilaterals calculations |
| 4 | Science | Particle model exploration |
| 5 | Mathematics | Fin design, area calculations |
| 6 | Science | Physical versus chemical change |
| 7 | Mathematics | Finishing fin designs, area calculations |
| 8 | Science | Chemical reaction word equations |
| 9 | Design and Technologies | Creating fins |
| 10 | Design and Technologies | Constructing rockets |
| 11 | Science | Beginning rocket testing |
| 12 | Mathematics | Congruence and quadrilaterals |
| 13 | Science | Continue rocket testing |
| 14 | Mathematics | Angles and congruence of fins |
| 15 | Science | Finalising rocket testing |
| 16 | Science | Finalising rocket testing |
| 17 | Science | Investigation report-writing |
| 18 | Science | Investigation report-writing |
| 19 | Science | Investigation report-writing |
| 20 | Science | Submitting reports and sequence reflections |

Learning sequence

Session 1

**Learning intention:**

We will understand that the reaction of acids and carbonates is an example of a chemical change and that this reaction can be used to power a rocket.

**Success criteria:**

I can identify signs of a chemical change in a reaction.

I can use a chemical reaction to launch a film canister rocket.

* Students will require the following equipment and resources for this session:
* approximately 50 millilitres white vinegar per student
* 200 grams sodium bicarbonate (bicarbonate of soda) per student
* approximately 20 sheets of paper towel, cut into 10 × 10 centimetre squares
* six identical film canisters per student. Teachers should test these in the manner described in the appendices.(**Tip:** You may be able to source film canisters from a local photography store, or you can buy empty film canisters via online shopping websites such as Amazon.com.)
* ‘Launch procedure’ [(Appendix 3)](#Appendix3)
* mass balances capable of measuring to an accuracy of 0.1 gram
* 10 millilitre and 25 millilitre measuring cylinders (preferably plastic)
* Introduce the concept of chemical change. Describe the reaction of acids (in the form of vinegar) and carbonates (in the form of bicarbonate of soda) and how this can be used to power a film canister rocket. This can be done in a number of ways, including by drawing the reactants and products on the whiteboard. Emphasise to students that we can identify this as a chemical change because a new substance (carbon dioxide) has been formed.
* Using [Appendix 3](#Appendix3), demonstrate to students how to launch rockets, using a set amount of sodium bicarbonate and vinegar (1.5 grams and 10 millilitres are reliable amounts for an effective launch) to create the fuel mixture that produces a gas, i.e. a chemical reaction.
* Help students practise using a balance to weigh out the prescribed amount of bicarbonate of soda and a measuring cylinder to measure the vinegar. Explicit teaching of how to read the volume using the bottom (glass measuring cylinders) or the top (plastic) of the curve of the meniscus will help students achieve more accurate measurement.
* Students can conduct multiple tests with these quantities of reagents to become familiar with the general launch procedure for the rockets. Guide students through reflection of what they noticed throughout the launching process and any questions they have regarding an improved rocket design.

Session 2

**Learning intention:**

We will be able to use our understanding of variables to conduct a fair experiment into the optimum fuel for a film canister rocket.

**Success criteria:**

I can correctly use the terms ‘variable that is to be measured’, ‘variable that is changed’ and ‘controlled variable’.

I can conduct a fair experiment and collect reliable results.

* Students will require the following equipment and resources for this session:
* ‘Testing fuel mixtures’ [(Appendix 4)](#Appendix4)
* approximately 50 millilitres white vinegar per student
* 200 grams sodium bicarbonate (bicarbonate of soda) per student
* approximately 20 sheets of paper towel, cut into 10 × 10 centimetre squares
* six identical film canisters per student. Teachers should test these in the manner described in the appendices.(**Tip:** You may be able to source film canisters from a local photography store, or you can buy empty film canisters via online shopping websites such as Amazon.com.)
* ‘Launch procedure’ [(Appendix 3)](#Appendix3)
* mass balances capable of measuring to an accuracy of 0.1 gram
* 10 millilitre and 25 millilitre measuring cylinders (preferably plastic)
* trundle wheel or measuring tape
* Introduce the problem to be investigated: What is the best fin shape for a rocket? Leave the idea of ‘best’ open at this stage, and brainstorm and discuss students’ ideas for defining ‘best’. Students should be guided to identify that ‘best’ in this context is referring to the fin shape that propels the rocket the furthest distance.
* Explain to students that to be certain that we have answered our question definitively, we will need to conduct a fair and rigorous experiment. Provide students with descriptions of *variables to be measured*, *variables to be changed* and *variables to be controlled*. Discuss how familiar students are with these words and provide methods for remembering the terms. Ensure that students can identify that a fair experiment only has one variable to be measured and one variable to be changed, with all others being controlled.
* Have students brainstorm variables that could fit into each category for the film canister rocket investigation and discuss their responses as a class. Ensure students can identify that the independent variable is the fin shape, the dependent variable will be the horizontal distance travelled by the rocket, and the controlled variables will include the amount of fuel used in each rocket, the angle at which each rocket is launched, the size (area) of the fins, the number of fins and the material from which the fins are constructed.
* Once students understand that the amount of fuel used will need to be a controlled variable, explain that we will want the amount of fuel that gives the optimum launch for the rockets. Introduce the structure for an investigation to determine the optimum amount of sodium bicarbonate and vinegar. Explain that this will involve testing different amounts of sodium bicarbonate (measured in grams) and vinegar (measured in millilitres). Revise the use of balances and measuring cylinders as needed.
* Provide students with ‘Testing fuel mixtures’ [(Appendix 4)](#Appendix4). Explain that this provides them with guidance about how much bicarbonate soda and vinegar to use, and a template for recording their results.
* Use a trundle wheel or measuring tape to mark out intervals on a firing range and discuss the need to follow the launch procedure from session 1 in order to ensure accurate results are collected. In particular, draw attention to the need to have the same angle formed between the rocket launcher and the ground for each firing.
* Give students time to conduct their investigation and record their results. If time permits, allow students to conduct repeat trials and calculate average distances.
* Direct students to identify their optimum fuel mixture and to justify their selection.

