Teaching chemistry and physics to students in the 3rd curs of ESO, by using the bilingual educational program CLIL (*Content and Language Integrated Learning)*

Teacher's Material

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INTRODUCTION

These materials are thought to be used in the Secondary Education by students of 3rd curs of ESO.

Materials have been elaborated in an easy and understandable way and they have been adapted to the age and adequate level of students.

Each unit has been organized in a similar way. First, some *questions* are arisen in order to evaluate the previous knowledge of students, then, a *theoretical explanation* of the concepts are introduced and, at the end, several *questions, exercises and experiments* are proposed to students. Experiments are easy to prepare and require cheap and easily available materials. Each unit finishes with a *self-evaluation questionnaire* to give the students the opportunity to know their evolution.

The project includes a workbook for students and another one addressed to the teacher. In the teacher's material, it has been included answers to the proposed questions, some additional information and new activities, and at the end of each unit, a new section named "Teacher's notes" has also been included, so the teacher can register, in the way of a logbook, the most frequent difficulties and mistakes made by students and their evolution along the course.

Finally, it is also presented a test of unit 6 for three different levels of students with solutions, treatment of English language for Chemistry and Physics and the bibliography used to conclude this project.

Meaning of icons:


Reinforcement activities


Extension activities


Initial evaluation, questions that students have to know.


Students can answer the questions looking at the vocabulary


Additional information


Computer activity


Solutions to the activities


Work in pairs


Work in groups


Correction of exercises


Experiments


Indications to solve or answer the questions


Lab material


Questions

Safety measures

Keywords:

Keywords are presented in the form of a table. In the first column the words are written and drawing, and in the second column the meaning of the word is included.

Students will take a look to the keywords in order to know what the unit is dealing with.

It is important to take a look to all these words, so the teacher can talk about the general contents of the unit.

Initial Activities

Initial activities are planned to know the previous knowledge of students.

UNIT 1: ATOMIC STRUCTURE

LEARNING AIMS:

At the end of the unit, students have:

- The postulates of Dalton's atomic theory, which are in force nowadays and which not.
- The characteristics of elemental particles of the atom, electrons, protons and neutrons.
- The difference between atomic number and atomic mass number.
- The meaning of isotope.
- The major uses of radioisotopes.
- How to solve questions related to electronic structure.
- The concept of mol.
- How to calculate the molecular mass of a compound.
- To calculate the number of moles, number of molecules and the mass of a chemical substance.
- To use the appropriate language to answer questions and to communicate with teacher and classmates.

TEACHING OBJECTIVES:

Content:

Unit 1 Atomic structure

1.1. Dalton's atomic theory
1.2. Components of the atom: electrons, neutrons and protons
1.3. Isotopes
1.4. Electron configuration
1.5. Atomic mass. Molecular mass. Mol

Solutions

Initial activities

Procedure

1. **2.** and **3.** Students solve individually each question.

4. This is an activity to work with a computer. Students work in pairs, so the students have the opportunity to practice English language.

Once the students have done these activities, the first three activities will be corrected asking the solution to one student and commenting if it is correct or not with the whole class.

Activity four will be corrected by teacher.

1. **Atom**

2. **a. Protons and neutrons**
   b. Protons and electrons

3. **a. Isotopes are atoms of an element with different number of neutrons.**
   c. Isotopes of the same element have different atomic mass.

Finally, teacher will explain the first point of the unit. Each point is followed of a series of questions. They will be solved before starting the following point. In order to practice English language It is important to comment the solutions of questions.

1.1 Dalton's atomic theory

1.
1.1. b
1.2. c

2. **a. 3, 1, 4**
b. 1, 1, 1

1.2 Components of the atom: electrons, neutrons and protons

1.
1.1. b
1.2. b
1.3. d
1.4. a
1.5. d
1.6. b
1.7. a

2.

Across

3 Electrons
5 Up
6 Down
7 Quarks

Down

1 Nucleus
2 Protons
4 Neutrons

3.

- A substance made from only one type of atom. **Element**
- The smallest piece of an element. **Atom**
- The central part of an atom containing protons and neutrons. **Nucleus**
- A subatomic particle that carries a positive charge. **Proton**
- A subatomic particle that carries no charge. **Neutron**
- Number of protons in a nucleus. **Proton number**
- Number of particles in a nucleus. **Nucleus number**
- A subatomic particle that carries a negative charge. **Electron**
- Atoms with the same number of protons but different number of neutrons. **Isotopes**

4.

Element	Symbol	Protons	Neutrons	Electrons	Atomic Mass	Atomic Number
Calcium	**Ca**	**20**	**20**	20	40	**20**
Sodium	**Na**	11	12	**11**	**23**	**11**
Hydrogen	**H**	1	**0**	**1**	1	**1**
Nitrogen	**N**	**7**	7	7	**14**	**7**
Sulphur	**S**	**16**	16	16	**32**	**16**
Iodine	**I**	53	**74**	**53**	127	**53**
Chlorine	**Cl**	**17**	**18**	**17**	35	17
Iron	**Fe**	**26**	30	26	**56**	**26**
Uranium	**U**	**92**	**146**	**92**	238	92
Silver	**Ag**	47	**61**	**47**	108	**47**
Gold	**Au**	**79**	118	**79**	**197**	79

1.3 Isotopes

To solve this exercise, students have to consult the web site: **http://www.ausetute.com.au/nuclesum.html**

a. Carbon-14 is used to determinate the age of carbon-containing artefacts up to about **70.000** years

b. Sodium-24 is used to locate **leaks** in water pipes, to study body **electrolytes**.

c. Iodine-131 is used as medical tracer to study and treat the **thyroid** gland.

d. Uranium-235 is used as a **fuel** for most nuclear reactors.

e. Cobalt-60 is used in cancer treatment as **tumour** cells tend to be more susceptible to radiation than other cells.

1.

An isotope is one of two or more atoms having the same atomic number but different mass numbers.

An element is composed of atoms having an identical number of protons in each nucleus.

2.

2.1. a
2.2. d

3.

Isotope	Protons	Neutrons	Electrons	Atomic Mass	Atomic Number
$^{2}_{1}H$	**1**	1	1	**2**	**1**
$^{14}_{6}C$	6	**8**	**6**	14	**6**
$^{15}_{8}O$	8	7	**8**	**15**	**8**
$^{228}_{90}Th$	**90**	**138**	90	228	**90**
$^{213}_{84}Po$	**84**	**129**	**84**	213	84
$^{30}_{15}P$	**15**	15	**15**	**30**	15
$^{1}_{1}H$	1	0	**1**	**1**	**1**

1.

This is a free answer question where students have to consult the website: http://library.thinkquest.org/C006669/data/Chem/nuclear/natural.html.

2.

An alpha particle is identical to a helium nucleus. They consist of two protons and two neutrons. The energy of an alpha particle depends on the nucleus they are emitted, higher energy alpha particles are emitted from larger nuclei. An alpha particle with a kinetic energy of 5 MeV has a speed of 15,000 km · s^{-1}. These particles are easily absorbed by materials. They can be absorbed by tissue paper or the outer layers of human skin, so they are dangerous to life when ingested or inhaled. They can travel only a few centimeters in air.

