Stage 1

Ratio and proportion

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Introduction

Today, you will use the same ratio and ratio simplification skills you have already practised in maths but will apply them to real chemical situations.

Learning objectives

1. Understand how to write ratios correctly and simplify them.
2. Know how and when to simplify ratios.
3. Work out the ratios of atoms in a chemical formula.
4. Use ratios to calculate required quantities.

Lesson question

Today we will be covering the mathematics skills needed to answer the following question:

A small statue made from a bronze alloy has a total mass of 105 g.

The bronze alloy is made from tin and copper in a **ratio** of 3:2



Calculate the mass of tin in the statue.

What is a ratio?

A ratio is used to compare the relative sizes of 2 or more values.

- What does the term 'relative' mean?

A ratio is written using the following format **a:b**.

Imagine:

I have 2 apples 

Jo has 4 apples 

The ratio of **my** apples to **Jo**'s apples is **2:4**

We can simplify this ratio to **1:2**

So, for every 1 apple I have, Jo has 2 apples.

What does simplifying a ratio mean?

To simplify a ratio means to write it in the **simplest form** while keeping the same relationship between the values.

This is a ratio of bananas to pears in a fruit bowl: **4:8**

Which number relates to the pears?

We can simplify **4:8** as both numbers in the ratio can be divided by 4.

This is known as the highest common factor (HCF).

$$4 \div 4 = 1$$
$$8 \div 4 = 2$$

The ratio is simplified to **1:2**

For every 1 banana, there are 2 pears in the fruit bowl.

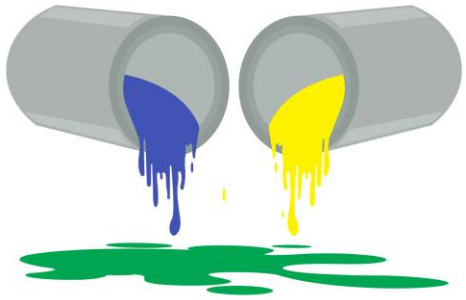
Can all ratios be simplified?

A ratio of **3:2** means that for every 3 of the first item there are 2 of the second item.

A green coloured paint can be made by mixing blue and yellow paint in a ratio of **3:2**

This means there are 3 parts of blue paint to every 2 parts of yellow paint.

Can the ratio 3:2 be simplified?



Simplifying ratios

Worked example

A bag contains 30 blue beads, 20 red beads and 15 green beads.

What is the ratio of red beads to blue beads?

- Write this in words first: **red:blue**
- Substitute in the values from the question: **20:30**

Can we simplify the ratio?

- The highest common factor is 10.
- Divide both sides of the ratio by 10.
- The simplified ratio is: **2:3**
- For every 2 red beads there are 3 blue beads.

What is the simplest whole number ratio of blue beads to green beads?

Simplifying ratios – answer

Answer

A bag contains 30 blue beads, 20 red beads and 15 green beads.

What is the simplest whole number ratio of blue beads to green beads?

blue:green

30:15

Highest common factor (HCF) is 15.

$\frac{30}{15} = 2 \quad \frac{15}{15} = 1$

The simplified ratio is 2:1.

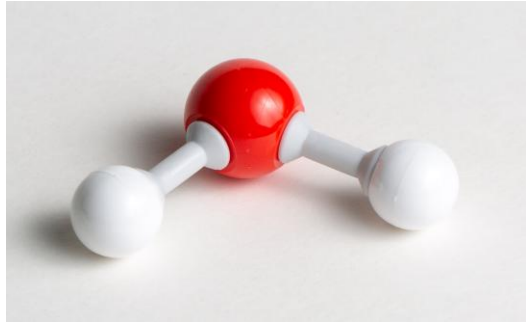
For every 2 blue beads there is 1 green bead.

Ratios in chemistry

We can use ratios to express how many atoms of an element make up a compound.

In a water molecule (H_2O) the ratio of hydrogen to oxygen is 2:1.

This means for every 2 hydrogen atoms there is 1 oxygen atom.



What is the ratio of carbon atoms to oxygen atoms in a molecule of carbon dioxide (CO_2)?



Ratios and chemical formulas

Activity

A chemical formula shows the ratio of atoms that make up a compound.

Look at the following compounds and complete the questions.

a) Ammonia (NH_3): what is the ratio of nitrogen atoms to hydrogen atoms?
b) Hydrochloric acid (HCl): what is the ratio of hydrogen to chlorine atoms?
c) Hydrogen peroxide (H_2O_2): what is the ratio of hydrogen to oxygen atoms?
d) Ethane (C_2H_6): what is the ratio of carbon atoms to hydrogen atoms?
e) Butane (C_4H_{10}): what is the ratio of carbon atoms to hydrogen atoms?