Session 3

**Learning intention:**

We will understand how to calculate the area of a range of quadrilaterals.

**Success criteria:**

I can accurately and consistently calculate the area of a range of quadrilaterals.

* Students will require the following equipment and resources for this session:
* ‘Fin shapes’ [(Appendix 5)](#Appendix5)
* [FUSE resource package B9XQ2X](http://fuse.education.vic.gov.au/ResourcePackage/ByPin?pin=B9XQ2X)
* [Mathematics Curriculum Companion](http://fuse.education.vic.gov.au/?N7NDQC)
* Explain to students that in their investigation they will be testing fins of six shapes – rectangle, triangle, parallelogram, rhombus, kite and trapezium. Display the ‘Fin Shapes’graphic [(Appendix 5)](#Appendix5).
* Ask students if it would be a fair experiment if the fins with different shapes also had different sizes or weights. Explain that for a flat/two-dimensional shape such as the fins, the easiest way to control for weight is to make sure that the surface area of the shapes is the same (this will mean they contain the same amount of material). Ensure students can articulate that this is a *controlled variable* for their investigation.
* Review the calculation of the area of rectangles and triangles by drawing examples of the shapes on the whiteboard and asking students to provide the formulae for each. Work through 2–3 examples of calculating area with the students.
* These formulae can be used to explicitly teach the calculations of the area of parallelograms, rhombuses, kites and trapeziums. Ensure students can correctly identify each of these shapes by displaying different versions of each, in different sizes and rotations.
* rectangle – two pairs of parallel sides with equal length, all internal angles equal to 90°
* parallelogram – two pairs of parallel sides with equal length, no internal angles equal to 90°
* kite – two pairs of adjacent sides with equal length; two pairs of equal angles opposite each other
* rhombus – four sides of equal length, no internal angles equal to 90°
* trapezium – a quadrilateral with only one pair of parallel sides
* Encourage students to identify rectangles and triangles within each of these shapes.
* Students can be scaffolded to understand the formulae needed in a range of ways. The [FUSE resource package B9XQ2X](http://fuse.education.vic.gov.au/ResourcePackage/ByPin?pin=B9XQ2X)and [Mathematics Curriculum Companion](http://fuse.education.vic.gov.au/?N7NDQC) provide a number of suggested activities, including:
* *Square centimetre paper proof of formulas*, in which students draw shapes on grid paper and estimate their area. They then identify cuts and translations of the shapes to create rectangles, squares or triangles, and confirm their estimates using the relevant area formula
* *NSpired measurement and geometry activities*, in which students can investigate relationships between length, height and area of parallelograms and rhombuses to derive the associated formulae.
* Provide students with time to record all relevant formulae and to reflect on their level of confidence using them to calculate area. Explain to students that they will continue to practise using these formulae as they design and construct their fins for the investigation.

Session 4

**Learning intention:**

We will understand that the particle model explains that all matter is made of discrete, moving particles.

**Success criteria:**

I can explain that all matter is made of tiny particles, such as molecules and atoms.

I can represent the particles in different states of matter.

* Students will require the following equipment and resources for this session:
* ‘Particles: states of matter’ [(Appendix 6)](#Appendix6)
* Direct students to stand as a group in the centre of the room. Explain that they are going to be creating a three-part model that will help them understand the key ideas of the lesson. Provide as little explicit instruction as possible throughout this activity, instead emphasising that as the session continues, students will understand what they have been doing:
* Part 1: Direct students to stand close to each other, shoulders touching or almost touching. Ask them to walk on the spot.
* Part 2: Direct students to move arm’s length from the person next to them on all sides and to walk slowly around each other. Direct students to keep within the same small area.
* Part 3: Direct students to walk quickly (but not run) around the entire room, in any direction. After a short period of this activity, ask them to take a seat.
* Ask students if they know what they were modelling in the activity. Ask them if they have heard the terms *particle model* or *states of matter* before. Collate students’ prior knowledge and ideas on the whiteboard.
* Explain to students that the particle model is a scientific theory that explains observations of matter in its different states. Explain that all matter is made of tiny, discrete particles. These particles are arranged and behave differently in each state of matter. Display and discuss ‘Particles: states of matter’ [(Appendix 6)](#Appendix6). Direct students to draw a version of these diagrams in their own workbooks. Emphasise that as a substance moves from solid to liquid to gas, the particles are becoming more energetic (linked to adding heat to the substance as it changes state).
* Brainstorm the properties of solids, liquids and gases with students. For example, solids have a definite shape, liquids take the shape of the container and gases expand to fill their container. Relate these properties to the behaviour of the particles and also to the modelling activity conducted at the beginning of the session.