Beta particles are high-energy and high-speed electrons or positrons emitted by unstable atomic nucleus with an excess of protons or neutrons. Unstable atomic nuclei with an excess of neutrons may undergo β^- decay:

$$n \rightarrow p + e^- + \nu_e$$

Unstable atomic nuclei with an excess of protons may undergo β^+ decay:

$$p \rightarrow n + e^+ + \nu_e$$

The energy of an alpha particle depends on the nucleus they are emitted. These particles have more penetrating ability than alpha particles; most beta particles can be stopped by a few millimeters of aluminum. Beta radiation is less ionizing than gamma radiation.

The mass of a beta particle is that of an electron, $9.10938188 \times 10^{-31}$ kg (0.000544662309 amu)

The Positron is an elementary particle, It is the antiparticle of the electron. It has a charge of $1,6 \cdot 10^{-19}$ C and a mass of $9.10938188 \times 10^{-31}$ kg.

A Neutron is a subatomic particle found in the nucleus of an atom. It has not electric charge and its mass is a little greater than a proton mass: 1.67495×10^{-27} kg.

Gamma rays are electromagnetic radiation of high energy, usually higher than 0,1 MeV. They are produced alongside other forms of radiation such as alpha or beta because when these radiations are produced an excited atom is obtained and this atom emits its excess of energy as an electromagnetic radiation.

$$^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$$

$$^{40}_{19}K + {}^{0}_{-1}e \rightarrow {}^{40}_{18}Ar$$

$$^{239}_{92}U \rightarrow {}^{239}_{93}Np + {}^{0}_{-1}e$$

$$^{222}_{86}Rn \rightarrow {}^{4}_{2}He + {}^{218}_{84}Po$$

$$^{216}_{84}Po \rightarrow {}^{212}_{82}Pb + {}^{4}_{2}He$$

$$^{225}_{89}Ac \rightarrow {}^{221}_{87}Fr + {}^{4}_{2}He$$

1. 37.500 years

2. 16.000 years old

3. To answer these questions, first, students have to look in the applet: http://www.colorado.edu/physics/2000/applets/iso.html.

a. The half live of ^{13}N is 9,96 minutes.
b. Helium-4, carbon-12 and berilium-9 are examples of stable isotopes.

1.4 Electron configuration

1. 

To answer this question, students have to consult the webpage: http://education.jlab.org/qa/electron_config.html

The electron configuration describes how many electrons are in each energy level of an atom and how the electrons are arranged within each energy level

The electron configuration also informs us about the position of the elements in the Periodic Table.

2.

$_{19}$K: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
$_{17}$Cl: $1s^2 2s^2 2p^6 3s^2 3p^5$
$_{8}$O: $1s^2 2s^2 2p^4$
$_{20}$Ca: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
$_{15}$P: $1s^2 2s^2 2p^6 3s^2 3p^3$
$_{13}$Al: $1s^2 2s^2 2p^6 3s^2 3p^1$

3.

Barium
Rubidium
Molybdenum
Sodium
Potassium
Arsenic
Yttrium

1.5 Atomic mass. Molecular mass. Mol

1.

a. **98**
b. **40**
c. **44**
d. **100**
e. **18**
f. **101**
g. **180**
h. **110**
i. **171**
j. **149**
k. **199**
l. **286**

2.

a. **0,25**
b. **0,5**
c. **0,1**

3.

a. 8 g
b. 31,8 g
c. $5{,}3 \cdot 10^{-3}$ g
d. $1{,}94 \cdot 10^{8}$ g

4.

a. $6{,}02 \cdot 10^{18}$
b. $9{,}03 \cdot 10^{25}$
c. $2{,}41 \cdot 10^{14}$

5.

a. 0,5
b. 0,5
c. 2
d. 1,2

6.

a. 4 g
b. 9,8 g
c. 409,5 g

http://www.carlton.srsd119.ca/chemical/molemass/moles6.htm: **In this website you will find extra exercises with solutions.**

7. 

a.

+	+	+	+	+	+	+	+	+	+	+	+	E	E	N
+	+	+	+	+	M	+	+	+	+	+	P	L	+	O
+	+	+	+	+	O	+	+	+	+	O	E	+	+	R
+	+	+	+	+	L	+	+	+	T	C	+	+	+	T
+	+	+	+	+	E	+	+	O	T	+	+	+	+	U
S	+	+	+	+	C	+	S	R	+	+	+	+	+	E
+	U	+	+	+	U	I	O	+	+	+	+	+	+	N
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+	+	+	+	C	+	+	+	+	A	+	+	+	+	+
+	+	+	+	+	U	+	+	+	+	T	+	+	+	+
+	+	+	+	+	+	N	P	R	O	T	O	N	+	+
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+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

b.

ATOM: **smallest part of a chemical element.**

ELECTRON: **elementary particle surrounding the nucleus of an atom.**

ELEMENT: **substance composed of atoms having the same number of protons in the nucleus.**

ISOTOPE: **one of two or more atoms with the same number of protons in the nucleus but a different number of neutrons**

MOLECULE: **smallest part of a chemical compound.**

NEUTRON: **subatomic particle, without charge, found in the nucleus of an atom.**

NUCLEUS: **central part of an atom where neutrons and protons are found.**

PROTON: **subatomic particle, with a positive charge and mass, found in the nucleus of an atom.**

8.  **Criss-cross**

Across

3. Molecule
5. Nucleus
6. Atom

Down

1. Neutron
2. Isotopes
4. Electron

9.- 

Cryptogram:

Radioactive isotopes are used to detect and treat tumours, in agriculture, in food preservation, industries, to generate electric power, etc.

TEACHER'S NOTES

Pupil misconceptions:

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Scientific understanding

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UNIT 2: THE PERIODIC TABLE

Content:

Unit 2 The periodic Table

2.1. Structure of the Periodic Table

2.2. Correlation with electron configuration

2.3. Metals, non-metals and semimetals

Learning Aims:

At the end of the unit, the student will know:

- How elements are arranged in the Periodic Table.
- The relationship between the electron configuration of an element and its position in the Periodic Table.
- The symbols of common elements.
- The main properties of metals, non-metals and semimetals.
- The uses of some elements in the everyday life.
- To use the computer to strengthen language and improve his/her knowledge.
- To use the appropriate language to answer questions and to communicate with teacher and classmates.

Solutions

Initial activities

1.

Bad electricity and heat conductors	**Non-Metal**
Malleable	**Metal**
Fragile	**Non-Metal**
Low density	**Non-Metal**
Shiny	**Metal**
Brittle	**Metal**
High density	**Metal**
Good electricity and heat conductors	**Metal**
Dull	**Non-Metal**
Hard	**Metal**

http://www.bbc.co.uk/schools/ks3bitesize/science/chemistry/m_m_physical_props_intro.shtml

2.

18 groups
7 periods

3. b

4. b

5.  **This is a free answer question where students have to imagine they are Dmitri Ivanovich Mendeléiev, and solve the following parts:**

a. Look for information about his biography (birth, family, studies, profession, predictions, etc)

b. Underline the main information.

c. Create a character in the website: http://www.voki.com/create.php

d. Write and comment the main information with your classmate.

2.1 Structure of the Periodic Table

1. The liquid elements in the Periodic Table at room temperature are: caesium, francium, gallium, mercury and bromine.

2.

