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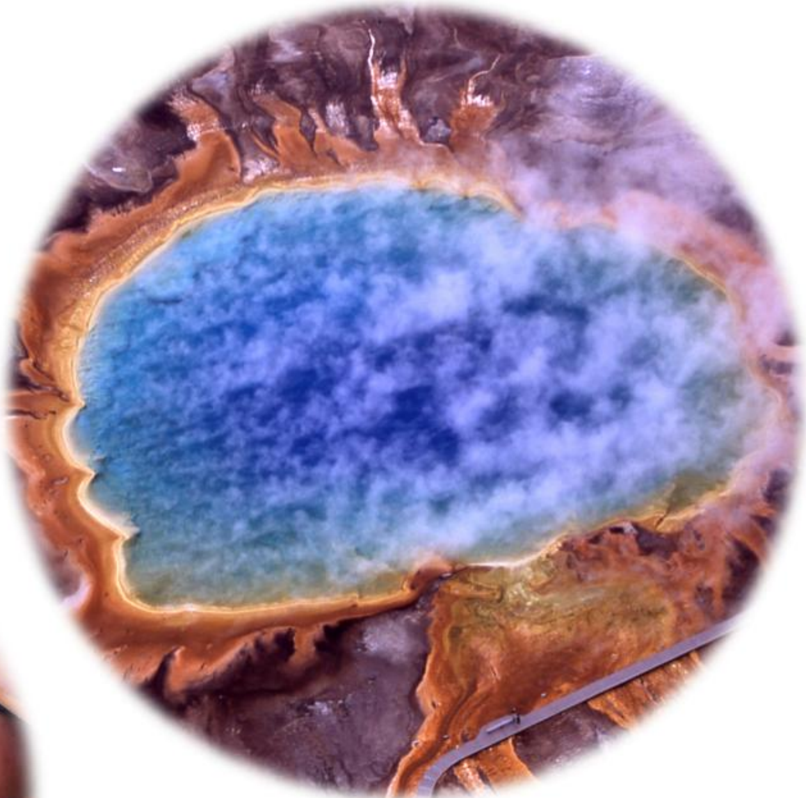

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Physics & Chemistry

WorkbooK

ESO

Adaptado a la LOMCE

Physics and Chemistry Workbook

3º ESO

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INDEX

UNIT 1: INTRODUCTION TO THE SCIENTIFIC METHOD

UNIT 2: MATTER. PROPERTIES OF MATTER

UNIT 3: PURE SUBSTANCES AND MIXTURES. ELEMENTS AND COMPOUNDS

UNIT 4. THE ATOM AND THE PERIODIC TABLE

UNIT 5. CHEMICAL BONDS

UNIT 6. CHEMICAL REACTIONS

UNIT 7. CHEMISTRY AND SOCIETY

UNIT 8. INTRODUCTION TO THE STUDY OF MOTION.

UNIT 9. INTRODUCTION TO THE STUDY OF FORCES. GRAVITATIONAL FORCE

UNIT 10: ELECTRICAL FORCE

UNIT 11. ELECTROMAGNETISM

UNIT 12: ENERGY

UNIT 13. ELECTRICAL CURRENT

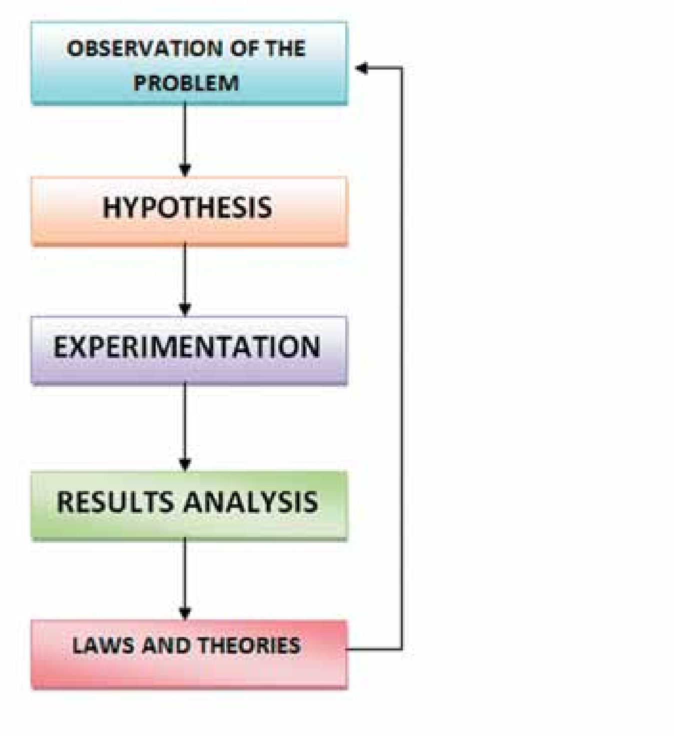
APPENDIX: INORGANIC FORMULATION

UNIT 1: Introduction to the Scientific Method

1. THE SCIENTIFIC METHOD. ITS STEPS.

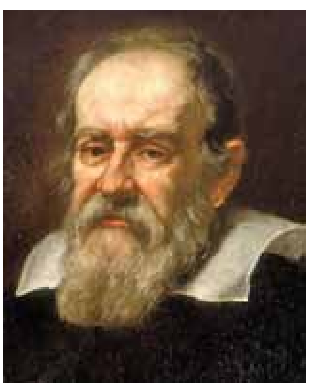
The scientific method is a set of techniques used by the scientist to construct knowledge.