Session 5

**Learning intention:**

We will be designing our fins of equal surface area for our film canister rockets.

**Success criteria:**

I can use grid paper and area formulae to design six fins of equal surface area.

* Students will require the following equipment and resources for this session:
* ‘Fin design template’[(Appendix 7)](#Appendix7)
* [FUSE resource package B9XQ2X](http://fuse.education.vic.gov.au/ResourcePackage/ByPin?pin=B9XQ2X)
* Provide students with the ‘Fin design template’[(Appendix 7)](#Appendix7). Templates can be provided as individual sheets or combined into a six-sheet booklet for students to work through for each shape. Students begin designing their fins with the same area using the fin design template booklet [(FUSE resource package B9XQ2X)](http://fuse.education.vic.gov.au/ResourcePackage/ByPin?pin=B9XQ2X). Step students through the features of the template and then demonstrate how to use this template with a worked example of a rectangle of 400 mm2. Remind students that these are scaled drawings (each square represents 100 mm2).
* Model how to use the squares to estimate area and then use the correct formula to check and confirm.
* If necessary, provide students with an explicit area to aim for in each shape: 300 mm2 or 400 mm2 are typically easy to work with for students.
* Some students may need to be provided with a completed initial shape, such as a rectangle, and then be supported to design the next shape to cover the same number of squares. For students who continue to find the task challenging, use a series of rectangles and triangles to construct each shape required to scaffold their designs.
* Encourage students to think about how they are confirming the area of each shape, asking questions such as If your rectangle covers [insert number] squares, what will the dimensions of the triangle need to be to cover the same number of squares?
* Provide time for students to complete designs of all six required shapes.

Session 6

**Learning intention:**

We will be able to distinguish between physical and chemical changes.

**Success criteria:**

I can identify if a change is a physical or chemical change.

I can explain the type of change that is occurring to launch our rockets.

* Students will require the following equipment and resources for this session:
* [FUSE resource package B9XQ2X](http://fuse.education.vic.gov.au/ResourcePackage/ByPin?pin=B9XQ2X)
* Ask students to decide whether they think their film canister rockets are being powered by a chemical change or a physical change. Collate answers and explain that students will be able to ‘lock in’ and explain their answer at the end of the lesson. (The reaction of sodium bicarbonate and vinegar is a chemical change.)
* Explain that there are a set of specific criteria we can use to help identify whether a change is purely physical (changing shape, for example) or whether a chemical change/reaction has occurred.
* Provide students with a definition of each type of change:
* A chemical change is when one or more new substances are formed during a change. In general, these changes are not reversible.
* Physical changes are when substances change their properties or appearance but do not change into new substances. These changes are often reversible.
* Explain to students that there are specific signs we can look for to identify a chemical change, including a change in colour, the formation of a precipitate, the creation of a gas or an increase or decrease in temperature because of the change (not to be confused with providing an external source of heat).
* Provide students with examples of changes such as burning wood, melting ice, dissolving substances or rusting of iron [(FUSE resource package B9XQ2X)](http://fuse.education.vic.gov.au/ResourcePackage/ByPin?pin=B9XQ2X). Direct students to categorise each change as either chemical or physical in nature using the criteria provided. Groups can share their findings the class, justifying their choices and discussing any differences between groups.
* To close the session, have students return to their answer to the question asked at the beginning of the lesson. Do they want to change their answer? Ask students to justify why they have or have not changed their answer based on what they explored throughout the lesson.

Session 7

**Learning intention:**

We will be finalising our designs for our fins of equal surface area for our film canister rockets.

**Success criteria:**

I can explain how I have designed my six fins, including how I know they will have an equal surface area.

* Students will require the following equipment and resources for this session:
* ‘Fin shapes’[(Appendix 5)](#Appendix5)
* Ask students to continue designing their fins of equal surface area. As a class, brainstorm the different types of materials students could use to make their fins. Display ‘Fin shapes’[(Appendix 5)](#Appendix5) as needed to remind students of the required shapes
* As students complete their designs using work done in Session 5 ([Appendix 7](#Appendix7)), conference with them to identify whether they are certain their fins are of equal surface area. Direct each student to show how they have calculated surface area for a sample of their shapes.
* Prior to closing the lesson, remind students that their design drawings are scaled (each grid square represents 100 mm2) and encourage them to ensure they have recorded the required dimensions. They will need these when they create their actual fins in Sessions 9 and 10.

Session 8

**Learning intention:**

We will understand how chemical changes can be represented using word equations.

**Success criteria:**

I can identify how the chemical change observed can be represented using a word equation.

I can write the word equation for the chemical change occurring in our rockets.