2.1. a **and** d
2.2. c
2.3. b
2.4. b
2.5. c
2.6. c
2.7. a
2.8. c
2.9. d

Note: **The 8 most common elements in Earth's crust (by mass):**

46.6% Oxygen (O)

27.7% Silicon (Si)

8.1% Aluminium (Al)

5.0% Iron (Fe)

3.6% Calcium (Ca)

2.8% Sodium (Na)

2.6% Potassium (K)

2.1% Magnesium (Mg)

2.10. b

2.11. a and b

2.12. d

3.

Name	Potassium	Selenium	Manganese	Iodine	Hydrogen	Carbon	Phosphorus
Symbol	**K**	**Se**	**Mn**	**I**	**H**	**H**	**P**
Name	Calcium	Lithium	Tin	Sulphur	Strontium	Helium	Osmium
Symbol	**Ca**	**Li**	**Sn**	**S**	**Sr**	**He**	**Os**
Name	Boron	Lead	Silicon	Sodium	Cobalt	Rubidium	Thallium
Symbol	**B**	**Pb**	**Si**	**Na**	**Co**	**Rb**	**Tl**

4.

Name	**Caesium**	**Radium**	**Aluminium**	**Iron**	**Francium**	**Nickel**	**Iridium**	**Nitrogen**
Symbol	Cs	Ra	Al	Fe	Fr	Ni	Ir	N
Name	**Vanadium**	**Beryllium**	**Cadmium**	**Gallium**	**Chromium**	**Magnesium**		**Barium** **Gold**
Symbol	V	Be	Cd	Ga	Cr	Mg	Ba	Au
Name	**Oxygen**	**Tungsten**	**Antimony**	**Platinum**	**Chlorine**	**Indium**	**Zinc**	**Arsenic**
Symbol	O	W	Sb	Pt	Cl	In	Zn	As

2.2. Correlation with electron configuration

1.

1.1. a

1.2. a

1.3. c

1.4. c

2. The elements of the same group have the same number of valence electrons, which usually gives them similar chemical and physical properties.

3. The elements of the same period have the same number of occupied energy levels.

4. The electron configuration of the elements, A, B, C, D, E, F and G is:

A: G: 2; P: 6

B: G: 1; P: 5

C: G: 6; P: 5

D: G: 1; P: 3

E: G: 1; P: 4

F: G: 15; P: 4
G: G: 3; P: 5

2.3. Metals, non-metals and semimetals

1. The metalloid elements are: Boron (B); Silicon (Si); Germanium (Ge); Arsenic (As); Antimony (Sb); Tellurium (Te) and Polonium (Po).

2.

2.1. c

2.2. a

2.3. c

2.4. c

3.- suitable; good conductor; copper; jewelry; react; hard; bridges; good conductor of heat; aluminum; airplanes.

4. This is a free answer question. Students have to use an interactive periodic table and their own knowledge to write a letter explaining how useful metals are. They have to start by saying how many elements are metals and try to fit these words in: hard, flexible, shiny, strong, conductors, heat, electricity, easy to shape.

5.

a. Silver; Copper; Gold; Zinc; Iron; Lead; Graphite; Sulphur and Oxygen.

b. Graphite

c. Silver; Copper; Gold; Zinc; Iron; Lead; Graphite; Sulphur and Oxygen.

d. Metals are good conductors of heat and electricity but non-metals are not. One exception to this rule is graphite, one of the allotropic forms of carbon, because it is a good conductor of heat and electricity.

e. State of each element:

Element	e.1. Room temperature	e.2. 500 ºC
Iron	Solid	Solid
Zinc	Solid	Liquid
Copper	Solid	Solid
Lead	Solid	Liquid
Gold	Solid	Solid
Silver	Solid	Solid
Sulphur	Solid	Gas
Oxygen	Gas	Gas
Graphite	Solid	Solid

f. Oxygen; Sulphur; Graphite; Zinc; Iron; Copper; Silver; Lead; Gold.

Websites used:

http://www.standnes.no/chemix/periodictable/melting-points-table.htm,

http://www.standnes.no/chemix/periodictable/electrical-conductivity-elements.htm ,

http://en.wikipedia.org/wiki/Periodic_table

6.

a.

Metals	Non-metals
High boiling point	Low boiling point
Sonorous, ring like a bell	Light, low density
High melting point	Does not ring like a bell
Electricity conductors	Do not conduct electricity
Good heat conductors	Bad heat conductors
High melting point	Low melting point
Strong, hard to break	Brittle, easy to break
Shiny when polished or scratched	Dull, not shiny
Heavy, high density	Solids, liquids or gases
Some attract magnets	Do not attract magnets

b.

Mercury is an unusual metal because it is liquid at room temperature.

Carbon graphite is an unusual non-metal because it conducts electricity.

Sodium is an unusual metal because it is soft and floats on water.

Aluminium is an unusual metal because it has a low density.

7. This question have to be solved watching the reaction of lithium, sodium or potassium with water in the following websites:

http://www.seilnacht.com/film/english.html or
http://www.open2.net/sciencetechnologynature/worldaroundus/akalimetals.html.

Student have to write their own conclusion and compare their answers with their mate's answers:

Lots of bubbles Na	Smoke forms K	A few sparks Na	Reacts very quickly K	Moves quickly about K
Reacts slowly Li	A few bubbles Li	Dissolves None	Burns with a bright flame K	Reacts explosively K
Very reactive K	In the middle of the reactivity series Na	At the top of reactivity series K	Very unreactive Li	Quite reactive Na

On the blank cards they have to write down any other observation they made, as for example:

Lithium, sodium and potassium float on water.

When sodium and potassium react with water they acquire a round shape and move around the container as a billiard ball does.

Activity:

a. Students have to look for a interactive Periodic Table (for example http://www.periodictable.com/, interactive periodic table with pictures)

b. They have to prepare a Power Point with the following slides:

- **a.1. Title**
- **a.2. Index**
- **a.3. Different slides that include how it works, groups, periods, information about elements,**
- **a.4. Bibliography**

In the website http://science.pppst.com/periodictable.html they will find different power points very useful to do this activity.

TEACHER'S NOTES

Pupil misconceptions:

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Scientific understanding

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UNIT 3: CHEMICAL BOUNDING. CHEMICAL COMPOUNDS

Content:

Unit 3 Chemical bond. Chemical compounds

Learning Aims:

At the end of the unit, the student will know:

- Atoms bond together with other atoms to make a compound.
- To formulate and name different chemical compounds: oxides, hydroxides, hydrides, hydracids, oxy-acids and Salts
- To use the appropriate language to answer questions and to communicate with teacher and classmates.

Solutions

Initial activities

1. **a**

2.

Ammonia: **NH_3**
Sodium hydroxide: **NaOH**
Sulphuric acid: **H_2SO_4**
Carbon dioxide: **CO_2**
Hydrochloride acid: **HCl**
Potassium Chloride: **KCl**
Nitric acid: **HNO_3**

3.1. Chemical bonding

1. Correct answer:

1.1. a
1.2. b
1.3. a
1.4. a
1.5. b
1.6. a
1.7. b
1.8. c
1.9. d

2.