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.

We will see an example on the next point.

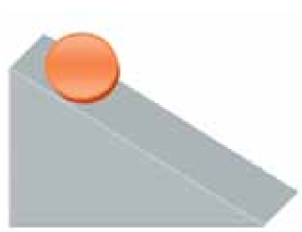


2. READING COMPREHENSION: GALILEO AND FALLING BODIES.

Since the ancient Greeks there was a thought among the scientist (mainly because of Aristotle): heavy bodies fall faster than light bodies.

Probably you think so too (or you have thought it) but what is really surprising is that for nearly 20 centuries nobody considered the possibility to prove that fact, they just believed it without asking.

But in the XVI century a greatest scientist, Galileo Galilei, was not very convinced that mass and velocity where proportional, so he designed an experiment to prove it.



You have to think that in those times watches weren't as accurate as they are nowadays (in fact, he used a water watch), so Galileo couldn't make the test with free falling bodies, he made build a 7 meter slide (very well polished to avoid friction) and let different balls fall.

What he discovered, after several measurements of time and distance, was that, when there is no friction, mass and velocity are independent and two bodies with different shapes and masses will fall within the same time.

Galileo, with this experiment, is considered the father of the scientific method.

Answer the next questions about the text:

1. Identify the different steps of the scientific method in Galileo's history.
2. What does it mean that mass and velocity are proportional?
3. Describe how you think a water watch works.
4. If mass and velocity are actually independent, why a piece of paper fall slower than a stone?

3. MEASUREMENTS AND MAGNITUDES. INTERNATIONAL UNITS SYSTEM. MULTIPLES AND SUBMULTIPLES.SCIENTIFIC NOTATION.

A Physical 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.

3.1. International System of Units

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 main units are the following:

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

Notice that the International System of Units 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 litre (L) which is the same as 1 dm^3

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

UNIT	ABBREVATION	Magnitude
INCH	In	Length
FOOT	Ft	Length
YARD	Yd	Length
MILE	Mi	Length
QUART	Qt	Volume
GALLON	Gal	Volume
PINT	Pt	Volume
OUNCE	Oz	Mass
POUND	Lb	Mass
FAHRENHEIT	ºF	Temperature

The equivalence between our system and the English one is:

1 inch = 0,0254 m.
1 foot = 0,3048 m.
1 yard = 0,9144 m.
1 mile = 1609,344 m.
1 quart = 1136,5225 mL.
1 gallon = 4546,09 mL.
1 pint = 568,2612 mL.
1 ounce = 28,349 g.
1 pound = 453,592 g.

The equivalence between degrees Kelvin, Celsius and Fahrenheit will be seen on the next unit.

3.2. 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	PREFIX	SYMBOL
10^{1}	Deca	da
10^{2}	hecto	h
10^{3}	Kilo	k
10^{6}	mega	M
10^{9}	Giga	G
10^{12}	Tera	T
10^{-1}	Deci	d
10^{-2}	centi	c
10^{-3}	Mili	m
10^{-6}	micro	µ
10^{-9}	Nano	n
10^{-12}	Pico	p
10^{-15}	femto	f
10^{-18}	Atto	a

LENGTH, SURFACE AND VOLUME. CHARTS OF UNITS

LENGTH UNITS	
	Equivalence with the International System Unit
Tm	1 Tm = 10^{12} m
Gm	1 Gm = 10^{9} m
Mm	1 Mm = 10^{6} m
Km	1 km = 10^{3} m
hm	1 hm = 10^{2} m
dam	1 dam = 10 m
m	
dm	10 dm = 1 m
cm	10^{2} cm = 1 m
mm	10^{3} mm = 1 m
µm	10^{6} µm = 1 m
nm	10^{9} nm = 1 m
pm	10^{12} pm = 1 m
fm	10^{15}fm = 1 m
am	10^{18} am = 1 m

SURFACE UNITS	
	Equivalence with the International System Unit
Tm^2	1 Tm^2 = 10^{24} m^2
Gm^2	1 Gm^2 = 10^{18} m^2
Mm^2	1 Mm^2 = 10^{12} m^2
km^2	1 km^2 = 10^{6} m^2
hm^2	1 hm^2 = 10^{4} m^2
dam^2	1 dam^2 = 10^{2} m^2
m^2	
dm^2	10^{2} dm^2 = 1 m^2
cm^2	10^{4} cm^2 = 1 m^2
mm^2	10^{6} mm^2 = 1 m^2
$µm^2$	10^{12} $µm^2$ = 1 m^2
nm^2	10^{18} nm^2 = 1 m^2
pm^2	10^{24} pm^2 = 1 m^2
fm^2	10^{30} fm^2 = 1 m^2
am^2	10^{36} am^2 = 1 m^2