* Students will require the following equipment and resources for this session:
* ‘Chemical change experiment’ [(Appendix 8)](#Appendix8)
* Explain to students that to help us understand a chemical change/reaction, we can represent it using a word equation. Word equations describe the reactants (the substances present *before* the change) and the products (the substances *produced* by the change) of a chemical change
* Model this representation using a simple chemical reaction, such as:
* magnesium + hydrochloric acid → hydrogen + magnesium chloride
* Ask students to identify both the reactants and products of this chemical change.
* Explain to students that they will be practising how to identify and represent chemical change as a word equation, focusing on the reaction that powers their rockets.
* Provide students with ‘Chemical change experiment’ [(Appendix 8)](#Appendix8). Ensure students understand how to follow the procedures and fill in the template to record their results.
* Give students time to conduct the experiment and to record their observations and conclusions
* Guide students to complete a reflection around the signs of a chemical change that they observed. How confident are they in identifying reactants and products in chemical changes?
* Prior to closing the lesson, direct students to write the word equation for the chemical reaction occurring inside their film canister rockets.

Session 9

**Learning intention:**

We are using our designs to efficiently and safely create our fins and begin constructing our film canister rockets.

**Success criteria:**

I can use my fin designs to efficiently and safely cut out my fins for my rockets.

* Students will require the following equipment and resources for this session:
* ‘Fin design template’ [(Appendix 7)](#Appendix7)
* ‘Fin attachment procedure’ [(Appendix 9)](#Appendix9)
* a variety of suitable materials for students to construct their fins, such as high-impact polystyrene and thick card or cardboard (supply a variety of thicknesses and types, if possible)
* scissors
* chalk
* 220-grit sandpaper
* hot glue gun and glue
* six identical film canisters per student
* Ask students to return to the materials they brainstormed for their fins in Session 7. Discuss how effective each of their suggested materials is likely to be, in terms of its weight, strength, ease of use and cost, for example.
* Show students the available materials for their fins, including high-impact polystyrene and cardboard.
* Provide a short period of time for students to decide whether their rockets will have two, three or four fins on each rocket (this is a controlled variable in their investigation).
* Demonstrate how to cut the material safely and efficiently, by using the edges of the sheet and the lines of previously cut shapes. Explain that this reduces the time needed to complete the task, increasing efficiency while also reducing the amount of waste.
* Demonstrate how to attach each fin to the rocket body, drawing attention to the need to sand the connecting surfaces on both the film canister and the fin and to safe operation of the hot glue gun. A sample procedure is provided in ‘Fin attachment procedure’ [(Appendix 9)](#Appendix9).
* Direct students to begin reproducing the fin shapes they produced in their ‘Fin design template’ [(Appendix 7)](#Appendix7) on the sheets of material and cut them out. If time permit, they can begin attaching their fins to their film canisters (this will be completed in Session 10).
* Students will need fins for each of the six prescribed shapes. If students have not yet completed all six fin designs, then they should do so before beginning this work.

Session 10

**Learning intention:**

We will be constructing our six film canister rockets.

**Success criteria:**

I can show my completed film canister rocket for each prescribed shape.

I can evaluate how well I have constructed my film canister rockets.

* Students will require the following equipment and resources for this session:
* ‘Fin design template’ [(Appendix 7)](#Appendix7)
* ‘Fin attachment procedure’ [(Appendix 9)](#Appendix9)
* a variety of suitable materials for students to construct their fins, such as high-impact polystyrene and thick card or cardboard (supply a variety of thicknesses and types, if possible)
* scissors
* chalk
* 220-grit sandpaper
* hot glue gun and glue
* six identical film canisters per student
* Explain to students that they will need to have all six of their rockets constructed and ready to launch by the end of this session.
* Throughout this production phase, encourage students to evaluate the quality of the products they are producing, including:
* ensuring the same edge on each fin is attached to the rocket
* ensuring the fin matches the design and dimensions they have recorded
* ensuring the fins are evenly spaced around the rocket
* ensuring the fins are all attached at the same height on the rocket
* Encourage students to consider the consequences of any of the above criteria not being met. What would this mean for the results of their experiment, particularly in terms of the fairness and reliability of their results?
* Encourage students to keep a record of the design of each rocket, either by drawing or taking digital images. Students should record any considerations of different alternatives and justify why they have selected that particular design.

Session 11

**Learning intention:**

We are beginning the collection of experimental data for our film canister rocket investigation.

**Success criteria:**

I can explain how we are ensuring a fair and accurate experiment is being conducted.

I have started to record results for my investigation.

* Students will require the following equipment and resources for this session:
* ‘Rocket testing record’ [(Appendix 10)](#Appendix10)
* measuring tapes and/or trundle wheels
* If construction of rockets is not yet finished, students need to complete this work prior to beginning testing of their rockets.
* Discuss the design of the experiment with the students. Remind them of the optimum fuel they identified to launch each rocket.
* The combination of sodium bicarbonate and vinegar that resulted in the longest flight should be used. This is because the error in determining the distance each rocket travelled is less significant when the total distance travelled is longer.
* Emphasise that each rocket must be launched with an identical combination and amount of fuel in order to ensure the experiment is be fair.
* Explain the importance of keeping the angle between the wooden rocket launch pad and the chair against which it is placed the same for each test. Demonstrate what could happen to the launch distances if the angle is not kept as a controlled variable.
* Students will repeat each test to develop a more indicative average result, given that each rocket will not fly the same distance for each test. Students should aim for a minimum of three tests per rocket; more if they have extra time.
* Students can be provided with or have modelled the formula for calculating an average (i.e. average flight distance = Sum of all flights / number of flights).
* Provide students with ‘Rocket testing record’ [(Appendix 10)](#Appendix10) and ensure all students understand how to record their results accurately.
* Provide time for students to begin testing their rockets. Ensure students are recording each launch and the distance flown.

