**NZQA**

**Approved**

Achievement standard: 91163 Version 2

Standard title: Demonstrate understanding of the chemistry used in the development of a current technology

Level: 2

Credits: 3

Resource title: A load of fertiliser!

Resource reference: Chemistry VP-2.3 v2

Vocational pathway: Primary Industries

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| Quality assurance status | These materials have been quality assured by NZQA.  NZQA Approved number A-A-02-2015-91163-02-8144 |
| Authenticity of evidence | Assessors/educators must manage authenticity for any assessment from a public source, because learners may have access to the assessment schedule or exemplar material.  Using this assessment resource without modification may mean that learners’ work is not authentic. Assessors/ educators may need to change figures, measurements or data sources or set a different context or topic to be investigated or a different text to read or perform. |

Vocational Pathway Assessment Resource

Achievement standard: 91163

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Learner instructions

# Introduction

This assessment activity requires you to demonstrate your understanding of the chemistry used in the development of urea fertiliser used in agriculture.

You are going to be assessed on how comprehensively you demonstrate understanding of the chemistry used in the development of urea fertiliser used in agriculture.

The following instructions provide you with a way to structure your work so you can demonstrate what you have learnt and achieve success in this standard.

# Task

The materials we use today are the result of historical developments, planned research, accident, and economic demand. The chemistry of new materials gives them certain properties. The properties of these materials make them useful to society.

You must carry out your work individually. Both your report and your notes will be assessed.

## Process, interpret and report

Research the chemistry involved in the development of urea fertiliser. Find out what experimentation, events and/or discoveries led to the development of this fertiliser.

Process and interpret secondary information that you have researched.

Prepare your report using your notes only. Show clearly your understanding of the chemistry used in the development of urea fertiliser. Hand in your notes with your report.

In your report include:

* historical development of the technology
* appropriate chemistry vocabulary, symbols and conventions (names, formulae and equations, where appropriate)
* description of the chemistry used in the development of urea fertiliser
* an explanation of the links between the chemistry and the development of urea fertiliser, and how it is useful to farmers
* an evaluation on how the chemistry influenced the development of urea fertiliser (this may involve elaborating, applying, justifying, relating, comparing and contrasting, and analysing information)
* evidence for your conclusions, for example historical milestones, quotes from your research.

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Assessor/Educator guidelines

# Introduction

The following guidelines are supplied to enable assessors/educators to carry out valid and consistent assessment using this internal assessment resource.

As with all assessment resources, education providers will need to follow their own quality control processes. Assessors/educators must manage authenticity for any assessment from a public source, because learners may have access to the assessment schedule or exemplar material. Using this assessment resource without modification may mean that learners' work is not authentic. The assessor/educator may need to change figures, measurements or data sources or set a different context or topic. Assessors/educators need to consider the local context in which learning is taking place and its relevance for learners.

Assessors/educators need to be very familiar with the outcome being assessed by the achievement standard. The achievement criteria and the explanatory notes contain information, definitions, and requirements that are crucial when interpreting the standard and assessing learners against it.

# Context/setting

This activity requires learners to demonstrate their comprehensive understanding of the chemistry involved in the development of a fertiliser used in agriculture, including the history of its development.

Decide on the format of the final presentation. It could be a poster, a computer presentation, a wiki, or any other suitable format.

# Conditions

This is an individual activity. You will determine the timeframe needed.

Learners may also use their own research findings. Information provided must be sufficient to meet the requirements of the standard.

# Resource requirements

None.

