Name: Class:

Chapter 5: Chemical reactions unleashed

5.1 Law of conservation of mass

This investigation relates to lesson 5A.

SCIENCE INQUIRY SKILL

Planning and conducting – Units

This investigation requires you to report data to the appropriate number of significant figures.

If you need to sharpen this skill check out 1B.4 Units.

What does happiness sound like? Coca-cola will tell you it's the sound of cracking open an ice cold bottle of Coke. Tsssssssss. That sound is the reaction of carbonic acid turning into water and carbon dioxide gas. This gas forms bubbles that escape when you open the drink.

Abramova Elena/shutterstock.com

Now, the law of conservation of mass states that mass is neither created nor destroyed during a chemical reaction. In other words, the mass of the reactants must be equal to the mass of the products. So, the mass of the carbonic acid must equal the mass of the water plus the mass of the carbon dioxide gas produced.

If this reaction takes place inside of a closed bottle, the mass will remain the same. This begs the question: what would happen to the mass if it was left open?

In this investigation, the law of conservation of mass will be measured in a closed and open system.

Materials

Part A - Demonstration (for teacher only)

- 1 × watch glass
- 1 × 100 mL beaker
- 1 × electronic balance
- 1 × zinc plate (2 cm x 10 cm)
- 50 mL 0.5 M copper sulfate solution

Part B - Per group

- 1 × balloon
- 1 × spatula
- 50 mL white vinegar
- 5 g sodium bicarbonate
- 1 × electronic balance
- 1 × 100 mL conical flask
- 1 × 100 mL measuring cylinder

Before you start

Read the instructions for the practical activity and complete these questions before you start.

Question 1

The aim of Part A of this investigation is to determine if the

A. law of conservation of mass is demonstrated in an open system.

B. law of conservation of mass is demonstrated in a closed system.

C. law of conservation of energy is demonstrated in an open system.

D. law of conservation of energy is demonstrated in a closed system.

Question 2

If you measured the mass of two substances using a scale that is accurate to 0.1 grams for one substance and a scale that is accurate to 0.01 grams for the other, what can be said about the certainty of a calculation combining these measurements?

A. The calculation can be more certain than both measurements.

B. The certainty of the calculation does not depend on the scales used.

C. The calculation can be only as certain as the least certain measurement.

D. The certainty of the calculation is based on how many times you use each scale.

Question 3

Scientific investigations must be valid. Which one of the following should be avoided in this scientific investigation to ensure validity?

A. a method that tests the hypothesis

B. using appropriately calibrated equipment

C. changing more than one variable at a time

D. a method that is designed to address the aim

Question 4

If your electronic balance measure to two decimal places, then the level of uncertainty it has is

A. ±0.001 gram

B. ±0.01 g

C. ±0.1 g

D. ±1 g

Introduction

Use the terms to fill in the blanks.

aim	conservation of mass	equals
hypothesised	open	

The law of _____ states that matter cannot be created nor destroyed. In this experiment a closed and open system are compared. In an _____ system it's expected that any gases produced can leave the system, and the mass decreases. In a closed system, gases are trapped and the mass of the reactants _____ the mass of the products. The _____ of this experiment is to compare the mass of products and reactants in open and closed systems. It is _____ that if a chemical reaction occurs in an open system and a gas is produced, then the gas will escape and the mass of the system will decrease.

Method

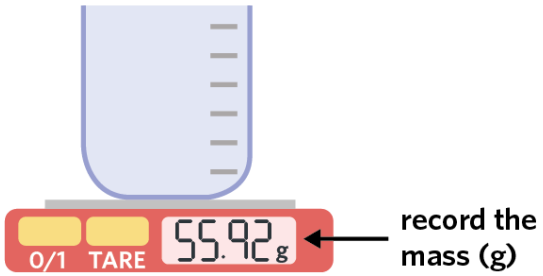
Safety alert!

You are using glassware. Handle with care and be sure to place them towards the middle of the bench away from the edge. Notify the teacher immediately of any breakages.