VOLUME UNITS		
	Equivalence with the International System Unit	Equivalence with Capacity units
Tm^3	1 Tm^3 = 10^{36} m^3	
Gm^3	1 Gm^3 = 10^{27} m^3	
Mm^3	1 Mm^3 = 10^{18} m^3	
km^3	1 km^3 = 10^{9} m^3	
hm^3	1 hm^3 = 10^{6} m^3	
dam^3	1 dam^3 = 10^{3} m^3	
m^3		1 kL = 1 m^3
dm^3	10^{3} dm^3 = 1 m^3	1L = 1 dm^3
cm^3	10^{6} cm^3 = 1 m^3	1 mL = 1 cm^3
mm^3	10^{9} mm^3 = 1 m^3	
$µm^3$	10^{18} $µm^3$ = 1 m^3	
nm^3	10^{27} nm^3 = 1 m^3	
pm^3	10^{36} pm^3 = 1 m^3	
fm^3	10^{45} fm^3 = 1 m^3	
am^3	10^{54} am^3 = 1 m^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 m $=10^2$ cm

We can obtain two conversion factors:

$$\frac{1\ m}{10^2\ m} \quad \text{And} \quad \frac{10^2\ cm}{1m}$$

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?

$$2\ cm \cdot \frac{1m}{10^2\ cm} = \frac{2\ cm \cdot 1\ m}{100\ cm} = \frac{2}{100}\ m = 0{,}02m$$

2- If there is no power of ten wec simply use the equivalence:

How many hours are 60 s?

$$60\ s \cdot \frac{1h}{3600\ s} = \frac{60\ s \cdot 1\ h}{3600\ s} = \frac{60}{3600}\ h = 0\ {,}016h$$

3- If we have to make more than one change we use more than one fraction

How many km/h are 20 m/s?

$$20\ \frac{m}{s} \cdot \frac{1\ Km}{1000\ m} \cdot \frac{3600\ s}{1\ h} = \frac{20\ m \cdot 1\ Km \cdot 3600\ s}{1\ s \cdot 1000\ m \cdot 1\ h} = 72\ km/h$$

EXERCISES

1. Convert the following measurements to meters using conversion factors:
   a. 100 mm
   b. 23 cm
   c. 40 fm
   d. 100 km
   e. 12 pm
   f. 45 µm
   g. 3 Gm

2. Convert the following measurements to square meters using conversion factors:
   a. 40 cm^2
   b. 3500 mm^2
   c. 3 km^2
   d. 3500 nm^2

3. Convert the following measurements to cubic meters using conversion factors:
   a. 45 dm^3
   b. 3500 hm^3
   c. 35 L
   d. 460 mL
   e. 460 mm^3

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. 4500 s to hours

5. Make the following mass conversions using conversion factors:
   a. 4500 kg to g
   b. 3700 mg to kg
   c. 600 Tg to Kg
   d. 40 dag to Kg
   e. 280 dg to mg

6. Make the following conversions using conversion factors:
   a. 5 cm to inches
   b. 4 km to miles
   c. 25 feet to meters
   d. 15 yards to km
   e. 2 pints to litres
   f. 30 pounds to kg

3.3. Scientific notation

In Physics and Chemistry we may find very long numbers, as the velocity of light which is 299792458 meters per second and very small numbers as the proton's mass, which is 0,00000000000000000000000000167 kg.

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: $299292458 = 2{,}99 \cdot 10^{8}$

- *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):*

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

  Example: $0{,}00000000000000000000000000167 = 1{,}67 \cdot 10^{-27}$

EXERCISES

1. Rewrite this numbers using scientific notation: (leave two decimals behind the coma)
   a. 0,003
   b. 125,45
   c. 345720,56
   d. 0,000023
   e. 725654000
   f. 245
   g. 8540
   h. 30000000
   i. 0,00025
   j. 8567985
   k. 0,000006
   l. 788566488,57
   m. 2,000004
   n. 0,000024
   o. 987654
   p. 4156,354
   q. 0,025

2. Rewrite these numbers into decimal notation:
   a. $2 \cdot 10^{-5}$
   b. $5{,}35 \cdot 10^{-6}$
   c. $6{,}7 \cdot 10^{3}$
   d. $4{,}56 \cdot 10^{9}$
   e. $2{,}4 \cdot 10^{-9}$

3. Solve the next operations:
   a. $(10^{3})^{5}$
   b. $(10^{2})^{3}$
   c. $(10^{2} \cdot 10^{5})^{3}$
   d. $10^{3} \cdot 10^{-3}$
   e. $10^{3} + 10^{2}$
   f. $(10^{5} + 10^{6})/100$
   g. $(10^{5} \cdot 10^{6})/100$

4. SENSITIVITY AND PRECISION. SIGNIFICANT DIGITS.

When we measure we use a measuring instrument, which will have certain sensitivity and precision:

- **Sensitivity:** The smallest change unit that an instrument can detect.
- **Precision:** Degree to which repeated measurements under the same conditions show the same results.

Therefore, when we talk about measurements, we have to considerate the sensitivity of the measuring instruments. The results of our calculations should never have more digits than the sensitivity of the instrument used.

4.1. Significant digits

The number of significant digits used in an answer to a calculation depends on the number of significant digits in the given data.

To know how many significant digits a measurement has, we have to follow the following rules:

1. Non-zero digits are always significant.
2. Zeroes placed between other digits are always significant; 5007 kg has four significant digits and 200,03 m has 5 significant digits.
3. Zeroes placed after other digits but behind a decimal point are significant; 6,50 has three significant digits.
4. Zeroes placed before other digits are not significant; 0,032has two significant digits.

Example: How many significant figures are present in the following numbers?