O_2: **Covalent**

NaCl: **Ionic**

HCl: **Covalent**

H_2O: **Covalent**

Al_n: **Metallic**

SO_2: **Covalent**

CaS: **Ionic**

3.

a) Na^+
b) Be^{2+}
c) F^-
d) S^{2-}
e) Al^{3+}

3.3. Nomenclature and Formulas

1.

1.1. a
1.2. b
1.3. c
1.4. d

2.

a) **CaS**
b) Fe_2O_3
c) $Al(OH)_3$
d) NH_3

3.

N_2O
NO
N_2O_3
N_2O_5
CO
CO_2
NaCl
ZnI_2

4.

NaOH: **sodium hydroxide**
HNO_3: **nitric acid**
$Al(OH)_3$: **aluminium hydroxide**
HF: **hydrofluoric acid**
$Ca(OH)_2$: **calcium hydroxide**
H_3PO_4: **phosphoric acid**
$HClO_2$: **chlorous acid**
$HClO_3$: **chloric acid**
HCl: **hydrochloric acid**
$NaNO_3$: **sodium nitrate**
H_2CO_3: **carbonic acid**
KClO: **potassium hypochlorite**
H_2SO_3: **sulphurous acid**
KOH: **potassium hydroxide**
NH_4OH: **ammonium hydroxide**
$CaSO_4$: **calcium sulphate**
$Fe(OH)_3$: **iron(III) hydroxide**
HBr: **hydrobromic acid**
H_2CrO_4: **chromic acid**
H_2S: **hydrosulphuric acid**
$Mg(OH)_2$: **magnesium hydroxide**
H_2SO_4: **sulphuric acid**

5. 

Sodium nitrate
Silver carbonate
Ammonium sulphate
Copper (II) oxide
Copper (I) oxide
Chromium (III) oxide
Hydrochloric acid
Hydrobromic acid
Hydrosulphuric acid
Chloric acid
Sulphuric acid
Nitric acid
Phosphorous acid
Chlorous acid
Hypochlorous acid

6. 

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+ + + S + + + + + + + +
+ + + + U + + + + + + +
E + + + + L + + E + + +
+ D + + A + P D + + + +
+ + I + M + I H + + + H
+ + + X M X + + I + Y R
C A R B O N A T E D T E
+ + + R N + + + R L E T
+ + D + I + + I A + + A
+ Y + + A + D S + + + W
H A C I D E N A R O B +
+ + + + + + + + + + + +
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ACID
AMMONIA
BORANE
CARBONATE
HYDRIDE
HYDROXIDE
OXIDE
SALT
SULPHIDE
WATER

7.  **Criss-cross**

Across

1. Ionic
3. Hydride
4. Marble
6. Covalent
7. Hydrogen
8. Acid

Down

2. Oxide
4. Metallic
5. Bleach

TEACHER'S NOTES

Pupil misconceptions:

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UNIT 4: MATTER: ELEMENTS, COMPOUNDS AND MIXTURES

Content:

Unit 4 Matter: Elements, Compounds and Mixtures

4.1. Difference between a pure substance and a mixture.
4.2. Classification of mixtures: homogeneous and heterogeneous.
4.3. Preparation of aqueous solutions.
4.3.1. Mass percentage.
4.3.2. Mass per unit volume.
4.3.3. Moles per cubic decimetre of solution (concentration).

Learning Aims:

At the end of the unit, the student will know:

- To distinguish a pure substance from a mixture.
- To distinguish an element from a compound.
- To distinguish an homogeneous mixture from an heterogeneous mixture.
- To prepare aqueous solutions.
- To work out questions related to mass percentage.
- To work out questions related to concentration.

Solutions

Initial activities

1.

a) Elements
b) Compound
c) Mixture
d) Heterogeneous
e) Homogeneous
f) Solution
g) Suspension

2. Distillate water is a compound and sea water is a solution.

3.

a) False

b) False

c) True

d) True

e) False

f) True

4.

$C_6H_{12}O_6$: **Compound**	O_2: **Element**	Running water: **Homogeneous mixture**
Bronze: **Homogeneous mixture**	CO_2: **Compound**	Aluminium: **Element**
Soft drink (Fanta …): **Homogeneous mixture**	Sugar aqueous solution: **Homogeneous mixture**	H_2SO_4: **Compound**

5. 10 g

4.1. Difference between a pure substance and a mixture

1. Sodium carbonate: **Compound**; vinegar: **Mixture**; platinum: **Element**; wine: **Mixture**; nitric acid: **Compound**; aluminium oxide: **Compound**; drinking water: **Mixture**; phosphorus: **Element**; iodine: **Element**; calcium fluoride: **Compound**.

2.

a) False

b) True

c) True

d) True

e) False

f) False

g) True

h) False

i) False

j) True

k) False

3.

3.1. c

3.2. b

3.3. b

3.4. a

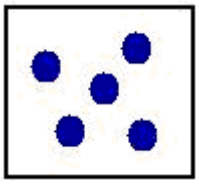
3.5. c

3.6. c

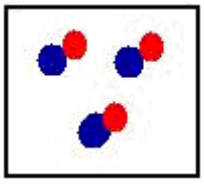
3.7. d

3.8. d

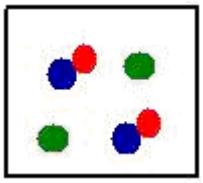
4.



This diagram corresponds to an element because there is only one kind of atoms.



This diagram corresponds to a compound because we can see three molecules with two kinds of atoms each.



This diagram corresponds to a mixture because we can see two separated atoms (represented in green) that represent an element and two molecules of a compound (represented in blue and red).

4.2. Classification of mixtures: homogeneous and heterogeneous

1.

a) Matter

b) Element

c) Mixture

d) Suspension

e) Atom

f) Molecule

g) Compound

h) Foam.

i) Colloid

j) Aerosol

2.

a) True
b) False
c) True
d) False
e) False
f) True
g) False
h) False
i) True
j) True
k) True
l) True
m) True
n) True
o) True

3. This is because particles often settle to the bottom over time and need to become resuspended or redispersed before the medicine can be used.

4. In the following table, examples of heterogeneous mixtures are written in blue and examples of homogeneous mixtures are written in red:

	Solid	Liquid	Gas
Solid	Sulphur and iron filings Bronze	Water and sand	Bread
Liquid	Solution of water and sugar	Oil and water Water and ethanol	Carbonated beverage
Gas			Air

5. Composition of composites:

a) Adobe brick is made from sand, clay, water and fibrous material such as sticks, straw, etc.

b) Plywood is a board made of thin layers of wood glued together under pressure.

c) Glass fibres are made by bonding fibreglass with a synthetic resin.

d) Tires are mainly made of rubber, sulphur and petroleum derivatives.

6. 

a) **An alloy is a solid homogeneous mixture made of two or more metals.**

b) **This is a free question. Students have to prepare a Power Point about alloys with the following slides:**

b.1. **Title**

b.2. **Index**

b.3. **Different slides that include definition of alloy, composition, properties and uses of the following alloys: *steel, duralumin, bronze, stainless steel, pewter, manganin, nichrome, cupronickel, solder, brass and dental amalgam.***

b.4. **Bibliography**

4.3. Preparation of aqueous solutions

1. **4%**

2. **0,047 kg · dm^{-3}**

3. **6,67 g · dm^{-3}**

4. **12 g · dm^{-3}**

5.