Session 12

**Learning intention:**

We will be able to use congruent triangles to develop the properties of quadrilaterals.

**Success criteria:**

I can identify the conditions for congruence of triangles.

I can bisect quadrilaterals and identify if the subsequent triangles are congruent or not.

* Students will require the following equipment and resources for this session:
* Mathematics Curriculum Companion
* Fin design template booklet (see Session 5 and [Appendix 7](#Appendix7))
* Explain that in this lesson students will be exploring the properties of quadrilaterals in terms of angles and congruent triangles. Prior knowledge of the concept of congruent triangles is assumed, including the conditions required:
* side-side-side (SSS)
* angle-side-angle (ASA)
* angle-angle-side (AAS)
* right angle-hypotenuse-side (RHS)
* If needed, review the definition of congruence and how to identify congruent triangles. [The Mathematics Curriculum Companion](http://fuse.education.vic.gov.au/?N7NDQC) identifies a number of strategies, including *Construct triangles given three sides or angles:*
* Students are given a set of initial conditions and they construct a triangle given those conditions. Students try to create different triangles from those constructed by their classmates.
* Provide three side lengths (SSS). Note: for any triangle to be possible, no side length may exceed the total length of the other two side lengths.
* Provide three angles that add to 180° (AAA). Note: for any triangle to be possible, the angles must add to exactly 180°.
* Provide two side lengths and the size of the angle between them (SAS). Note: One side length must be taken as the base and drawn first.
* Provide one angle (say, 45°) and the lengths of two sides that are not the arms of the angle (say, 12 centimetres and 10 centimetres) (ASS). This creates two possible triangles, one obtuse and one acute.
  + - If students see that all triangles constructed are congruent, then the conditions must always specify the same triangle.
    - If more than one triangle can be drawn, then the conditions cannot specify congruence.
* Revise the criteria for identifying quadrilaterals from Session 3 as needed:
* Rectangle – two pairs of parallel sides with equal length, all internal angles equal to 90°
* Parallelogram – two pairs of parallel sides with equal length, no internal angles equal to 90°
* Kite – two pairs of adjacent sides with equal length; two pairs of equal angles opposite to each other
* Rhombus – four sides of equal length, no internal angles equal to 90°
* Trapezium – a quadrilateral with only one pair of parallel sides
* Demonstrate to students that, by drawing a line bisecting each quadrilateral, all quadrilaterals can be divided into two triangles. By using their knowledge of the properties of each quadrilateral and the rules of congruence, students can infer whether the triangles that make up the quadrilateral are congruent or not.
* For example, by dividing a rhombus into two triangles, we can infer that the two triangles that compose the rhombus are congruent. We know that all sides of the rhombus are equal, therefore all the non-common sides of each triangle are also equal. The third side of each triangle is in common, so it must, by definition, be equal as well. Thus the two triangles that make up a rhombus are congruent by the side-side-side rule.
* These inferences can also be shown for:
* a rectangle and parallelogram (always contain congruent triangles)
* a kite (triangles are congruent when the bisecting line is drawn between the vertices with unequal angles; triangles are not congruent when the bisecting line is drawn between the vertices with equal angles)
* a trapezium (not composed of similar triangles).
* Students can apply and practise these points by taking their fin design template booklet and drawing bisecting lines on each fin design to divide it into two triangles. Direct students to measure the side lengths to see if the inferences taught are valid.
* For example, when they divide their rhombus into two triangles, students should measure the sides of each of the new triangles to reinforce that these two new triangles have identical side lengths and are therefore congruent.

Session 13

**Learning intention:**

We will continue testing our rockets and record accurate results.

**Success criteria:**

I can show my progress in testing my six rockets and ensure I am recording results accurately.

* Students will require the following equipment and resources for this session:
* completed rockets
* Direct students to continue testing their rockets. Ensure students set up their experiment in the same manner as they did in Session 11.
* If any students have still not finished their rocket construction, direct them to test the rockets they have already constructed so that they have some results to report. Once they have finished testing the rockets they have made, they can construct an additional rocket, test it, and continue until all rockets have been tested. Sessions 15 and 16 can be used to complete rocket testing.

Session 14

**Learning intention:**

We will be able to identify the angles in quadrilaterals and use angles to identify congruent triangles within them.

**Success criteria:**

I can use the angles of a quadrilateral to infer congruence of triangles within it.

* Students will require the following equipment and resources for this session:
* completed fin design templates
* Direct students to measure and record the angles on their fins in their fin design templates.
* Students can then use this information to identify the angles in each of the triangles created by the bisecting lines in Session 12. Students need to label these angles.
* Direct students to use the conditions for congruence of triangles and the measured angles to identify the congruent triangles present.
* Discuss whether the congruent triangles match those from Session 12.