Number	Significant Figures	Rule(s)
35,712	5	1
2469	4	1
400,05	5	1,2
0,003 = 3 10^{-3}	1	1,4
6,500	4	1,3
705,0200	7	1,2,3,4
3000000 = 3 10^{6}	1	1
1,000	4	1,3

When we are operating, we should pay attention to the following rules:

- In additions and subtractions the result of the operation cannot have more decimal places than the smallest number of decimal places in the numbers being added or subtracted
- In multiplication and division the answer cannot contain more significant digits than the numbers being multiplied or divided.

EXERCISES

1. How many significant digits are there in the next numbers?
   a. 3400
   b. 0,000078

c. 0,340

d. 123,00

e. 24

f. 12302,02

g. 23,002

2. Round off the next numbers so they have 4 significant digits:

Example: 1,8359 = 1,836

a. 23,5

b. 0,023456

c. 23,456

d. 12,03

3. Solve the next operations leaving the result with the appropriate number of digits:

a. 45 · 125

b. 123,4 + 13,4567

c. 12,34 · 34,5 + 123

d. 1,56 + 12,3 · 4,5

5. MEASUREMENTS ERRORS.

When we measure, as we are humans, we make errors.

We can classify errors into two groups:

- Random errors are always present in every measurement. They are unpredictable and unavoidable.
- Systematic errors are caused by a bad measure or for a bad calibration of the measuring instrument. So this kind of errors can be avoidable.

As we cannot avoid random errors we have to keep them in mind when we measure. The best way to minimize them is to make as many measures as possible and, in this way, we can consider the average of our result as the best value:

$$\overline{x} = \frac{x_1 + x_2 + \ldots + x_n}{n}$$

Being n the number of measures taken and x_i the value of each measure.

But then, what is the error of our measurement? We have two ways of measuring errors:

- **Absolute error**: $\varepsilon_{ai} = \left| \overline{x} - x_i \right|$ gives as the error for each measure compared with the average (always positive)
- The **average of the absolute error** is the one that we usually take as the error of the measure, although if this average is lower than the sensitivity of the measurement instrument, we should take this sensitivity as the final error.

For example, the correct value of a mass measurement expressed as **1,234 ± 0,004 g**, means that the measurement value is between 1,230g and 1,238g.

- **Relative error:** is calculated by division of the absolute error into the average measurement. To express percentage, it is multiplied by a hundred. For example, if the correct value of a measurement is expressed as **2,345 ± 0,003 g** it is known that:

    a. The average mass is 2,345 g

    b. The absolute error is 0,003 g

The relative error is calculated:

$$\varepsilon_r = \frac{\varepsilon_r}{\overline{x}} \cdot 100$$

In the previous example

$$\varepsilon_r = \frac{0{,}003g}{2{,}345g} \cdot 100 = 0{,}128\%$$

A relative error under 1% means a good precision in the measuring method.

A relative error over 10% implies a non precise measuring method.

EXAMPLE:

In the lab, we have been measuring the temperature of boiling water. With a digital thermometer we have measured the next temperatures:

100,1 ºC	98,7 ºC	99,2 ºC	101,2 ºC	100,0 ºC

a) What is the sensitivity of the thermometer?

0,1 º C

b) What is the average of the measure?

$$\overline{x} = \frac{100{,}1\ ºC + 98{,}7\ ºC + 99{,}2\ ºC + 101{,}2\ ºC + 100{,}0\ ºC}{5} = 99{,}8\ ºC$$

c) What is the absolute error of each measure?

$$\varepsilon_{a1} = |99{,}8ºC - 100{,}1ºC| = 0{,}3ºC$$
$$\varepsilon_{a2} = |99{,}8ºC - 98{,}7ºC| = 1{,}1ºC$$
$$\varepsilon_{a3} = |99{,}8ºC - 99{,}2ºC| = 0{,}6ºC$$
$$\varepsilon_{a4} = |99{,}8ºC - 101{,}2ºC| = 1{,}4ºC$$
$$\varepsilon_{a5} = |99{,}8ºC - 100{,}0ºC| = 0{,}2ºC$$

d) What is the average of the absolute error?

$$\varepsilon_a = \frac{0{,}3ºC + 1{,}1ºC + 0{,}6ºC + 1{,}4ºC + 0{,}2ºC}{5} = 0{,}7ºC$$

e) What is the relative error of this measure?

$$\varepsilon_r = \frac{0{,}7ºC}{99{,}8ºC} \cdot 3 = 0{,}7\%$$

f) How should we write the result of our experiment?

Temperature = (99,8 ± 0,7) ºC

g) Has it been a precise experiment?

Yes, as the relative error is lower than 1%

EXERCISES

1. Five people in your class have measured the height of one of your classmates and they have obtained these five different results:

   1,65 m ; 1,57 m; 1,63 m; 1,67 m; 1,68 m;

   a) What height will you take as the most likely?
   b) What absolute error has made each of your classmates?
   c) What is the average of that absolute error?
   d) How will you write the final result of this experiment?
   e) What relative error has been made?
   f) Has it been a precise experiment?

2. Your partners have made a race and you are helping with other 3 people to measure the time. For the first, you have measured the next times:

   45,6 s; 47,5 s; 48,2 s; 43,1 s;

   a) What time will you take as the most accurate?
   b) What absolute error have you and your mates made?
   c) What is the average of that absolute error?
   d) How will you write the final result of the race?
   e) What relative error has been made?
   f) Has it been a precise experiment?