# Additional information

The following websites may be useful:

<https://en.wikipedia.org/wiki/Urea>

<http://www.teara.govt.nz/en/fertiliser-industry/page-2>

<http://www.teara.govt.nz/en/photograph/15844/kapuni-urea-plant>

<http://www.teara.govt.nz/en/photograph/21659/kapuni-ammonia-urea-plant>

<http://www.teara.govt.nz/en/interactive/15848/fertiliser-imports>

<http://www.britannica.com/science/urea>

<http://www.ballance.co.nz/>

<http://www.dairynz.co.nz/publications/farmfacts/fertiliser-and-nutrient-management/farmfact-7-11/>

http://www.google.co.nz/url?sa=t&rct=j&q=&esrc=s&source=web&cd=8&cad=rja&uact=8&ved=0CD8QFjAHahUKEwjUy46z84TJAhVENqYKHZkuBg8&url=http%3A%2F%2Fnzic.org.nz%2FChemProcesses%2Fproduction%2F1A.pdf&usg=AFQjCNE4Y78ZX0qRKhoDDZD0fWL4FEVuDQ

# Assessment schedule: Chemistry 91163 – A load of fertiliser!

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| Evidence/Judgements for Achievement | Evidence/Judgements for Achievement with Merit | Evidence/Judgements for Achievement with Excellence |
| The learner demonstrates understanding of the chemistry used in the development urea fertiliser by:   * describing the development of urea fertiliser * giving an overview of the history of urea‘s development * using chemistry vocabulary to describe the development and composition of urea   For example:  *Urea is of great importance to the primary industry as a nitrogen rich fertiliser. It has the highest nitrogen content of all solid nitrogenous fertilizers in common use. Urea is made from ammonium and contains nitrogen. Ammonium and nitrate are readily absorbed by plants, and are the dominant sources of nitrogen for plant growth.*  *Urea was first discovered in urine in 1727 by the Dutch scientist* [*Herman Boerhaave*](https://en.wikipedia.org/wiki/Herman_Boerhaave)*, though this discovery is often attributed to the* [*French*](https://en.wikipedia.org/wiki/France) *chemist* [*Hilaire Rouelle*](https://en.wikipedia.org/wiki/Hilaire_Rouelle)*. In 1828, the* [*German*](https://en.wikipedia.org/wiki/Germany) *chemist* [*Friedrich Wöhler*](https://en.wikipedia.org/wiki/Friedrich_W%C3%B6hler) *obtained urea artificially by treating* [*silver cyanate*](https://en.wikipedia.org/wiki/Silver_cyanate) *with* [*ammonium chloride*](https://en.wikipedia.org/wiki/Ammonium_chloride)*.*  *AgNCO + NH4Cl → (NH2)2CO + AgCl*  *This was the first time an organic compound was artificially synthesized from inorganic starting materials, without the involvement of living organisms. The results of this experiment implicitly discredited* [*vitalism*](https://en.wikipedia.org/wiki/Vitalism)*— the theory that the chemicals of living organisms are fundamentally different from those of inanimate matter. This insight was important for the development of* [*organic chemistry*](https://en.wikipedia.org/wiki/Organic_chemistry)*. His discovery prompted Wöhler to write triumphantly to* [*Berzelius*](https://en.wikipedia.org/wiki/J%C3%B6ns_Jakob_Berzelius)*: "I must tell you that I can make urea without the use of kidneys, either man or dog. Ammonium cyanate is urea." For this discovery, some consider Wöhler the father of organic chemistry.*  *Urea is widely used in* [*fertilizers*](https://en.wikipedia.org/wiki/Fertilizer) *as a source of nitrogen and is an important* [*raw material*](https://en.wikipedia.org/wiki/Raw_material) *for the* [*chemical industry*](https://en.wikipedia.org/wiki/Chemical_industry)*. Urea is manufactured from ammonia and then converted in to urea.*  *To make ammonia, it is synthesised from hydrogen from natural gas, and nitrogen from the air. Natural gas contains some sulphurous compounds which damage the catalysts used in the process. These are removed by reacting then with zinc oxide e.g. ZnO + H2S → ZnS + H2O. The methane from the natural gas is then converted to hydrogen*  *CH4 + H2O ↔ 3H2 + CO*  *CH4 + 2H2O ↔ 4H2 + CO2*  *CO + H2O ↔ H2 + CO2*  *Air is mixed in with the gas stream to give a hydrogen : nitrogen ratio of 3:1*  *Water, carbon monoxide and carbon dioxide are removed. The carbon monoxide is converted to carbon dioxide for the use in urea production and the carbon dioxide is removed. CO + H2O ↔ H2 + CO2. The remaining traces of CO and CO2 are converted to methane and then the gases cooled until the water becomes liquid and can be easily removed. The nitrogen and hydrogen are then reacted at high temperature and pressure using an iron catalyst to form ammonia. N2 + 3H2 ↔ 2NH3.