Sessions 15–16

**Learning intention:**

We will finalise our film canister rocket testing and the collection of our results

**Success criteria:**

I can demonstrate that I have completed at least three tests for each of my six rockets

I have calculated the average flight distance for each of my six rockets

* Students will require the following equipment and resources for this session:
* completed rockets
* Direct students to finalise the testing of their rockets. Remind students that they should conduct at least three trials for each of their rockets.
* Provide time for students to calculate the average flight distance for each rocket.
* As students complete their rocket testing, they can begin to complete their experimental reports (see Sessions 17–19).

Sessions 17–19

**Learning intention:**

We will be summarising our investigation, results and conclusions in a scientific report.

**Success criteria:**

I can identify the key features of a scientific report.

I can summarise my findings and draw conclusions about the most effective fin design.

I have completed and submitted my scientific report.

* Students will require the following equipment and resources for this session:
* ‘Scientific report features’[(Appendix 11)](#Appendix11)
* ‘Assessment rubric’ [(Appendix 1)](#Appendix1)
* [FUSE resource package B9XQ2X](http://fuse.education.vic.gov.au/ResourcePackage/ByPin?pin=B9XQ2X)
* Explain to students that a key part of the scientific inquiry process is the evaluating and communicating of experimental methods, results and conclusions. This can be done in a number of ways, including a written scientific report.
* Explain to students the key features of a scientific report and their function. Display ‘Scientific report features’[(Appendix 11)](#Appendix11) to support this discussion. This can be provided to students to support their report-writing.
* Provide students with ‘Assessment rubric’ [(Appendix 1)](#Appendix1), and ensure the qualities of a high-level report are understood.
* Provide time for students to complete their reports.
* For students who require additional support, consider providing a report template [(FUSE resource package B9XQ2X)](http://fuse.education.vic.gov.au/ResourcePackage/ByPin?pin=B9XQ2X) or a version that is modified or partially completed. An alternative format, such as a poster, could also be considered, based on student need.

Session 20

**Learning intention:**

We are finalising our reports and reflecting on our investigation.

**Success criteria:**

I have submitted my final report.

I can discuss the skills and knowledge I have developed throughout this investigation.

* Direct students to make any final additions or adjustments and then submit their scientific reports.
* Students spend the remainder of the lesson reflecting on the findings of their investigation and the skills and knowledge used throughout the project.
* Some key prompts that can be used to guide this reflection are:
* What shape did students find was the best?
* How confident are they in this finding?
* How did we define the term ‘best’? Are there any other factors aside from the distance travelled that should be consider when deciding on the ‘best’ rocket?
* If students had to repeat the experiment, what would they change to improve fairness and reliability or to reduce the limitations of their conclusions?
* What learning areas were used during this experiment? How did we use Mathematics, Design and Technologies and Science throughout the investigation? What does this tell you about the role of these areas in real life?
* Did we require other skills, such as persistence, communication and collaboration? Why were these important?
* Summarise in a sentence what you learned while doing this investigation.