6. DATA ANALYSIS IN CHARTS AND GRAPHS.

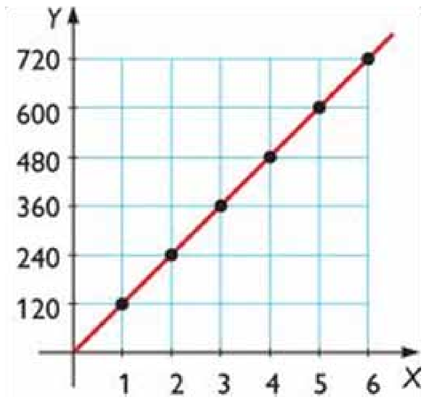
Once scientists have made their experiment and have taken measures, it is time to interpret those data so laws and theories can be made.

To organize and analyze data scientists use charts and graphs.

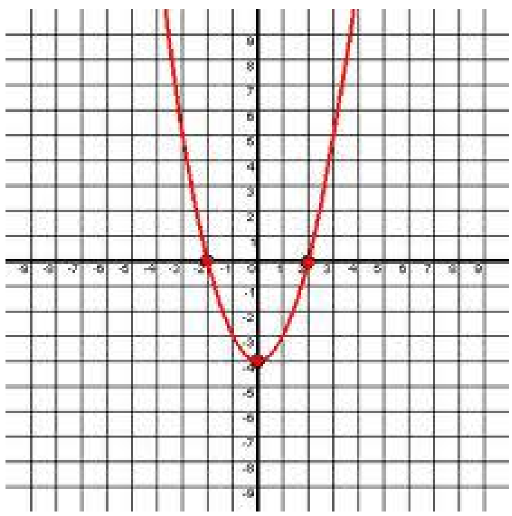
They also allow us to make predictions.

There are several types of graphs, this year we will see just the most important ones that are:

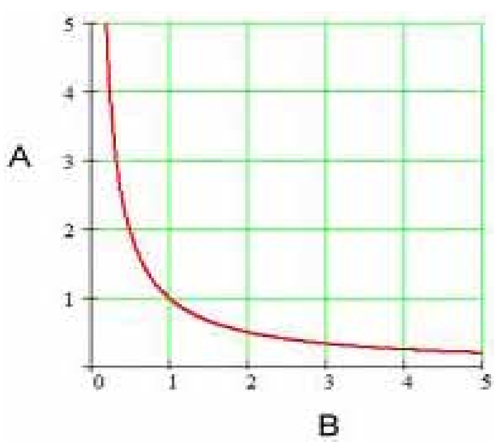
- Proportional graph: With the equation $y = ax + b$



- Quadratic graph: With the equation $y = ax^2 + b$



- Inverse proportion: It has the equation $y= 1/x$



We can see how it works in the next example:

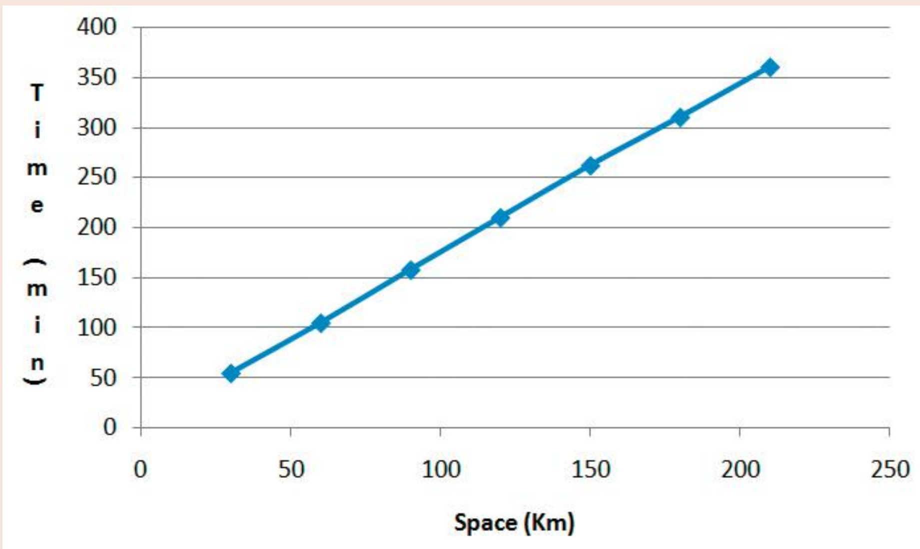
EXAMPLE:

Jesus is travelling in a car from Madrid to Valencia. To amuse himself he writes how many kilometres he makes every thirteen minutes. He made 7 measures: 55 km; 105 km; 158 km; 210 km; 262 km; 310 km; 360 km.

a) Made a chart with the results:

Time (min)	30	60	90	120	150	180	210
Space (km)	55	105	158	210	262	310	360

b) Draw a graph



c) How many km had he made when he had travelled for 100 minutes?

If we follow the lines in the graph we can see that he had travelled 175 km. approximately.

d) What kind of function does it represent?

Proportional function

EXERCISES

1. A vehicle starts to move. Time and space are measured obtaining the next results:

Time (s)	0	2	3	4	5	6	7
Space (m)	0	20	45	80	125	180	245

a) Draw a graph with these data.

b) What kind of graph is it?

c) How many meters will it have run at 10 seconds?

d) How much time will it take to run 300 meters?