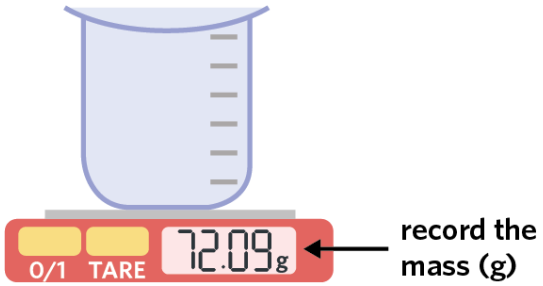
Part A – Teacher demonstration: Investigating the law of conservation of mass in a closed system

1. Calibrate the electronic balance by taring (display should read 0.0 g) before weighing.

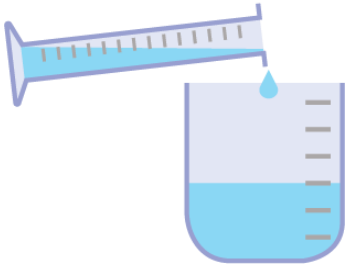
2. Place a 100 mL beaker on the electronic balance and record the mass in Table 1.



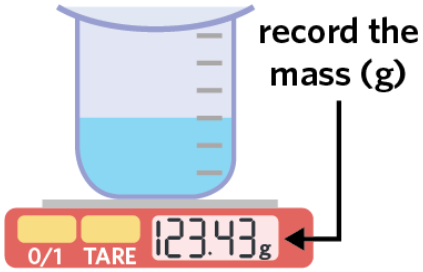
3. Add an empty watch glass onto the beaker and record the new mass in Table 1.



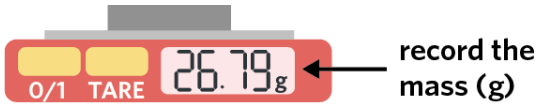
4. Remove the watch glass and beaker from the balance. Measure 50 mL of copper sulfate solution and pour it into the beaker.



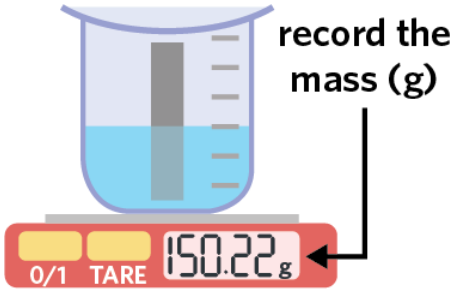
5. Tare the balance. Replace the watch glass on the beaker and record the mass of the beaker, watch glass and beaker contents. Calculate the mass of copper sulfate in Table 1.



6. Remove the beaker and tare the balance. Weigh a piece of zinc metal and record the mass in Table 1.



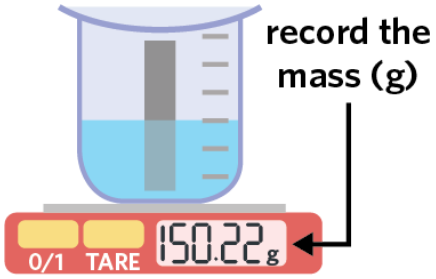
7. Remove the zinc and tare the balance. Carefully put the zinc metal into the beaker, replace the watch glass and record the total mass in Table 1.



8. Record any observations of a chemical change in Table 2. Remember COBALT.

Signs of a chemical reaction COBALT:					
Colour change	**O**dour produced	**B**ubbles produced	**A**ppearance or disappearance of a solid	**L**ight or sound produced	**T**emperature change

9. After five minutes, carefully remove the beaker and tare the balance. Reweigh the beaker, the watch glass, and beaker contents. Record the mass. Then, calculate the difference between the products and reactants.

