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Physics & Chemistry



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UNIT 1

INTRODUCTION TO THE SCIENTIFIC METHOD.

1. READING COMPREHENSION: STEPS OF THE SCIENTIFIC METHOD.

The scientific method is a set of techniques used by the scientist to construct knowledge.

The steps of the scientific method are the following:



It is important to understand that laws and theories are not valid forever. Often, throughout the history of science, some theories were considered to be true for centuries until something observed made them to be replaced with other new theories.

Let review the Scientific method steps deeply, to understand them and to apply it to your own experimentation:

Observation and questioning

The scientific method starts when you ask yourself a question about something that you observe. The study should answer how, what, when, who, which, why, or where. It is known that a good scientist must be a good observer.

The question in most of the projects should be about something you can measure.

Example: "Do greenhouse gasses (methane and carbon dioxide) really make the planet warmer?"

Do background research

Before starting experimentation, you need to be an acute scientist using bibliography and Internet research to help you find the best way to do things and ensure that you don't repeat mistakes from the past.

Make a hypothesis

A hypothesis is a statement about how things work. It is a try to answer your question with an explanation that can be tested. A good hypothesis allows you to make a prediction: "If [you do this], then [this] will happen."

Example: "If you increase the amount of carbon dioxide or methane, then the temperature will be higher."

Plan your experiment

This step requires to consider the measurements you are going to do and the instruments and conditions you need to do them.

Perform the experiment

Your experiment tests if your prediction is accurate or it isn't and if your hypothesis is supported or not. In your experimentation you should change only one factor at a time, while keeping all other conditions the same. You should also repeat your experiments several times to make sure that the first results weren't just an accident.

Analyze your data

Once your experiment is complete, you collect your measurements, order them in tables and represent them in graphs to analyze and see if they support your hypothesis or not.

Draw a conclusion

From the analysis of data, one or more conclusions must be extracted. Several conclusions from different research can lead to a scientific law. Several laws can lead to a theory.

Communicate your results

To complete your research, you will communicate your results to others in a final report. Professional scientists publish their final report in a scientific journal or by presenting their results on a poster or during a talk at a scientific meeting. Even if the hypothesis is not supported, scientist communicate the results of their experiment and then go back and construct a new hypothesis and prediction based on the information they learned during their experiment.

Answer the next questions about the text:

- 1. List the different steps of scientific method.
- 2. Define hypothesis.
- 3. What is experimentation?
- 4. Think about research you can do easily, do a hypothesis and plan the experiment. Don't forget details.
- 5. According to the planning, what measurements do you need to do?

2. Measurements and Magnitudes. International Units System. Multiples and Submultiples. Scientific notation.

scientists must **measure magnitudes**.

The longest step of experimental research is "perform the experiment" because

A Magnitude is any property that can be measured. For example, temperature and volume are magnitudes but beautiful or happiness are not.

But, what is to Measure? **To Measure a magnitude** is to compare it with another that we have chosen as unit to determine how many times the magnitude contains the unit.

For measuring we need a unit. We cannot say "that glass has a volume of 300", we need to indicate the unit in which we measure.

2.1 International Units System.



To avoid misunderstandings when we talk about measurements, it is necessary to use the same Unit System for everybody.

That is what the International Units System represents for most of the countries in our world.

According to it, the International System Units for **fundamental magnitudes** are the following:

UNIT	ABBREVATION	FUNDAMENTAL MAGNITUDE	
METRE	m	Length	
KILOGRAM	kg	Mass	
SECOND	S	Time	
AMPERE	А	Current	
KELVIN	К	Temperature	
MOLE	Mol	Amount of substance	
CANDELA	cd	Luminous intensity	

Derived magnitudes

Notice that the International Unit System for measuring surfaces will be the square meter (m^2) and for volumes will be the cubic meter (m^3) although the most used unit for volumes is the liter (ℓ) which is the same as 1 dm³. **Volume and surface are derived magnitudes** because they depend on length, that is a fundamental magnitude. Other derived magnitudes are:

- **Density** that depends on mass and length. International System unit is kg/m³.
- **Velocity** than depends on length and time. International System unit is m/s.

UNIT	ABBREVATION	MAGNITUDE	
INCH	in		
FOOT	ft	Length	
YARD	yd		
MILE	mi		
QUART	qt		
GALLON	gal	Volume	
PINT	pt		
OUNCE	OZ	Mass	
POUND	lb	ividss	
FAHRENHEIT	٥F	Temperature	

However, in some countries, like the English ones, other units are used:

The equivalence between our system and the English one is:

1 in = 0,0254 m	1 qt = 1136,5225 mℓ
1 ft = 0,3048 m	1 gal = 4546,09 mℓ
1 yd = 0,9144 m	1 pt = 568,2612 mℓ
1 mi = 1609,344 m	1 oz = 28,349 g
	1 lb = 453,592 g