2. In the laboratory, we have measured the pressure and the volume of a balloon, obtaining the next results:

Pressure (atm)	1	2	3	4	5
Volume(L)	5,00	2,50	1,67	1,25	1,00

a) Draw a graph with these data.
b) What kind of graph is it?
c) At what pressure the balloon will have a volume of 6 litres?

7. LABORATORY ACTIVITY: MEASUREMENT ERRORS.

STUDY OF THE TIME INVERTED BY A BALL FALLING TROUGH A SLIDE

OBJECTIVES:

1. To measure the time that a ball uses to cover distances.
2. To calculate the average time used by the ball
3. To calculate the error made in the measurements.
4. To decide if the experiment has been precise.
5. To draw a graph and identify the relation between time and space.

MATERIAL: BALL, SLIDE, CRONOMETER

ACTIVITY:

1. **Look at the chronometer:** What is its sensitivity?

2. **Measure the time** that the ball uses to cover three different distances and complete the following chart with the necessary calculations.

invested time in covering ___cm		invested time in covering ___cm		invested time in covering ___cm	
Experimental time (s)		**Experimental time (s)**		**Experimental time (s)**	
t_A		t_A		t_A	
t_B		t_B		t_B	
t_C		t_C		t_C	
t_D		t_D		t_D	
Average time		**Average time**		**Average time**	
Error in measured times (s)		**Error in measured times (s)**		**Error in measured times (s)**	
E_A		E_A		E_A	
E_B		E_B		E_B	
E_C		E_C		E_C	
E_D		E_D		E_D	
Absolute error		**Absolute error**		**Absolute error**	
Average time ± absolute error		**Average time ± absolute error**		**Average time ± absolute error**	
% relative error		**% relative error**		**% relative error**	

After doing the practice answer the next questions:

a) Observe the average error in which measurement had we made the biggest error?

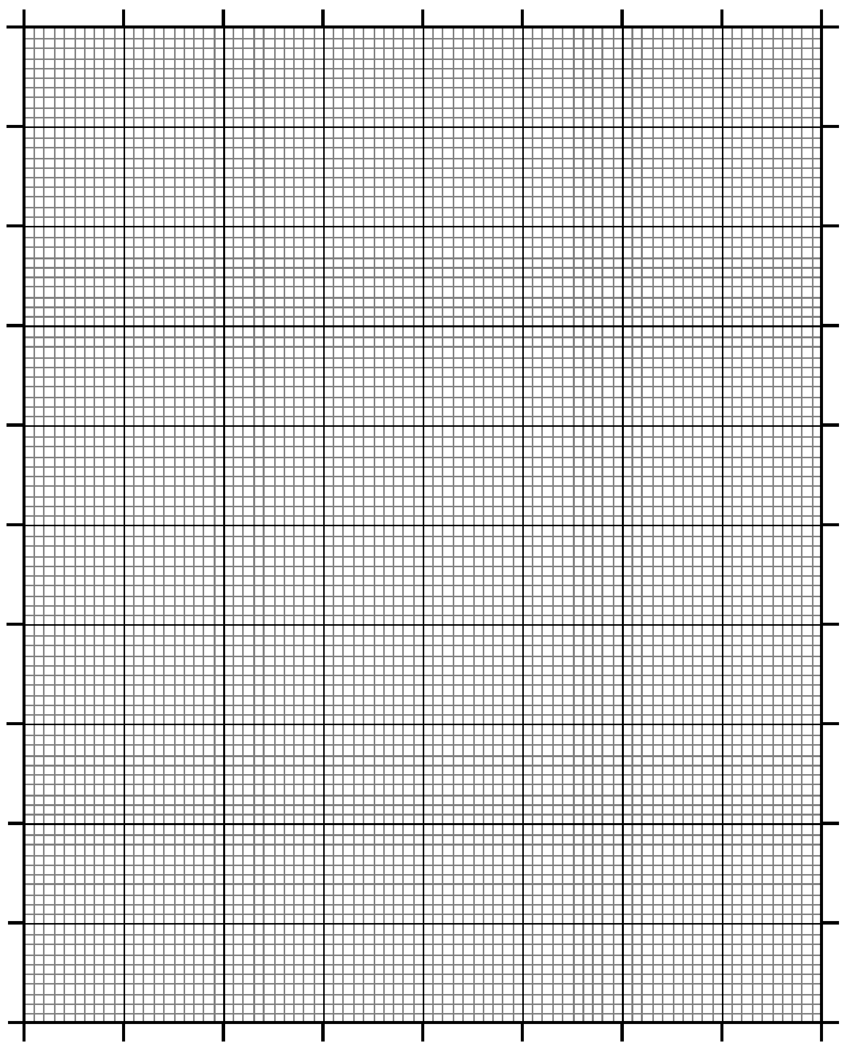
b) In which had we made the smallest error?

c) Based in questions a) and b), make a hypothesis, if it is possible, explaining the reasons.

d) Can our method be considered precise?

e) Draw a graph relating the distance and time and say what kind of function it represents.

f) Can you predict how much time the ball will invest to fall 100 cm?