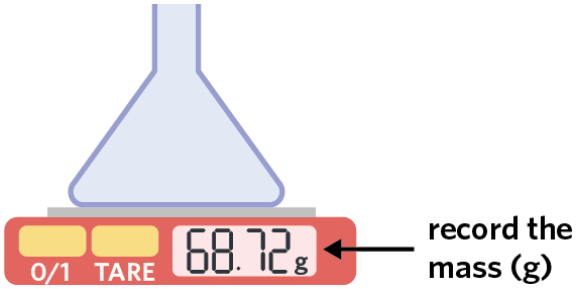


Part B – Mass in an open system

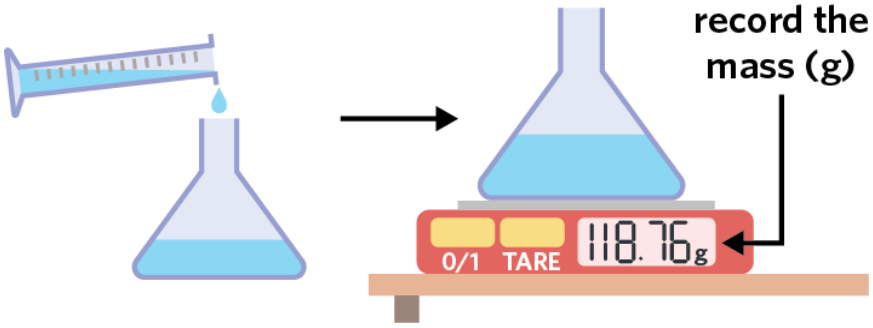
It is important to record the correct number of significant figures shown on the electronic balance. To do so, record exactly the number of decimal places shown on the display.

1. Tare the electronic balance (display should read 0.00 g). Record the mass of the empty balloon in Table 3.

2. Remove the empty balloon. Tare the balance, place a 100 mL conical flask on the electronic balance and record its mass in Table 3.

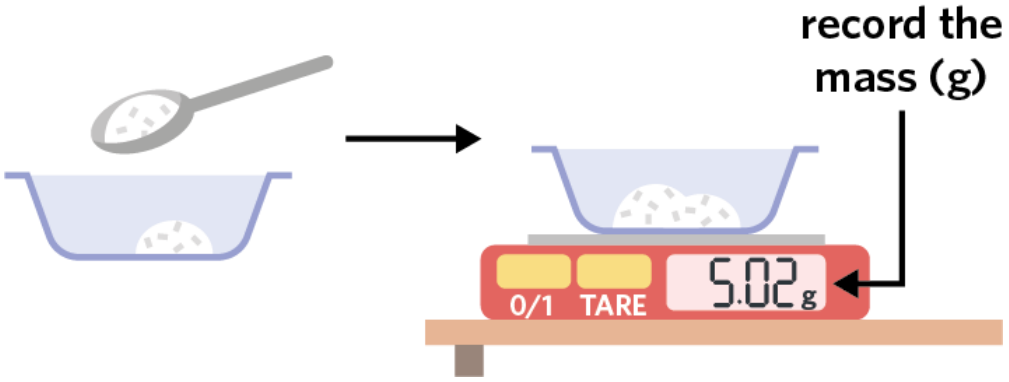


3. Remove the flask. Measure 50 mL of vinegar and pour it into the conical flask. Record the total mass in Table 3.

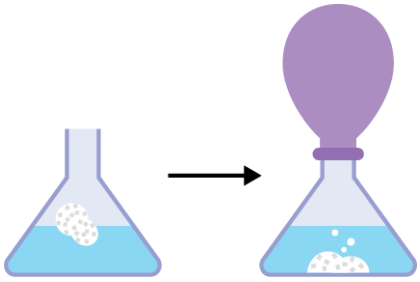


4. Remove all items from the electronic balance. Place the watch glass on the balance and then tare it.

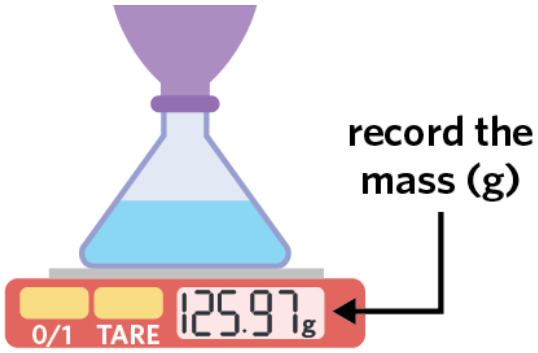
5. Measure 2 spatulas of sodium bicarbonate. Record the mass in Table 3.



6. Using the spatula, carefully transfer the sodium bicarbonate into the conical flask. Immediately place the balloon over the neck of the conical flask.

