Excellence
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For Achievement with Excellence the student response also includes:

1. Combination

In the garden shed, some metal tools were left outside, and now they're starting to get a reddish-brown powder on them called rust. I know this is a combination reaction because iron (Fe) a solid, grey coloured metal from the tools combines with oxygen (O_2) a colourless gas in the air, to form one product, iron oxide (Fe_2O_3). The provided formula also supports this conclusion.

Reactants, products, and conservation of mass: The chemical equation for rusting is: $4Fe+3O_2 \rightarrow 2Fe_2O_3$. This balanced equation means that the number of iron and oxygen atoms stays the same on both sides of the reaction. For example, in the equation there are four iron atoms and six oxygen atoms on the reactants side, and there are four iron atoms and six oxygen atoms on the products side. The iron wasn't bonded to anything else before the reaction, but after the reaction, it has bonded with the oxygen to make the rust. Even though the iron and oxygen atoms have recombined, no atoms were lost or gained, so this shows conservation of mass.

Observations and patterns in context: I can tell that this is a combination reaction because of the predictable pattern in the equation of two reactants (iron and oxygen) becoming one product (iron oxide). I can tell the reaction is happening because of the reddish-brown colour forming on the surface of the tools. The colour change is evidence of a chemical change. On the resource sheet there is a table of metal oxide colours and the colour for iron oxide is reddish-brown. This is like a lab experiment I did where I heated copper metal to make copper oxide. The colour changed to black showing that the copper had reacted with oxygen to form copper oxide. When we scraped the black copper oxide off with sandpaper, you could see the unreacted copper underneath. For the iron tools, if you scrape rust off with sandpaper you should see unreacted iron underneath. Then the exposed iron would be touching the air so you would expect to see the colour change on the tools again when the iron and oxygen react by combination to make more iron oxide.

Implications of conservation of mass in context: An implication of conservation of mass in this reaction is that the iron oxide can't be made without oxygen, so preventing the iron in the tools from touching the oxygen will stop the rust from forming. Because the oxygen comes from the air, you would need to stop the air from touching the tools, so you could coat them with something like paint or varnish. Another implication of conservation of mass is that if the rust reaction was allowed to go to completion, all of the iron in the tools would turn into iron oxide. This is because there is an unlimited supply of oxygen in the air, so as long as the oxygen can keep coming into contact with the iron, the reaction will keep going until all of the iron has recombined to make iron oxide.

2. Decomposition

The scone recipe that we used had flour, butter, salt, water and baking soda or baking powder. Baking powder is a mixture of baking soda and tartaric acid. We tested all the ingredients to see if they were acids or bases. We also heated them to see if they made any gas and tested what it was, and mixed them together one by one to see if they reacted. The scones we baked with baking soda were bitter, but the ones we baked with baking powder were not bitter and they were very fluffy. I am going to talk about two different reaction types in scones: decomposition and neutralisation.

Baking soda is used to make scones rise because it decomposes to make CO_2 when it is heated.

The chemical reaction for this is:

$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

Sodium bicarbonate → sodium carbonate + water + carbon dioxide

You can predict from the equation that it is a decomposition reaction because there is one reactant (baking soda) and it makes 3 products. Conservation of mass says that all of the products come from the reactants and no matter is created or destroyed, just rearranged. Sodium bicarbonate is a white solid powder and when it is heated to decompose, the atoms are rearranged to make the sodium carbonate (also a white powder), water (a clear, colourless liquid) and carbon dioxide (an odourless gas). Although the sodium carbonate is a white powder like the sodium bicarbonate, we tried heating it for ages and it didn't decompose because it is different from the sodium bicarbonate. The equation above shows that the two sodium atoms in the sodium bicarbonate (reactant) do not disappear, and can be found in the product sodium carbonate. We can also see that the two hydrogens in the sodium bicarbonate (reactant) do not disappear, but are in the product water. The two carbons from the sodium bicarbonate (reactant) are found in two separate products, sodium carbonate (1 carbon) and carbon dioxide (1 carbon). Something similar has happened with the 6 oxygens in the sodium bicarbonate (reactant), they can now be found in three of the products, sodium carbonate (3 oxygens), water (1 oxygen) and carbon dioxide (2 oxygens).