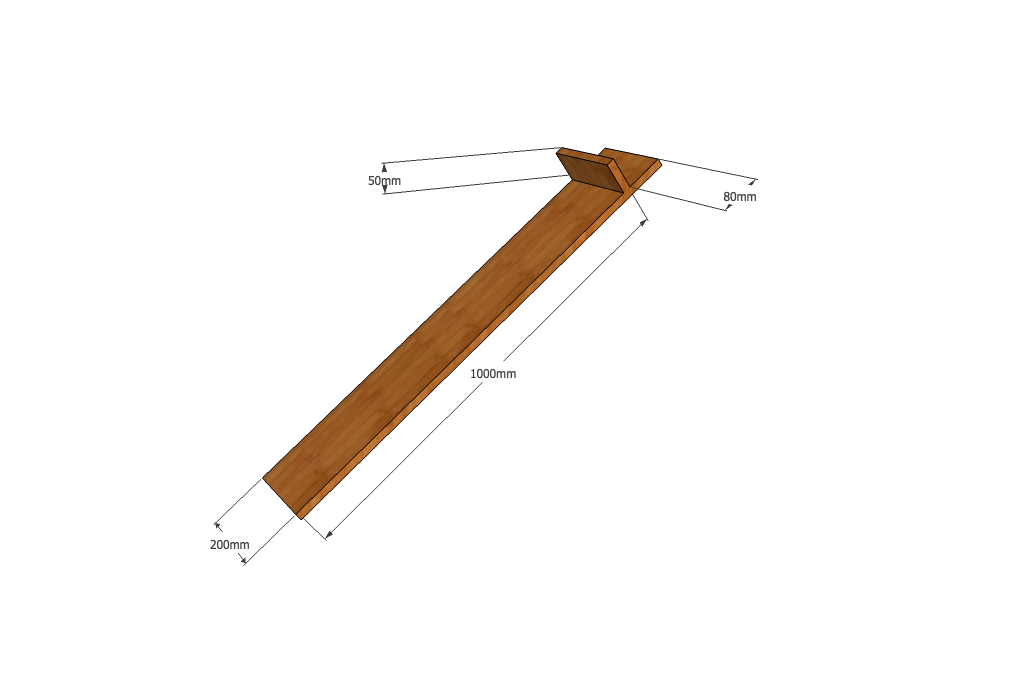
**Assessment strategies**

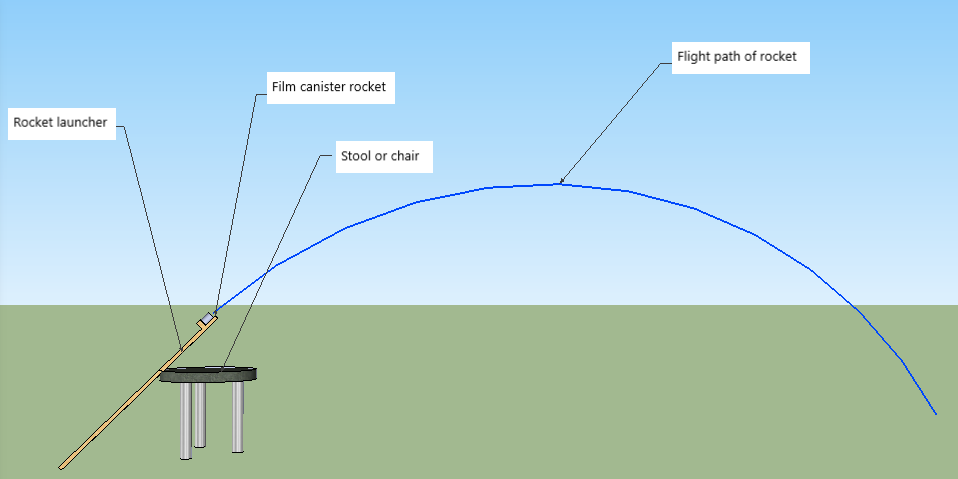
* Developmental rubric for all strands explicitly taught ([Appendix 1](#Appendix1))
* Student reflection in Session 20

Appendix 1: Assessment rubric

| **Learning area** | **Sub-strand** | **Working towards Level 8** | | **Level 8** | **Beyond Level 8** |
| --- | --- | --- | --- | --- | --- |
| **Science – Science Understanding** | **Chemical sciences** | No evidence | I can compare the properties of different states of matter  I can classify changes as reversible or irreversible | I can recognise signs of a chemical change  I can represent chemical reactions using word equations | I can write balanced equations for chemical reactions using chemical symbols |
| **Science – Science Inquiry Skills** | **Planning and conducting** | No evidence | I can identify variables to be changed and measured in our experiment  I can record accurate observations and experimental data | I can plan a fair experiment, identifying all variables  I can choose equipment to record results with appropriate accuracy | I can systemically collect reliable data and use repeat trials to increase accuracy |
| **Recording and processing** | No evidence | I can organise data into tables | I can summarise data from my investigation in an appropriate graph  I can accurately calculate averages for experimental data | I can create summary statistics and graphs to represent trends and patterns in data sets |
| **Analysing and evaluating** | No evidence | I can compare my data to my predictions when making a conclusion  I can identify ways that an experimental method can be improved | I can use my experimental data to identify relationships and draw a conclusion  I can explain how improvements to an experimental method could improve the quality of data | I can analyse patterns in results and describe relationships between variables  I can use evidence from secondary sources to evaluate claims, including my own |
| **Communicating** | No evidence | I can refer to my findings when writing a simple scientific report | I can use appropriate scientific language and representations when communicating my findings | I can use appropriate scientific language, conventions and representations when communicating findings and evidence-based arguments |
| **Mathematics – Measurement and Geometry** | **Using units of measurement** | No evidence | I can accurately calculate the area of triangles, rectangles and parallelograms | I can accurately calculate the area of a range of quadrilaterals | I can calculate the area of composite shapes |
| **Geometric reasoning** | No evidence | I can classify triangles based on side and angle properties | I can use triangles and congruence to identify properties of quadrilaterals | I can formulate proofs for congruent triangles and angle properties |
| **Design and Technologies – Creating Designed Solutions** | **Investigating** | No evidence | I can use a provided material to develop fin designs | I can use the physical properties of materials to identify those that are suitable for making fins | I can critically evaluate the available materials and identify the most suitable for constructing rocking fins |
| **Generating** | No evidence | I can develop design drawings for making fins | I can develop and adapt accurate design drawings for making fins | I can develop accurate design drawings and make connections between different elements of a design |
| **Producing** | No evidence | I can accurately produce designed fins for the film canister rockets | I can efficiently and accurately produce all fins and designed film canister rockets | I can evaluate and justify production methods for constructing the film canister rockets |
| **Evaluating** | No evidence | I can use provided criteria to decide which fin design has been most effective | I can use developed criteria to evaluate the most effective fin design for a film canister rocket | I can develop detailed criteria to evaluate the effectiveness of each fin design for the film canister rockets |
| **Planning and managing** | No evidence | I can record the processes and plans for making a film canister rocket | I can develop and follow designs and plans for creating film canister rocket fins | I can sequence production plans and apply management ideas to ensure efficient completion of the film canister rockets |

Appendix 2: Custom-made launcher suggested design and set-up





Appendix 3: Launch procedure

The following procedure is a general guide for launching film canister rockets. They will rarely fly further than 15 metres.