5.1. **c**

5.2. **d**

5.3. **a**

5.4. **c**

5.5. **c**

5.6. **b**

5.7. **b**

5.8. **a**

5.9. **c**

5.10. **d**

6. 

6. 1. 2 g of KNO_3 and 48 g of water

6.2. 1,32 g of NaI

6.3. 80%

6.4. 10%

6.5. 10 g · dm^{-3}

6.6. 1.000 g

6.7. 0,19 mol · dm^{-3}

6.8. 240 mL

6.9. 6,67 g · dm^{-3}

6.10. 1,11 g

Hint: In some questions about molarity concentration, remember first to calculate the number of moles.

Held: Web site **http://www.unitconversion.org/** will help you to prove if you have done correctly mass, volume, etc. arithmetic conversions.

Experiments:

Prepare the equipment and materials for each experiment

Students work in pairs

Experiment 1: Elements, Compounds and Mixtures

OBJECTIVE

Investigate some of the characteristics of both elements and compounds.

EQUIPMENT

Safety goggles
Magnet
Watch glass
Bunsen burner
Test tube
Test tube tongs
Beaker

MATERIALS

Iron filings,
Powdered sulphur
Water

PROCEDURE

5*.

a) **Teacher** will combine the mixture of sulphur and iron filings from several students in a test tube mixing them well.

b) Pick up the test tube with test tube tongs and heat the tube with the flame of a Bunsen burner for five minutes.

c) After five minutes, immerse the test tube cold water to break the test tube. If the test tube does not break, wrap it with paper towels and carefully broke it with an object.

d) Carefully remove the substance from the pieces of glass.

e) Observe the compound obtained, repeat the tests previously made with the reactants and annotate the observations in the table.

Do not point the open end of the test tube away from people!

Wear eye protection (safety goggles)

* This part of the activity will be conducted by the **teacher**.

Solutions

Questions

1. **Students have to compare the properties (colour, state, if they are attracted by a magnet or not, density respect to water –they float in water or not-, etc) of iron and sulphur with those of compound obtained.**
2. **Yes, it is. No, it isn't.**
3.

Iron + **Sulphur** → **Iron (II)** sulphide

Experiment 2: Preparation of aqueous solution

OBJECTIVE

Prepare 100 cm^3 of a 2 $g \cdot dm^{-3}$ aqueous solution of sugar.

EQUIPMENT

Beaker
Balance
Spatula
Funnel
Watch glass
Balance
100 mL volumetric flask
Pipette
100 ml graduated cylinder
Densimeter

MATERIALS

Sugar
Distilled water

Solutions

Procedure

1. Mass of sugar to be weighted: **0,2** g

Questions

1. A clean spatula has to be used to get a solid to avoid contamination with other substances.

2. Sugar has to be weighted on a watch glass to keep clean the balance and to avoid the mixture of sugar with other substances.

3. All the sugar has to be added to the flask to be sure the solution concentration is the correct one.

4. We have to look at the flask signal with the eyes at the same height of signal and the liquid meniscus has to be tangent to the flask signal.

5. This mixture of sugar in water is a homogeneous mixture because we can not distinguish the components of the mixture.

6. The density of the prepared solution is a little higher than the distilled water density because particles have different mass and they are bonded in a different way.

Activity

Students have to go to web page http://sciencehack.com/videos/category/2 and watch the video about solutions.

a) If students have some problem in word pronunciation, they can consult the wed site **http://www.thefreedictionary.com/** (dictionary with pronunciation).

b) If students want to listen with a good pronunciation a text, paragraph, etc, of these chemistry units, web sites: **http://vozme.com/index.php?lang=ca** and **http://www.voki.com/create.php** have a program to generate sound.

TEACHER'S NOTES

Pupil misconceptions:

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UNIT 5: SEPARATION OF MIXTURES

Content:

Unit 5 Separation of mixtures

5.1. Filtration

5.2. Decantation. Liquid-liquid extraction

5.3. Crystallization

5.4. Chromatography

5.5. Distillation

Learning Aims:

At the end of the unit, the student will be able to:

- Define key words related to this unit: solution, solvent, solute, filtrate, residue, immiscible and miscible liquids, distillate, ebullition, condensation, boiling point, crystallization, evaporation, aadsorption, desorption and chromatography.
- Select the best method for separating a given mixtures.
- Describe the different methods of separating mixtures.
- Use properly laboratory equipment to conduct the experiment.
- Perform simple experiments involving separation of mixtures.
- Use the appropriate language to answer questions and to communicate with teacher and classmates.

Solutions

Initial activities

1.

1.1. **a**

1.2. **c**

1.3. **d**

1.4. **b**

2.

a) Alcohol from wine: **3**

b) Iron filings from sand: **1**

c) Chalk powder from water: **4**

d) Ether from water: **2**

Questions

1.

a) Sodium chloride and water: **Crystallization**

b) Chalk powder and iron filings: **With a magnet**

c) Chlorophyll in spinaches: **Chromatography**

d) Sunflower oil and water: **Liquid-liquid extraction**

e) Copper(II) sulphate and sulphur: **Filtrate after adding water**

2.

a) **Evaporation takes place on the surface and ebullition in the whole liquid.**

b) **In a solution, solute is the substance that is dissolved, whereas solvent is what it is dissolved in.**

c) **In miscible liquids, liquids can mix together, but in immiscible liquids, the liquids can not mix together and remain separates.**

d) **Filtrate is the liquid which pass through the filter and residue is the solid remaining in the filter.**

e) **Condensation is the change from gas to liquid and ebullition is the change from liquid to gas.**

f) **Distillate is the collected liquid in a distillation process and filtrate is the liquid which pass through the filter in a filtration process.**

g) **Melting point is the temperature at which a substance goes from solid to liquid and boiling point is the temperature at which a substance goes from liquid to gas.**

3.

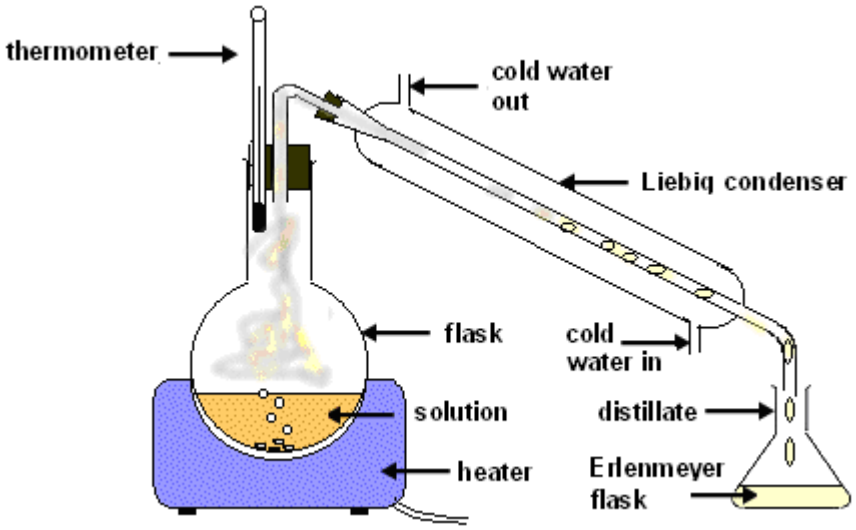
a) **Sugar is solved but sulphur doesn't.**

b) **Sugar solution pass through the filter paper but sulphur doesn't.**

c) **Making a crystallization of sugar solution.**

4. **By distillation.**

5.



http://phys.free.fr/images/dist.gif (there is a simulation)

b) It is where the distillate goes from gas to liquid.

c) To know the temperature of the substances leaving the flask.