Because the product CO_2 is a gas, it will make the scone dough rise, but this comes with implications from the law of conservation of mass. The atoms in the CO_2 have to come from somewhere, so to make a lot of CO_2, you need to add a lot of $NaHCO_3$ to the scone mixture, because that is where the carbon and oxygen atoms will come from. The problem with this is that all of the products from the decomposition reaction will get made at the same time, so you can't make CO_2 without also making Na_2CO_3 and H_2O. Na_2CO_3 makes the scones taste really bitter, so this is another implication of the conservation of mass. The two implications I have talked about are that you can't make something from nothing, so to get lots of CO_2 you need to add lots of $NaHCO_3$. And you also can't make one product without making the others because matter can't just disappear without going somewhere, so making lots of CO_2 means making lots of Na_2CO_3 at the same time. The scones will be very fluffy, but they will taste bitter.

3. Neutralisation

The other reaction I am going to talk about is neutralisation. This happens in scones if you use baking powder because it is made up of baking soda (a base) and tartaric acid. The equations for this reaction are:

Base + acid → salt + carbon dioxide + water

Sodium bicarbonate + tartaric acid → sodium tartrate + carbon dioxide + water

$2NaHCO_3 + C_4H_6O_6 \rightarrow Na_2C_4H_4O_6 + 2CO_2 + 2H_2O$

The number and type of atoms in the reactants is exactly the same as the number and type of atoms in the products. This is the law of conservation of mass. You can see from the totals in the table that everything has been rearranged, but nothing has been created or destroyed. The arrows on the table show the relationship between the reactants and the products where, for example, all of the Na+ from the sodium bicarbonate (in the reactants) went into the chemical structure of the salt (in the products). All of the atoms in all of the products came directly from the reactants. They have been rearranged but nothing has been made or destroyed.

	Reactants (where the atoms start)			**Products** (where the atoms end up)			
	$2NaHCO_3$	$C_4H_6O_6$	**Total**	$Na_2C_4H_4O_6$	CO_2	H_2O	**Total**
Sodium	2	0	**2**	2	0	0	**2**
Carbon	2	4	**6**	4	2	0	**6**
Hydrogen	2	6	**8**	4	0	4	**8**
Oxygen	6	6	**12**	6	4	2	**12**
Total	12	16	**28**	16	6	6	**28**

In this reaction the acid and base are both solid, white powders that can dissolve in water. In class we dissolved the sodium bicarbonate in water and tested it with universal indicator, it turned purple showing it was a base. We dissolved the tartaric acid in water and tested it with universal indicator and it turned yellow showing that it was an acid. When we added tartaric acid to the solution of sodium bicarbonate and universal indicator, it slowly turned from purple to bluey-green and then green when it was neutral. This observation identifies a neutralisation reaction. The predictable pattern of a neutralisation reaction is that an acid and a base will make salt and carbon dioxide and water. In this reaction, the word equation below matches the predictable pattern, and tells us that sodium tartrate will be the salt.

Sodium bicarbonate + tartaric acid → sodium tartrate + carbon dioxide + water

One of the implications of conservation of mass for the neutralisation reaction in scones is that even if you have a lot of sodium bicarbonate in your scone mix, you have to add enough tartaric acid to the mixture or you won't convert all of the sodium bicarbonate into the neutral products. You need both reactants for the neutralisation reaction to happen, and they must be in the same ratio as the balanced equation, or the reaction won't go to completion. That is because you can only make the products by rearranging the combination of atoms in the reactants. Another implication of conservation of mass for this reaction is that the mixture will taste different after the reaction is complete, because the reactants won't be present in their original form anymore. When we investigated all of the ingredients we found out that baking soda tastes bitter and tartaric acid tastes sour. The finished scones will not taste bitter or sour because conservation of mass shows that there is no acid or base left once the salt, water, and carbon dioxide have been produced.

92021 Excellence Exemplar Notes

Sufficiency: To Achieve with Excellence the student work must interpret three chemical reactions.

The student has interpreted a chemical reaction in contexts by:

- Discussing at least one implication of conservation of mass for a combination reaction in this context, with reference to the predictable pattern of combination, and observations, and a relevant equation.
  The simplified equation for rusting reflects that Achievement Standard 92021 is derived from the Science Learning Area at Level 6 of the New Zealand Curriculum.
- Discussing at least one implication of conservation of mass for a decomposition reaction, with reference to the predictable pattern of chemical decomposition, and observations, and a relevant equation. Student has linked observations to the context of baking scones and related implications of conservation of mass to the context of the scones.
- Discussing at least one implication of conservation of mass for a neutralisation reaction, with reference to the predictable patterns and observations of neutralisation, and a relevant equation. Student has linked the reaction to the context of baking scones and related conservation of mass to implications of quantity and chemical properties in the scones.