8. 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:

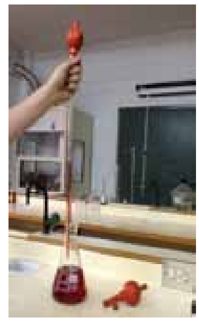
Glass material used for measuring volume of liquids

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

Watch glass

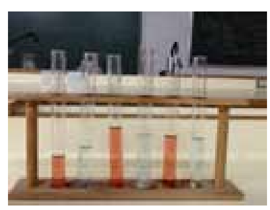
Crystallizer

Conical flask

Spherical flask

Test tube

Dish



Other useful materials

Beaker

Tripod

Washing bottle

Funnel

Dropper

Spatula

Agitator stick

Separating funnel

Mortar/ Pestle for mortar

Bunsen burner

2. Write some sentences to explain the use of some of these materials.

You can use the following type of sentences:

……. Is a	laboratory	material used for	verb-ing …..
	glass		
	separating		
	measuring		

9. DEVELOPMENT OF A RESEARCH PROJECT.

Soon, you will have to develope your own research project. To face this new work, you need to bear in mind the steps of the scientific method that you have just learned in this unit. Let´s remember some interesting advice.

Firstly, do the background research looking into books or web pages the most important concepts, theories or laws related to your project. Remember to note down the used bibliography and web addresses. This information must be included in your final report.

Once you have clearly understood the theoretical bases of your work, you will be able to decide the goal of your project and to decide your hypothesis. Remember to be honest and evaluate the actual possibilities to develop your work and ask for your teacher´s opinion.

Plan carefully your experimental work, taking into account the materials and instruments you will need and the variables or magnitudes you will have to measure. Before developing the experimental work, revise your planning with your teacher.

Do your measurements carefully and accurately. Be patient and invest the time you need to develop your work as well as possible. Ask your teacher if you have any doubt and don´t forget he or she is your guide.

To order and analyze your data you can use a computer. Some spreadsheet programs, such as excel, draw the graph once you have included your numerical results. But before using it, try to draw first your graph by hand in order to understand how the program works.

Analyze conscientiously your results and get a conclusion. It can turn out to be difficult for you, so once more it is recommended to ask for your teacher's view.

And finally write your report; the following points must be included:

1. Title
2. The name of the components in the working group

3. The objectives of the experimental study. Infinitive tenses must be used, such as:

   "To investigate the properties of the matter"

4. A review of the theory related to the work that you have found in the bibliography.

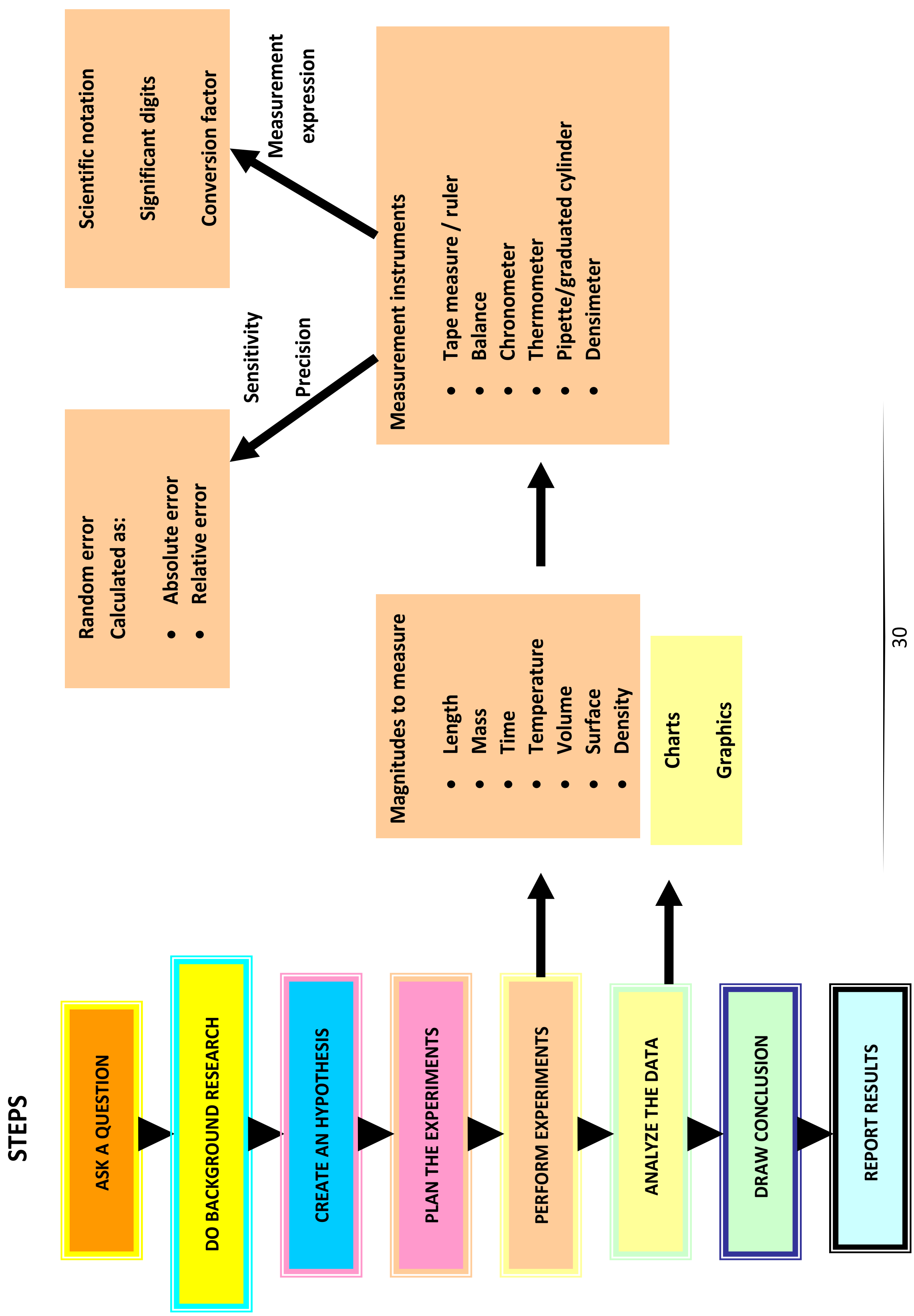
5. Material used in the experimental work. Information about the sensitivity of the measuring devices and a drawing of the materials should be included.