6. Hidden word

a) .

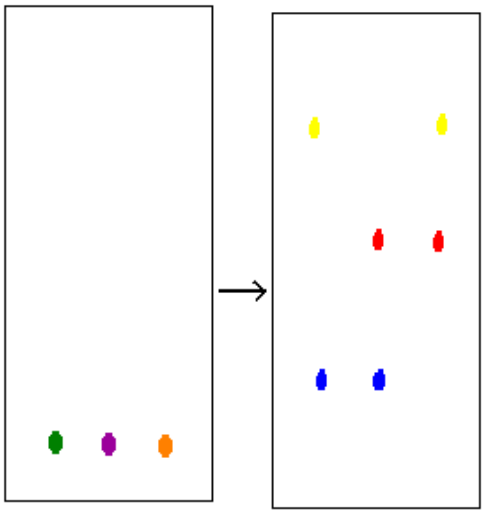
Physical method used to analyze a mixture.	C	H	R	O	M	A	T	O	G	R	A	P	H	Y
Goes from liquid to gas.	E	V	A	P	O	R	A	T	E					
Technique in which an evaporation followed by a condensation takes place.	D	I	S	T	I	L	L	A	T	I	O	N		
Substance that remains on the filter paper in a filtration	R	E	S	I	D	U	E							
Liquid used to dissolve a substance	S	O	L	V	E	N	T							
Dissolved substance in a solution.	S	O	L	U	T	E								
Liquid that flows through the filter paper in a filtration	F	I	L	T	R	A	T	E						
Technique in which a solid with a crystalline structure is separated.	C	R	Y	S	T	A	L	I	Z	A	T	I	O	N

The hidden word is	C	O	N	D	E	N	S	A	T	I	O	N

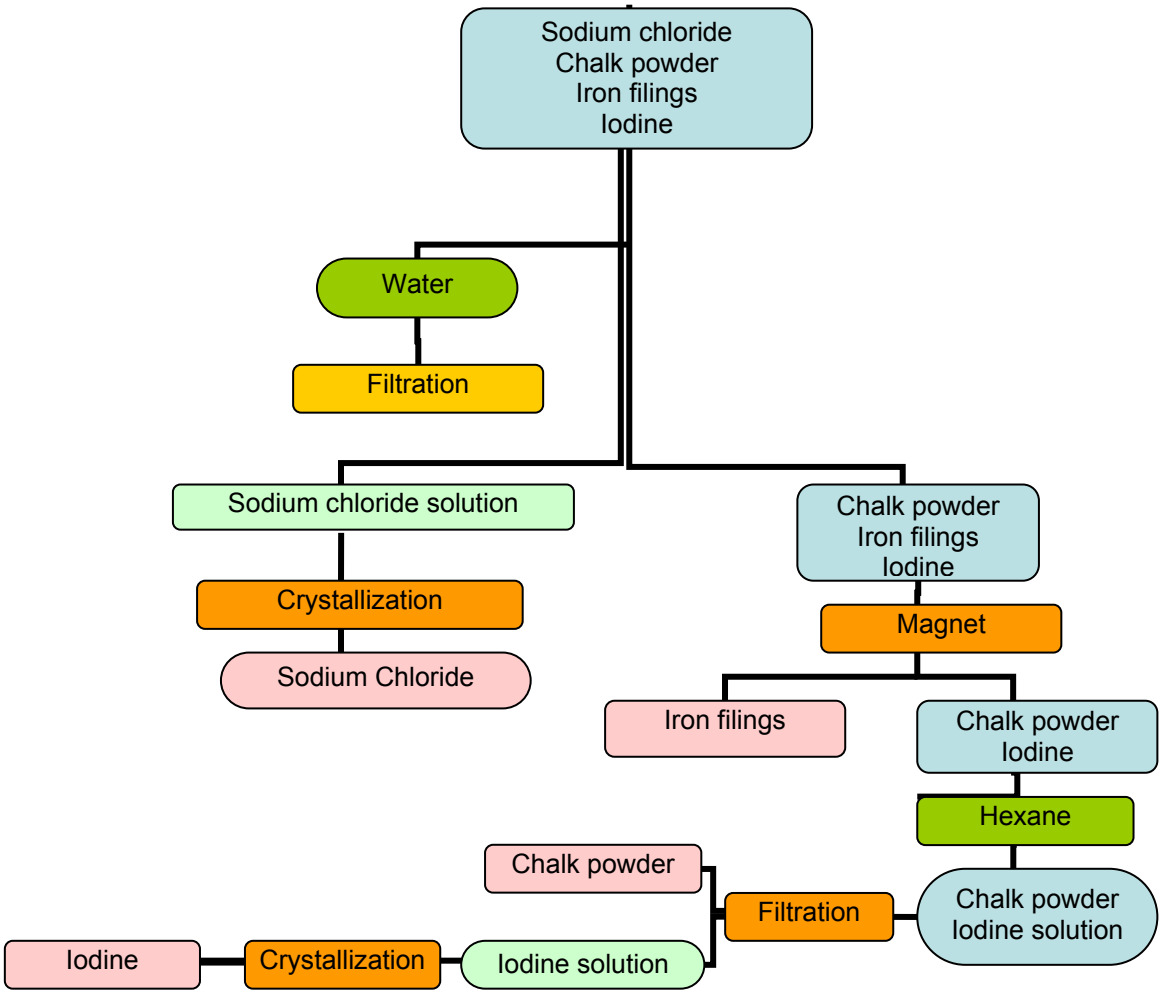
b) Condensation is the change from gas to liquid.

7. By the process of distillation.

8.



9. a



Hint: Sodium chloride is soluble in water but it is not soluble in hexane. Iodine is soluble in hexane but it is not soluble in water.


10. This is a free activity. Students have to prepare sand filter beds and make a report of the activity. They will find information in the web site http://www.wessexwater.co.uk/education/threecol.aspx?id=1444 (a video is included).

Precaution in case the web site could be eliminated (reproduction of the experiment found in the web site):

You will need:

- a two litre lemonade bottle
- cotton wool
- clean washed sand
- scissors
- sample of muddy water

Step 1

Cut the lemonade bottle just below half way and ensure the edges are smooth.

Step 2

Remove the lid from the top half of the bottle and then hold the bottle so it is upside down. Place some cotton wool in the neck and position the inverted top over the base of the bottle.

Step 3

Pour in 8 to 10cm of sand over the cotton wool.

Step 4

Ensure the filter is stable and pour through the sample of muddy water.

Explanation

A filter is a device that stops certain objects or substances while letting others through. Here the sand is acting as a filter stopping the particles of dirt while letting the water pass through.

Grains of sand are not perfectly symmetrical meaning that although they can be close together there will always be gaps in between them. These tiny gaps will let the water pass through but not the dirt and so the fine particles get trapped in the layers.

The water looks cleaner but is definitely NOT clean enough to drink since microscopic bacteria could still be in the water. This is only one stage of the water treatment process.