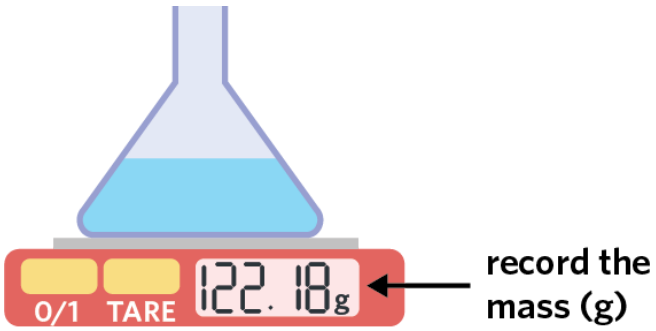


7. Tare the balance. Record the total mass of the conical flask, balloon and contents in Table 3.



8. Record any signs of chemical change in Table 4.

9. Release the balloon from the top of the conical flask. Record the mass of the conical flask and its contents in Table 3.



Results

Part A – Teacher demonstration: Investigating the law of conservation of mass in a closed system

Table 1 Mass recordings

	Part(s) to weigh	Mass (g)
a	beaker	
b	beaker and watch glass	
c	beaker, watch glass and copper sulfate	
d	copper sulfate (c-b = d)	
e	zinc metal	
f	beaker, watch glass, copper sulfate and zinc metal	
g	beaker and contents after 5 minutes	
h	difference of the beaker and mass of reactants to the beaker and mass of products (g-f)	

Table 2 Evidence of a chemical change

Appearance of reactants	Evidence of chemical change

Part B – Investigating the law of conservation of mass in an open system

Table 3 Mass recordings

	Part(s) to weigh	Mass (g)
a	empty balloon	
b	conical flask	
c	conical flask and vinegar	
d	sodium bicarbonate	
e	conical flask, vinegar, sodium bicarbonate and balloon	
f	conical flask and contents when balloon has been removed	
g	mass of gas produced (e-f-a = g)	

Table 4 Evidence of a chemical change

Appearance of reactants	Evidence of chemical change

Discussion

Question 1

Summarise the key results from Parts A and B of the investigation by identifying evidence that a chemical reaction occurred and stating how the law of conservation of mass was fulfilled.

_____

_____

_____

Question 2

The chemical reaction in Part A can be summarised with the following balanced chemical equation:

$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

Using the law of conservation of mass, state why it is important to balance equations

_____

_____

_____

Question 3

The chemical reaction in Part B can be summarised with the following chemical equation:

$C_2H_4O_2 + NaHCO_3 \rightarrow NaC_2H_3O_2 + CO_2 + H_2O$

Show that this equation is balanced by completing the atom count.

C: _____ C: _____

H: _____ H:_____

O: _____ O:_____

Na: _____ Na: _____

Question 4

Outline the purpose of taring the balance. Explain any errors that could occur if the balance was not tared before mass measurements were taken.

Question 5

Calculate the mass of the gas that was produced in Part B. Report this measurement to three significant figures. Explain your calculation.

Question 6

Describe how the results of this investigation could be made more precise.

Conclusion

Write a conclusion that summarises the investigation using the relevant sections of RERUN.

Answers

Introduction

The law of **conservation of mass** states that matter cannot be created nor destroyed. In this experiment a closed and open system are compared. In an **open** system it's expected that any gases produced can leave the system, and the mass decreases. In a closed system, gases are trapped and the mass of the reactants **equals** the mass of the products. The **aim** of this experiment is to compare the mass of products and reactants in open and closed systems. It is **hypothesised** that if a chemical reaction occurs in an open system and a gas is produced, then the gas will escape and the mass of the system will decrease.

Before you start

Question 1

B. Part A is a closed system because there are no gases as reactants or products.

Question 2

C. When measurements are used together in a calculation, the uncertainty (or the level of accuracy) of the final result cannot be finer than the least certain measurement.

Question 3

C. In a valid investigation only one variable should be changed at a time.

Question 4

B. When an electronic balance measures to two decimal places, it means that the balance can distinguish and report the mass of items down to one-hundredth of a gram (0.01 g).

Results

The results are an example only.