2.2 Multiples and submultiples

Sometimes, for measuring very large or very small quantities it is useful to use different units than the ones of the International System. For that reason, we use the multiples and submultiples than can be seen in the next table:

MULTIPLES AND SUBMULTIPLES				
FACTOR	SYMBOL			
10 ¹	deca	da		
10 ²	hecto	h		
10 ³	kilo	k		
10 ⁶	mega	Μ		
10 ⁻¹	deci	d		
10 ⁻²	centi	C		
10-3	mili	m		
10 ⁻⁶	micro	μ		

LENGTH, SURFACE AND VOLUME. CHARTS OF UNITS

Length is a fundamental magnitude whose International System unit is "meter". Other units are in the following chart:

LENGTH UNITS		
	Equivalence with the International System Unit	
Mm	1 Mm = 10 ⁶ m	
km	1 km = 10 ³ m	
hm	1 hm = 10 ² m	
dam	1 dam = 10 m	
dm	10 dm = 1 m	
cm	10 ² cm = 1 m	
mm	10 ³ mm = 1 m	
μm	10 ⁶ μm = 1 m	

Surface or Area is a derived magnitude whose International System unit is "square meter". Imagine a square 1 m edge; its area corresponds to $1m^2$.

SURFACE UNITS		
Equivalence with the International System Unit		
km ²	$1 \text{ km}^2 = 10^6 \text{ m}^2$	
hm²	1 hm² = 10 ⁴ m²	
dam²	$1 \text{ dam}^2 = 10^2 \text{ m}^2$	
dm ²	$10^2 dm^2 = 1 m^2$	
cm ²	$10^4 \mathrm{cm}^2 = 1 \mathrm{m}^2$	
mm ²	$10^6 \text{ mm}^2 = 1 \text{ m}^2$	

Volume is other derived magnitude whose International System unit is "cubic meter". Imagine a cube 1m edge; its volume corresponds to $1 m^3$.

VOLUME UNITS				
Equivalence with the Equivalence with the				
	International System Unit	units		
km³	1 km ³ = (10 ³) ³ m ³ =10 ⁹ m ³			
hm³	1 hm ³ = (10 ²) ³ m ³ = 10 ⁶ m ³			
dam ³	1 dam ³ = 10 ³ m ³			
m ³		1 k² = 1 m³		
dm ³	1 m ³ = 10 ³ dm ³	1 ℓ = 1 dm ³		
cm ³	1 m ³ = (10 ²) ³ cm ³ = 10 ⁶ cm ³	1 mℓ = 1 cm³		
mm ³	1 m ³ =(10 ³) ³ mm ³ =10 ⁹ mm ³			

2.3 CONVERSION FACTORS.

To change from one unit to another we use conversion factors. A conversion factor is a fraction that expresses the equivalence between two units. For example:

From the equivalence $1 \text{ m} = 10^2 \text{ cm}$

We can obtain two conversion factors:

 $\frac{1m}{10^2 cm}$ and $\frac{10^2 cm}{1m}$

But, how conversion factors are used? Look at the following examples:

1. To convert from one unit to a multiple or submultiples we use powers of ten:

How many meters are 2 cm?

$$2 \, cm \cdot \frac{1 \, m}{10^2 cm} = \frac{2 \, cm \cdot 1 \, m}{100 \, cm} = \frac{2}{100} \, m = 0.02 \, m$$

2. If there is no power of ten we simply use the equivalence:

How many hours are 60 s?

$$60 \ s \cdot \frac{1 \ h}{3600 \ s} = \frac{60 \ s. \ 1h}{3600 \ s} = \frac{60}{3600} h = 0.016$$

EXERCISES

1. Convert the following measurements to meters using conversion factors:

a.	100 mm	e.	12 dm
		•••	

- b. 23 cm f. 45 μm
- c. 400 mm g. 3 hm
- d. 300 km
- 2. Convert the following measurements to meter squared using conversion factors:
 - a. 40 cm^2 c. 3 km^2
 - b. 4700 mm^2 d. 3500 cm^2
- Convert the following measurements to meter cubed using conversion factors:
 - a. 45 dm³ d. 460 me
 - b. 3500 hm³ e. 460 mm³
 - c. 35 l f. 57 cm³

- 4. Make the following time conversions using conversion factors:
 - a. 4500 s to hours
 - b. 5 h to min
 - c. 45 s to min
 - d. 7600 cs to seconds
- 5. Make the following mass conversions using conversion factors:
 - a. 45 kg to g
 - b. 3700 mg to kg
 - c. 600 hg to kg
 - d. 40 dag to kg
 - e. 280 dg to mg
- 6. Rewrite the next measurements into the International System of units:

a.	27 inch	e.	3 pt

- b. 35 ft f. 50 oz
- c. 500 yd g. 35 lb.
- d. 300 mi

2.4 Scientific notation

To write that type of numbers we use scientific notation, which uses powers of ten to rewrite the numbers in a shorter way.