Experiments:

Prepare the equipment and materials for each experiment
Students work in pairs

Experiment 1: Filtration

OBJECTIVE

Prepare the mixture and separate the components.

EQUIPMENT

Funnel	2 beakers
Filter paper	Watch glass
Spatula or coffee spoon	Balance

MATERIALS

Water	Salt
Sand	

Solutions

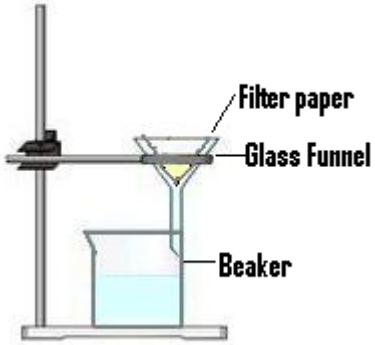
Questions

1. **Heterogeneous. We can distinguish the compounds.**

2. **Heterogeneous. We can distinguish the compounds.**

3. **No, they haven't.**

4.



5.

4. Pour the mixture into the funnel

3. Put the funnel into the flask

1. Fold the filter paper

5. The liquid is in the flask and the residue in the paper

2. Put the paper into the funnel

6.

The sand is in the paper because it can not go through the paper.

Solution is in the flask because it can go through the paper.

Experiment 2: Liquid-Liquid Extraction

OBJECTIVE

Prepare the mixture and separate the components.

EQUIPMENT

Decantation funnel	Separating funnel,
Beaker	Stand
Ring holder	

MATERIALS

Iodine	Water
Hexane	

Solutions

Questions

1. Heterogeneous. We can distinguish the compounds.

2. Iodine has been dissolved in hexane because the two substances are apolar and water is polar.

3. Hexane is in the top layer because it is less dense than water.

Experiment 3: Crystallization

OBJECTIVE

Prepare the solution and separate the components.

EQUIPMENT

Crystallizer	Beaker
Stirring rod	Bunsen burner

MATERIALS

Copper (II) sulphate	Water

Solutions

Questions

1. The mixture of ´copper (II) sulphate and water is homogeneous because we can not distinguish the compounds.

2. The answer to this question is free. Students have to describe and draw the crystals obtained.

3. It is not correct to say crystal when we are taking about the window glasses because the molecules, ions or atoms in a crystal have a regular structure but in window glasses do not.

Experiment 4: Chromatography

OBJECTIVE

Prepare the filter paper with the mixture and separate the components.

EQUIPMENT

Filter paper	Bottle with wide mouth
Lid	

MATERIALS

Felt-tipped pen (different colours)

Solutions

Questions

1. No, it isn't, because once the chromatography is made we can see different spots.

2. Homogeneous because we can distinguish the compounds.

3. The answer to this question is free. Students have to describe all they observe.

Experiment 5: Distillation

OBJECTIVE

Set the devise and separate the essential oil from mint.

EQUIPMENT

Clamp stand	Clamp
Thermometer	Distillation flask
Broken porcelain	Bunsen burner
Condenser	Erlenmeyer flask

MATERIALS

Mint	Water

Solutions

Questions

1. Broken porcelain is used to smooth down the ebullition.

2. Substances go from liquid to gas in the flask and from gas to liquid in the condenser.

3. The thermometer is placed close to the opening to know the temperature of gases leaving the flask.

4. The first substance leaving the flask is the essential oil of mint because is the substance with the lowest boiling point.

5. The temperature when the essential oil is leaving the distillation flask remains the same until all the essential oil has left the flask.

6.

5. The whole process is called distillation	**1.** Mint and water is heated in a flask
2. Mint essential oil evaporates to steam above the mixture	**3.** The steam cools down and condenses to form oil
4. The essential oil is collected in an Erlenmeyer flask	

TEACHER'S NOTES

Pupil misconceptions:

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UNIT 6: CHEMICAL REACTIONS

Content:

Unit 6: Chemical reactions

Learning Aims:

At the end of the unit, the student will know:

- The difference between physical and chemical changes.
- The concept of mol and its application in a chemical reaction
- The meaning of a chemical equation.
- The meaning of the different kinds of chemical reactions.
- How to solve problems and questions related to stoichiometric calculations.
- How to use the chemical and mathematical language appropriated to the problem solutions.
- How to follow a guided experiment in the laboratory.
- How to manipulate in a correct way the material and reactants in the laboratory.
- The difference between an exothermic and an endothermic reaction.
- The meaning of kinetics.

Solutions

Initial Activities

Procedure

1. Thought shower. Students will have some previous knowledge of physical and chemical changes, so the unit will start with a brainstorm about this kind of changes (students say aloud different words related with these two terms (physical change and chemical change); teacher or student writes them on the board).

When teacher decides that there are enough words, the second step is to separate the words in different columns.

2. and **3.** Students can consult the vocabulary that they have in their textbook.

.

2. **In a physical change the composition of substance remains the same.**

3. **In a chemical change substances react and new ones are obtained.**

4.

Distillation: **Physical change**
Iron oxidation: **Chemical change**
Combustion: **Chemical change**
Evaporation: **Physical change**
Condensation: **Physical change**
Sublimation: **Physical change**
Ammonia production from nitrogen and hydrogen: **Chemical change**
. Water decomposition in hydrogen and oxygen: **Chemical change**
.
. Apple oxidation: **Chemical change**
Decantation: **Physical change**
Filtration: **Physical change**

Once the students have done these activities, with help of the teacher, they will take a look to the keywords in order to know what the unit is dealing with. Then, the teacher will introduce the concept of chemical and physical change.

Solutions

6.1. Physical and chemical changes

Procedure

1. This exercise is thought to work in pairs, so the students have the opportunity to practice English language.

The teacher will give the initial letters and the total number of letters to those students who have some difficulties to learn:

CH - - - -
CH - - - - - -
CO - - - -
FI - - - - - - - -
OX - - - - - - -
PH - - - - - -
PR - - - - - - - - -
SU - - - - - - - - -

2.  Teacher will present the following words to the students who have some difficulties to learn:

new; back; colour; gas; heat; difficult; start; energy

5.  This exercise, for the same reason as in exercise 1, will be solved in pairs.

6. and **7.**  These exercises are thought for those students who are able to solve them (according to the appreciation of the teacher).

Solutions

The complete set of questions will be corrected by different students on the blackboard and the rest of students have to participate. The teacher will ask for their opinion, telling if they got the same answers and what they think of the proposed answer.

1. 

-

C I Y D B S U B N N F Z Q N N P
L H D P R K Y E G O D X O H D H
N T E I R G C E O I K I F G L Y
Q K S M H L X U P T T H N T Q S
C A J R I O X I D A T I O N Q I
P A U U O C U T R M J V J A T C
J N T A P A A T U I K Z J R J A
X U T O A E L L F L N M S B L L
H L O L N I T S O B E G N A H C
D F Z X F S I A L U I L I C O C
M X T W U N R B T S P I Q E I Z
S E D F C N T N C I B S B K P F
L S C P P C X T C W P Y O O L T
P A X E O X U Y D E Z I O X G R
S V E L C T G L Y Q V I C U B Y
A F O V V V K Z O F P I T E C U
E U M W A Z P K H D T H R X R T
R Z E T R J L X P U Y E Q F M P

b.