Ratios and chemical formulas – answers

Answers

a) Ammonia (NH_3) **1:3**
b) Hydrochloric acid (HCl) **1:1**
c) Hydrogen peroxide (H_2O_2) **1:1**
d) Ethane (C_2H_6) **1:3**
e) Butane (C_4H_{10}) **2:5**

Using ratios – worked example

A gas mixture contains hydrogen and oxygen in a ratio of 2:1 by volume.

The total volume of gas is 12 dm^3.

What is the volume of hydrogen in the mixture?

To work out the volume of hydrogen:

- The ratio is 2:1 which means there are 3 parts.
- We must find the volume of one part: $12 \div 3 = 4\ \mathrm{dm}^3$
- Hydrogen is present in 2 parts so $2 \times 4 = 8\ \mathrm{dm}^3$.

Check: What is the volume of oxygen in the mixture?

Worked example

Using ratios

A compound contains sodium and sulfur in a 2:1 ratio.

If a sample is formed from 8 sodium atoms how many sulfur atoms are needed?

Activity

Using ratios – answer

Answer

The ratio of sodium to sulfur atoms making up the substance is 2:1.

If there are 8 sodium atoms, then there must be half the amount of sulfur atoms $8 \div 2 = 4$

So, the number of sulfur atoms is 4.

The ratio is 8:4 which is simplified to 2:1 so we know the correct ratio has been maintained.

An alloy

Activity

An alloy is a mixture of two or more metals combined by melting and solidifying.

A jewellery maker is producing an alloy of gold and silver.



25.0 g of gold is mixed with 10.0 g of silver.

a) What is the ratio of gold to silver in the alloy?

b) What is the ratio of gold to silver if the amounts used were (i) doubled (ii) tripled ?

c) What happens to the ratio if 1.0 g of gold and 1.0 g of silver are removed from the original mixture?

d) What happens to the ratio if 1.0 g of gold and 1.0 g of silver are added to the original mixture?

An alloy – answers

a) The ratio of gold to silver is 5:2.

b) (i) Nothing changes the ratio is still 5:2. (ii) Nothing changes the ratio is still 5:2.

c) If 24.0 g of gold and 9.0 g of silver are added, the ratio changes to 24:9 or simplified to 8:3.

d) If 26.0 g of gold and 11.0 g of silver are added, then the ratio remains as 26:11 as there is no common factor here.



Activity

Discussing ratio

Three learners are discussing this question.

A compound contains hydrogen and oxygen in the ratio 2:1. How many atoms of each element are there if the compound is formed from 18 atoms in total?

Learner A

2:1 means there are 3 parts in total.
$18 \div 3 = 6$
atoms per part.
So, there are $2 \times 6 =$ **12 hydrogen atoms** and $1 \times 6 =$ **6 oxygen atoms**.

Learner B

The ratio 2:1 means there are **2 hydrogen atoms** present and **1 oxygen atom** with 15 atoms left over. The ratio stays the same.

Learner C

Hydrogen is 2 and oxygen is 1. Multiply both by 18.
$2 \times 18 =$ **36 hydrogen atoms**
$1 \times 18 =$ **18 oxygen atoms.**

Which learner is correct? Explain why the other learners are incorrect.

Discussing ratio – answer

Learner A is correct.

Learner B is incorrect because they have treated the ratio numbers as actual quantities. They think there are 2 hydrogen atoms and 1 oxygen atom rather than 18 atoms.

Learner C is incorrect because they have multiplied each part of the ratio by the total number of atoms. This would give 54 atoms in total rather than 18 as per the question.

Learner A

2:1 means there are 3 parts in total.
$18 \div 3 = 6$
atoms per part.
So, there are $2 \times 6 =$ **12 hydrogen atoms** and $1 \times 6 =$ **6 oxygen atoms**.

Answer

Returning to the lesson question

A small statue made from a bronze alloy has a total mass of 105 g.

The bronze alloy is made from tin and copper in a ratio of 3:2

Calculate the mass of tin in the statue.



Lesson question – answer



The ratio 3:2 means there are 3 parts of tin to every 2 parts of copper.

The total number of parts is $3 + 2 = 5$.

The total mass is 105 g, so we can find the mass of one part by $105 \div 5 = 21$ g.

The tin represents three parts, so **the mass of tin is $3 \times 21 = 63$ g.**

We can double check this by working out how much copper there is as well.

Copper forms two parts so $2 \times 21 = 42$ g.
$63 + 42 = 105$ g

Answer

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