6. Experimental work: you have to describe everything you did and observed during your experimental work. Use past tenses

7. Charts and graphics with the measurement of magnitudes

8. Conclusion of your work.

10. SCIENTIFIC METHOD. VOCABULARY



11. FINAL ACTIVITIES

1. Make the following change of units:

    a) 108 Km/h to m/s
    b) 400 mm to Km
    c) 50 $m^2$to Km^2
    d) 400 $m^3$to L
    e) 200 m/s to Km/h
    f) 5,6 g/$cm^3$to Kg/m^3
    g) 100 $dm^3$to dam^3
    h) 200 nm to m
    i) 30 L to cm^3
    j) 400 dm^2 to mm^2

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

    a) 100 km
    b) 300 L
    c) 25 mm
    d) 400 cm^3
    e) 300 g
    f) 120 Km/h
    g) 40 g/L
    h) 340 Kg/L

3. Rewrite the next measurements into the International System of units:

    a. 27 inch
    b. 35 ft
    c. 500 yd
    d. 300 miles
    e. 3 pt
    f. 50 oz
    g. 35 lb.
    h. 35 mph (miles/hour)

4. In English-speaking countries a person height is measured using feet and inches. Express your height in that system.

5. In English-speaking countries the weight of a person is measured using pounds. If somebody has a weight of 60 kg, what would be his weight in pounds?

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

    a. 5 km
    b. 100 mg
    c. 6 hours
    d. 25 km
    e. 25000 ns
    f. 2.5 years
    g. 300 μg
    h. 3 mm
    i. 3 Mm
    j. 4500 pm
    k. 2.73 Mg,
    l. 0.358 Gs
    m. 40 μs.

7. Rewrite the next numbers using scientific notation and using two decimals behind the coma:

    a. 3454500000
    b. 0,0000034562
    c. 324600
    d. 3103000
    e. 0,00000000000003
    f. 0,00456
    g. 233400000000000000

8. Rewrite this numbers to decimal notation:

   a. $3,5 \cdot 10^{-8}$

   b. $4,76 \cdot 10^{3}$

   c. $9 \cdot 10^{-9}$

   d. $4,47 \cdot 10^{5}$

9. Five people in your class have measured the length of their table and they have obtained the following results:

   34,5 cm; 34,2 cm; 35,1 cm; 34,9 cm; 36,0 cm

   a) What length should be taken as the most accurate?

   b) What absolute error has made each of your classmates?

   c) What is the average of that absolute error?

   d) How will you write the final result of this experiment?

10. You are weighting in an old (non digital) scale. As it is not very accurate, you take four different results:

   61,3 kg; 60,9 kg; 62,0 kg; 61,8 kg

   a) What do you think is your weight?

   b) What absolute error have you made in each measure?

   c) What is the average of that absolute error?

   d) How will you write your weight?

11. In the lab, we measure the volume and temperature of a balloon, obtaining the next results:

Volume (L)	0,5	0,53	0,55	0,59
Temperature (K)	293	313	323	343

a) Draw a graph with these data.

b) What kind of graph is it?

c) If the balloon explodes when its volume it’s 0,6 L, at what temperature will it happen?

12. Measuring force and acceleration in a moving object we obtain the following data:

Force (N)	10	20	30	40
Acceleration (m/s^2))	2	4	6	8

a) Draw a graph with these data.

b) What kind of graph is it?

c) Which force will produce an acceleration of 5 m/s^2 in the object?

How much have you learnt?

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

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

Fundamental magnitude	Derived magnitude	International System Unit	Other units	Measuring instrument

2. Make the following change of units and express the result in scientific notation:

a. 3267 Mm to dam
b. 234 mm^2 to hm^2
c. 4213 cm^3 to dam^3
d. 567 mm^3 to daL
e. 0,034 kL to cm^3
f. 130 km/h to m/s
g. 220 dam/min to m/s
h. 33 dam/min to km/h
i. 458 kg/m^3 to g/cm^3
j. 4,2 g/cm^3 to kg/m^3
k. 31 cg/mm^3 to kg/m^3

3. Decide which is the sensitivity of the following measuring instruments:

a) A graduated cylinder with the scale:

b) A pipette with the scale:

c) A balance that measures 32,23g

d) A stopwatch that measures: 2,34s and 2,36s.

4. Underline the significant figures in the following measurements:

a. 0,03207 mm
b. 34000 km
c. 230 hg
d. 3,450 g