Part A – Teacher demonstration: Investigating the law of conservation of mass in a closed system

Table 1 Mass recordings

	Part(s) to weigh	Mass (g)
a	beaker	55.92
b	beaker and watch glass	72.09
c	beaker, watch glass and copper sulfate	123.43
d	copper sulfate (c-b = d)	51.34
e	zinc metal	26.79
f	beaker, watch glass, copper sulfate and zinc metal	150.22
g	beaker and contents after 5 minutes	150.22
h	difference of the beaker and mass of reactants to the beaker and mass of products (g-f)	0.00

Table 2 Evidence of a chemical change

Appearance of reactants	Evidence of chemical change
Zinc - grey silver metal	Colour change of metal
Copper sulfate solution - blue liquid	Fading of blue liquid

Part B – Investigating the law of conservation of mass in an open system

Table 3 Mass recordings

	Part(s) to weigh	Mass (g)
a	empty balloon	2.19
b	conical flask	68.72
c	conical flask and vinegar	118.76
d	sodium bicarbonate	5.02
e	conical flask, vinegar, sodium bicarbonate and balloon	125.97
f	conical flask and contents when balloon has been removed	122.18
g	mass of gas produced (e-f-a = g)	1.60

Table 4 Evidence of a chemical change

Appearance of reactants	Evidence of chemical change
Sodium bicarbonate white solid	appearance of bubbles
Vinegar colourless liquid	underneath of beaker increases in temperature

Discussion

Question 1

Example answer

[In Part A, a colour change indicated that a chemical reaction occurred.[1]][The law of conservation of mass was demonstrated because the mass of the products equalled the mass of the reactants.[2]][In Part B, the presence of bubbles indicated that a chemical reaction occurred.[3]][The law of conservation of mass was observed. When the inflated balloon was removed from the conical flask, the mass of the system decreased, demonstrating that the gas that escaped the system contained mass.[4]]

Checklist

- I have identified a sign of chemical change from Part A.[1]
- I have stated that the law of conservation of mass was observed in Part A.[2]
- I have identified a sign of chemical change from Part B.[3]
- I have stated that a gas contains mass supporting the law.[4]

Question 2

Example answer

[Chemical equations should be balanced to show that mass is not created or destroyed,[1]][in accordance with the law of conservation of mass.[2]]

Checklist

- I have stated that equations should be balanced to show conservation of mass.[1]
- I have connected this to the law of conservation of mass.[2]

Question 3

Example answer

C: 3	C: 3
H: 5	H: 5
O: 5	O: 5
Na: 1	Na: 1

Question 4

Example answer

[Taring is conducted to make the balance read zero before measurements take place.[1]][If the balance is not tared before taking a reading then the measurement will be higher or lower than the true result making the measurement less accurate.[2]]

Checklist

- I have outlined taring.[1]
- I have explained the effect of not taring the balance on the accuracy of the obtained measurements.[2]

Question 5

Example answer

[125.97 − 122.18 − 2.19 = 1.60[1]][1.60g.[2]][The mass of the gas lost was the difference between the mass of the conical flask, vinegar, sodium bicarbonate and the balloon, and the mass of the conical flask and its contents when the balloon was removed (minus the mass of the empty balloon).[3]]

Checklist

- I have calculated the mass of the gas lost from the open system.[1]
- I have reported the mass to three significant figures and included the correct units.[2]
- I have explained how I calculated the mass.[3]

Question 6

Example answer

[This investigation would be made more precise by conducting trails of each part of the investigation and averaging the results[1]]

Checklist

- I have described how the results of the investigation could be made more precise.[1]

Conclusion

Example answer

[The aim of the investigation was to determine if the law of conservation of mass was observed in chemical reactions.[1]][The hypothesis was supported because when a gas was produced in an open system, the gas escaped leading to a decrease in mass of the system.[2]][In a closed system, the mass of the reactants equaled the mass of the products. In an open system, the difference in mass between the reactants and products represented the mass of gas lost to the environment.[3]][The accuracy of the scales used to measure mass could introduce uncertainty.[4]][Next time we could vary the concentrations of reactants to observe if the law of conservation of mass if consistently observed.[5]]

Checklist

- I have restated the purpose of the investigation.[1]
- I have explained whether the hypothesis was supported.[2]
- I have summarised the results.[3]
- I have included uncertainties.[4]
- I have indicated possible next steps or new questions for further investigation.[5]