HOW TO WRITE NUMBERS IN SCIENTIFIC NOTATION:

You should leave just one number before the coma. To know how many decimals you should write, read point 4.

- If the number is bigger than one:
 - Multiply for 10 powered to the number of places you move to the coma

Example: 299292458 = 2,99 · 10⁸

- If the number is smaller than one:
 - Multiply for 10 powered to minus the number of places you move the coma (remember that multiplying for a negative power is the same as dividing for it):

$$2 \cdot 10^{-3} = \frac{2}{10^3}$$

EXERCISES

c. 345720,56

6. Rewrite this numbers using scientific notation: (leave two decimals behind the coma)

2

- a. 0,003 i. 0,00025
- b. 125,45 j. 8567985
 - k. 0,000006
- d. 0,000023 l. 788566488,57
- e. 725654000 m. 2,000004
- f. 2458 n. 0,000024
- g. 540 o. 987654
- h. 3000000 p. 4156,3

3. WORKING IN THE LAB. LABORATORY MATERIAL

As a younger scientist, you need to know the names of laboratory materials that you will use for your future experimental work during this course.

Pay attention and complete the following exercises:

1. Join the name and the drawing: Glass material used for measuring volume of liquids Pipette Burette Graduated cylinder Volumetric Flask Answer the question: Which material can be used to measure volume of solids? Material used as container of substances Dish Crystallizer **Conical flask**

Spherical flask

	Test tube Watch glass	
	Other useful materials	
	Beaker	
	Tripod	
	Washing bottle	
	Funnel	
	Dropper	
	Spatula	
	Agitator stick	
2	Separating funnel	



2. Write some sentences to explain the use of some of these materials. You can use the following type of sentences:

ls a	laboratory	material used for	verb-ing
	glass		
	separating		
	measuring		



4. WORKING IN THE LAB. LABORATORY RULES

Before start working in the laboratory some important rules have to be known:

1. Concentrate in your teacher explanation about the steps you have to follow during your



work. In addition, read carefully the printed instructions. It is the first step toward avoiding accidents.

2. Avoid getting distracted by the tools and supplies you will find in the laboratory and mainly, never touch that tools and devices you are not going to use.

3. It's essential to ask any questions you need to understand the experimental work. These questions can bring up important safety topics that the teacher can have forgotten.

4. Get ready all the material you are going to use during your experimental work. This will avoid comes and goes in the laboratory and wastes of time.

- 5. Follow the steps printed on the instructions sheet.
- 6. To avoid accidental intoxication, never eat or drink in the laboratory.

- 7. Be careful with glass tools. If they are crashed you can be injured. What is more, it's impossible to notice if they are hot and you will be burnt when you touch them.
- 8. After finish the activity tidy and clean your working table, following the instructions of your teacher.
- 9. Never pour liquid remains through the sink. They may be dangerous to the environment.
- 10. Solid remains should be left in the laboratory bins.
- 11. Before leaving the laboratory wash your hand with soap and water.
- 12. Observe the reactant labels and follow the recommended security rules while you are using them. Be especially careful with the corrosive substances and wear security glasses and globes.



5. VOCABULARY REVIEW

6. FINAL ACTIVITIES

7. Make the following change of units:

a)	400 mm to km	g)	400 dm ² to mm ²
b)	50 m ² to km ²	h)	3267 km to dam
c)	400 m ³ to ℓ	i)	234 mm ² to hm ²
d)	100 dm ³ to dam ³	j)	4213 cm ³ to dam ³
e)	200 µm to m	k)	567 mm ³ to dae
f)	30ℓto cm ³	I)	0,034 kℓ to cm³

8. Express the next measurements in the International System of units:

a)	100 km	e)	300 g
b)	300 l	f)	40 min
c)	25 mm	g)	3 h
d)	400 cm ³	h)	300 cs

9. Convert these quantities into the International System of Units:

a)	5 km,	e)	25000 ms
b)	100 mg	f)	2,5 years
c)	6 hours	g)	700 mg
d)	25 km	h)	3 cm

10. Rewrite the next numbers using scientific notation. Use two decimals behind the coma:

a)	3454500000	e)	0,0000000000003
b)	0,0000034562	f)	0,00456
c)	324600	g)	2334000000000000000

- c) 324600
- d) 3103000

11. Rewrite this numbers to decimal notation:

- a) 3,5.10-8
- b) 4,76.10³
- c) 9.10⁻⁹
- d) 4,47.10⁵

12. Classify and order the following nouns in the chart below and complete it with the information you know:

Metre, surface, volume, litre, microgram, time, temperature, Kelvin, decametre squared, kilometre per hour, kilogram, decilitre, Celsius degree, velocity, cubic metre.

Fundamental magnitude	Derived magnitude	International System Unit	Other units	Measuring instrument