*  *To make urea, it is made from ammonia and carbon dioxide. The ammonia and carbon dioxide are fed into the reactor at high pressure and temperature and the urea is formed in a two-step reaction*  *2NH3 + CO2 ↔ NH2COONH4 (ammonium carbamate)*  *NH2COONH4 ↔ H20 + NH2CONH2 (urea)*  *The urea contains unreacted NH3 and CO2 and ammonium carbamate. As the pressure is reduced and heat applied the NH2COONH4 decomposes to NH3 and CO2. The ammonium and carbon dioxide are recycled. The urea solution is then concentrated to give 99.6% w/w molten urea and granulated for use as fertiliser and chemical feedstock.*  *The above expected learner responses are indicative only and relate to just part of what is required.* | The learner demonstrates in-depth understanding of the chemistry used in the development of urea fertiliser by:   * describing the development of urea fertiliser * giving an overview of the history of urea‘s development * using chemistry vocabulary to describe the development and composition of urea * making and explaining links between the chemistry and the development of urea   For example:  *The key to the most efficient use of urea is to incorporate it into the soil during a tillage operation. It may also be blended into the soil with irrigation water. A rainfall of as little as 2cms is sufficient to blend urea into the soil to a depth at which ammonia losses will not occur. Nitrogen from urea can be lost to the atmosphere if fertilizer urea remains on the soil surface for extended periods of time during warm weather. Urea breakdown begins as soon as it is applied to the soil. If the soil is totally dry, no reaction happens. But with the enzyme urease, plus any small amount of soil moisture, urea normally hydrolizes and converts to ammonium and carbon dioxide. This can occur in 2 to 4 days and happens quicker on high pH soils. Unless it rains, urea must be incorporated during this time to avoid ammonia loss. Losses might be quite low in the spring if the soil temperature is cold. The chemical reaction is as follows:*  *CO(NH2)2 + H2O + urease → 2NH3 +CO2 (urea)*  *The problem is the NH3, because it is a gas, but if incorporated the NH3, acts the same as incorporated anhydrous ammonia. Also, half of 28% liquid N is urea and the same thing happens with this half as with regular urea.*  *If properly applied, urea and fertilizers containing urea are excellent sources of nitrogen for crop production. After application to the soil, urea undergoes chemical changes and ammonium (NH4 +) ions form. Soil moisture determines how rapidly this conversion takes place.*  *When a urea particle dissolves, the area around it becomes a zone of high pH and ammonia concentration. This zone can be quite toxic for a few hours. Seed and seedling roots within this zone can be killed by the free ammonia that has formed. Fortunately, this toxic zone becomes neutralized in most soils as the ammonia converts to ammonium. Usually it is just a few days before plants can effectively use the nitrogen.*  *Although urea imparts an alkaline reaction when first applied to the soil, the net effect is to produce an acid reaction.*  *Urea or materials containing urea should, in general, be broadcast and immediately incorporated into the soil. Urea-based fertilizer applied in a band should be separated from the seed by at least 10cms of soil.*  *The above expected learner responses are indicative only and relate to just part of what is required*. | The learner demonstrates comprehensive understanding of the chemistry used in the development of urea fertiliser by:   * describing the development of urea fertiliser * giving an overview of the history of urea‘s development * using chemistry vocabulary to describe the development and composition of urea * making and explaining links between the chemistry and the development of urea * evaluating how the chemistry influenced the development of urea with respect to its use by farmers   For example the learner includes in their report:  *More than 90% of world industrial production of urea is destined for use as a nitrogen-release fertilizer. Due to having