1. Take a 10 centimetre × 10 centimetre piece of paper towel.
2. Place 1.5 grams of sodium bicarbonate in the centre of the paper towel and fold each side over the powder, wrapping it entirely.
3. Place the wrapped package into the film canister.
4. Pour in 10 millilitres of vinegar.
5. Quickly replace the lid, give the film canister a single, quick shake, then place it on a flat surface, lid-side down.
6. Move away from the film canister and wait for it to launch. This can be instantaneous, or it may take up to two minutes.

Appendix 4: Testing fuel mixtures

|  |  |  |
| --- | --- | --- |
| Mass of sodium bicarbonate (grams) | Volume of vinegar (millilitres) | Distance travelled (metres) |
| **1** | 5 |  |
| **1** | 10 |  |
| **1** | 15 |  |
| **2** | 5 |  |
| **2** | 10 |  |
| **2** | 15 |  |
| **3** | 5 |  |
| **3** | 10 |  |
| **3** | 15 |  |

Appendix 5: Fin shapes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Triangle | Rectangle | Parallelogram | Kite | Rhombus | Trapezium |
|  |  |  |  |  |  |

Appendix 6: Particle states of matter

|  |  |  |
| --- | --- | --- |
| Arrangement of particles in a solid | Arrangement of particles in a liquid | Arrangement of particles in a gas |
|  |  |  |
| Particles in a fixed position, vibrating in place | Particles move around each other, but not enough to break free from the mass | Particles break free from each other and move randomly, bumping off each other and the sides of the container |

Appendix 7: Fin design template

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ◄ 10 mm on model ► |  |  |  | Scale : 50 mm on page = 10 mm on fins |
| ◄ 10 mm on model ► |  |  |  |
| ◄ 10 mm on model ► |  |  |  |
| ◄ 10 mm on model ► |  |  |  |
|  | ◄ 10 mm on model ► | ◄ 10 mm on model ► | ◄10 mm on model ► |

Appendix 8: Chemical change experiment

How do we know that a chemical change is happening in our rockets?

**Aim**

To identify the signs of a chemical change in our rocket fuel and to identify the word equation for this reaction

**Equipment**

* beakers × 2
* safety glasses
* sodium bicarbonate
* vinegar
* mass balances capable of measuring to an accuracy of 0.1 gram

**Method**

1. Weigh 10 grams of sodium bicarbonate and add to one beaker.
2. Use the second beaker to measure 50 millilitres of vinegar and add this to the sodium bicarbonate.
3. Record your observations.
4. Repeat at least two more times to ensure consistent results.

**Results**

When we added the vinegar to the sodium bicarbonate we observed …

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

The word equation for this reaction is

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ → \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_+\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

The reactants were \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

The products were \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**CONCLUSION**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Appendix 9: Fin attachment procedure

The following procedure outlines the steps for attaching high-impact polystyrene fins to the film canister rockets.

1. Sand the edge of the fin that is going to be attached to the film canister.

2. Sand the area of the film canister where the fin will be attached.

3. Use the hot glue gun to place a strip of glue along the edge of the fin.

4. Quickly attach the fin to the rocket and hold it in place until the glue is set.

5. Repeat the process for the remaining fins.

Note:

* Ensure the same edge on each fin is attached to the rocket.
* Make sure that the fins match the design recorded.
* Space the fins evenly around the rocket and make they are at the same height.

Appendix 10: Rocket testing record

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Fin shape | Flight distance (metres) | | | Average distance (metres) | Observations |
| Test flight 1 | Test flight 2 | Test flight 3 |
| rectangle |  |  |  |  |  |
| triangle |  |  |  |  |  |
| parallelogram |  |  |  |  |  |
| rhombus |  |  |  |  |  |
| kite |  |  |  |  |  |
| trapezium |  |  |  |  |  |

Appendix 11: Scientific report features

|  |  |
| --- | --- |
| Aim | One or two sentences outlining the purpose of the experiment |
| Hypothesis | One or two sentences outlining what the student believes will happen, with a reason. Can follow an ‘If … then … because …’ structure |
| Equipment | A list of the equipment used, with as much detail as possible given about the type and quantity of each material |
| Method | A step-by-step, numbered description of how the experiment was conducted, written in past tense, which is prescriptive enough that a reader unfamiliar with the experiment could repeat it.  Should include a record of the production method of each fin, with justification (i.e. how the fins were drawn onto the material and cut out) |
| Results | A table containing the numerical and observational results of the tests, with a graph to summarise the average performance of each rocket. |
| Discussion | Several (3–4) paragraphs describing:   * the chemical word equation that represents the reaction that powers the rocket * the chosen designs for each rocket and consideration of alternatives * an identification of the independent, dependent and controlled variables * a suggestion about how the accuracy of the experiment could be improved * some secondary data from a similar experiment with a comparison to the student’s findings (for example, from another student) * a justification of the material chosen to construct the fins. |
| Conclusion | One or two sentences that summarise what was found by the student. |