the highest nitrogen content, it has the lowest transportation costs per unit of nitrogen* [*nutrient*](https://en.wikipedia.org/wiki/Nutrient)*. The standard crop-nutrient rating (*[*NPK rating*](https://en.wikipedia.org/wiki/NPK_rating)*) of urea is 46-0-0. Many soil bacteria possess the enzyme* [*urease*](https://en.wikipedia.org/wiki/Urease)*, which catalyzes conversion of urea to ammonia or ammonium ion and bicarbonate ion. Thus, urea fertilizers rapidly transform to the ammonium form in soils. Among soil bacteria known to carry urease, some ammonia-oxidizing bacteria (AOB), such as species of* [Nitrosomonas](https://en.wikipedia.org/wiki/Nitrosomonas)*, can also assimilate the carbon dioxide the reaction releases to make biomass via the* [*Calvin Cycle*](https://en.wikipedia.org/wiki/Calvin_Cycle)*, and harvest energy by oxidizing ammonia (the other product of urease) to nitrite, a process termed* [*nitrification*](https://en.wikipedia.org/wiki/Nitrification)*. Nitrite-oxidizing bacteria, especially* [Nitrobacter](https://en.wikipedia.org/wiki/Nitrobacter)*, oxidize nitrite to nitrate, which is extremely mobile in soils because of its negative charge and is a major cause of water pollution from agriculture. Ammonium and nitrate are readily absorbed by plants, and are the dominant sources of nitrogen for plant growth. Urea is also used in many multi-component solid fertilizer formulations. Urea is highly soluble in water and is, therefore, also very suitable for use in fertilizer solutions (in combination with* [*ammonium nitrate*](https://en.wikipedia.org/wiki/Ammonium_nitrate)*:* [*UAN*](https://en.wikipedia.org/wiki/UAN)*), e.g., in 'foliar feed' fertilizers. For fertilizer use, granules are preferred over prills because of their narrower particle size distribution, which is an advantage for mechanical application. The most common impurity of synthetic urea is* [*biuret*](https://en.wikipedia.org/wiki/Biuret)*, which impairs plant growth. Urea is usually spread at rates of between 40 and 300 kg/ha but rates vary. Smaller applications incur lower losses due to leaching. During summer, urea is often spread just before or during rain to minimize losses from* [*volatilization*](https://en.wikipedia.org/wiki/Ammonia_volatilization_from_urea) *(process wherein nitrogen is lost to the atmosphere as ammonia gas). Urea is not compatible with other fertilizers. Because of the high nitrogen concentration in urea, it is very important to achieve an even spread. The application equipment must be correctly calibrated and properly used. Drilling must not occur on contact with or close to seed, due to the risk of germination damage. Urea dissolves in water for application as a spray or through irrigation systems. In high rainfall areas and on sandy soils (where nitrogen can be lost through leaching) and where good in-season rainfall is expected, urea can be side- or top-dressed during the growing season. Top-dressing is also popular on pasture and forage crops. In irrigated crops, urea can be applied dry to the soil, or dissolved and applied through the irrigation water. Urea dissolves in its own weight in water, but becomes increasingly difficult to dissolve as the concentration increases. Dissolving urea in water is endothermic—the solution temperature falls when urea dissolves. As a practical guide, when preparing urea solutions for* [*fertigation*](https://en.wikipedia.org/wiki/Fertigation) *(injection into irrigation lines), dissolve no more than 3 g urea per 1 L water. In foliar sprays, urea concentrations of 0.5% – 2.0% are often used in horticultural crops. Low-*[*biuret*](https://en.wikipedia.org/wiki/Biuret) *grades of urea are often indicated. Urea absorbs moisture from the atmosphere and therefore is typically stored either in sealed bags on pallets or, if stored in bulk, under cover with a tarpaulin. As with most solid fertilizers, storage in a cool, dry, well-ventilated area is recommended.*  *The above expected learner responses are indicative only and relate to just part of what is required.* |

Final grades will be decided using professional judgement based on an examination of the evidence provided against the criteria in the Achievement Standard. Judgements should be holistic, rather than based on a checklist approach.