CHANGE
CHEMICAL
COLOUR
FI LTRATION
OXIDATION
PHYSICAL
PRECIPITATE
SUBLIMATION

2. In a chemical reaction new substances are made. The colour may change or you may see gas bubbles. The change is difficult to reverse. You cannot easily get back the substances you started with. There is an energy change at the same time. You may need heat or electricity to start the reaction and the mixture may generate heat.

3.

3.1. d
3.2. d
3.3. d
3.4. c
3.5. e
3.6. c

4.-

1. **Precipitate**
2. **Bubbles**
3. **Odour**
4. **Chemical**
5. **Heat**

5.- In a chemical reaction, in many cases we can observe an apparent change, for example, we can see a new colour, a precipitate or the formation of bubbles, the generation of heat, etc.

6.- 

The answer to this question is free. Students have to give 5 examples of chemical changes and 5 examples of physical changes that they have observed in their kitchen, at home.

7.- 

a. The atoms in the molecules of hydrogen and chorine are reordered and molecules of hydrochloric acid are obtained.

b. It is a chemical change.

6.2. Chemical equations

1. Balance the following equations and write the names of the compounds:

a) $2\ NH_3 + 5/2\ O_2 \rightarrow 2\ NO + 3\ H_2O$

b) $PbO_2 + 4\ HCl \rightarrow PbCl_2 + Cl_2 + 2\ H_2O$

c) $2\ NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2\ H_2O$

d) $(NH_4)_2CO_3 \rightarrow 2\ NH_3 + CO_2 + H_2O$

e) $Fe_2(SO_4)_3 + 12\ K(SCN) \rightarrow 2\ K_3Fe(SCN)_6 + 3\ K_2SO_4$

f) $2\ Cu + ½\ O_2 \rightarrow Cu_2O$

g) $CaCl_2 + 2\ AgNO_3 \rightarrow 2\ AgCl + Ca(NO_3)_2$

h) $H_2 + ½\ O_2 \rightarrow H_2O$

i) $6\ Mg + P_4 \rightarrow 2\ Mg_3P_2$

j) $Ca(OH)_2 + 2\ HCl \rightarrow CaCl_2 + 2\ H_2O$

k) $CH_4 + 2\ O_2 \rightarrow 2\ H_2O + CO_2$

l) $C_4H_{10} + 13/2\ O_2 \rightarrow 4\ CO_2 + 5\ H_2O$

m) $C_3H_7OH + 9/2\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$

n) $Fe_3O_4 + 4\ CO \rightarrow 4\ CO_2 + 3\ Fe$

2.  In web sites: http://chemistry2.csudh.edu/newlechelp/rxnbalancing.html and http://richardbowles.tripod.com/chemistry/balance.htm advanced students will find more exercises about balancing equations where checking answers are included.

Hint: web site http://www.trimen.pl/witek/calculators/wspolczynniki.html is an interactive site to calculate coefficients to balance chemical equations

6.3. Mol and chemical reaction. Calculations

1.

a) **True**
b) **False**
c) **False**
d) **True**
e) **False**

2.

a) **True**
b) **True**
c) **False**
d) **True**
e) **True**

3.

a) **False**
b) **True**
c) **True**
d) **False**

4.

a) **True**
b) **True**
c) **False**
d) **False**

5.

a) **True**
b) **False**
c) **False**
d) **True**

6. 213 g

7. 169,3 g

8.

a) **False**
b) **True**
c) **False**
d) **False**

9. **40,26 g**

10.  Advanced students can do the exercises they will find in web site: http://lrc-srvr.mps.ohio-state.edu/under/chemed/qbank/quiz/bank3.htm (in this web site they can check the answer).

Precaution in case the web site could be eliminated (reproduction of the exercises found in the web site):

Calculate the number of moles of Na_2CS_3 produced from 0.6 moles of CS_2 by the following reaction.

$$3\ CS_2 + 6\ NaOH \longrightarrow 2\ Na_2CS_3 + Na_2CO_3 + 3\ H_2O$$

a) 0.9
b) 0.2
c) 0.8
d) 0.4
e) 0.6

Calculate the number of moles of Fe_3O_4 produced from 0.75 moles of Fe by the following reaction.

$$3\ Fe + 4\ H_2O \longrightarrow Fe_3O_4 + 4\ H_2$$

a) 0.50
b) 0.75
c) 0.15
d) 0.25
e) 2.25

How many grams of carbon is required to produce 0.460 moles of SiC?
(Atomic weights: C = 12.0, Si = 28.09, O = 16.00).

$$SiO_2 + 3\ C \longrightarrow SiC + 2\ CO$$

a) 15.4
b) 16.6
c) 17.8
d) 16.0
e) 17.2

A photosynthetic bacterium can convert CO_2 and H_2S into glucose ($C_6H_{12}O_6$), water and sulphur. How many moles of glucose can be formed from 0.340 g of H_2S?
(Atomic weights: C = 12.01, O = 16.00, H = 1.008, S = 32.06).

$$12\ CO_2 + 24\ H_2S \longrightarrow 2\ C_6H_{12}O_6 + 12\ H_2O + 3\ S_8$$

a) 2.00×10^{-2}
b) 8.31×10^{-4}
c) 4.00×10^{-3}
d) 1.00×10^{-2}
e) 8.32×10^{-2}

How many moles of HCl are produced from 1.23 g $TiCl_4$ according to the following reaction?
(Atomic weights: Ti = 47.90, Cl = 35.45, H = 1.008).

$$TiCl_4 + 2\ H_2O \rightarrow TiO_2 + 4\ HCl$$

a) 0.0410
b) 0.0259
c) 0.0157
d) 0.00648
e) 0.00236

Aluminium and sulphur react at elevated temperatures to form aluminium sulphide, Al_2S_3. Calculate the mass of aluminium that reacts with 1.00 g of sulphur.
(Atomic weights: Al = 26.98; S = 32.06).

a) 0.812
b) 0.280
c) 0.928
d) 0.701
e) 0.561

Silver tarnishes in the presence of hydrogen sulphide according to the given balanced equation. What mass (g) of "tarnish" is produced from 0.136 g of H_2S?
(Atomic weights: Ag = 107.87, O = 16.00, H = 1.008, S = 32.06).

$$4\ Ag + 2\ H_2S + O_2 \rightarrow 2\ Ag_2S + 2\ H_2O$$

a) 0.293
b) 1.98
c) 0.136
d) 0.496
e) 0.989

White phosphorus (P_4) is used in military incendiary devices because it ignites spontaneously in air. How many g of P_4 will react with 25.0 g of O_2?
(Atomic weights: P = 30.97, O = 16.00).

$$P_4 + 5\ O_2 \rightarrow P_4O_{10}$$

a) 24.2
b) 4.83
c) 27.1
d) 3.88
e) 19.4

6.4. Types of chemical reactions

a) Double displacement
b) Synthesis
c) Double displacement
d) Double displacement
e) Double displacement
f) Combustion
g) Decomposition
h) Synthesis
i) Double displacement
j) Single displacement
k) Combustion
l) Single displacement
m) Decomposition
n) Synthesis
o) Double displacement
p) Acid-base
q) Synthesis
r) Decomposition
s) Decomposition

6.5. Energy in a chemical change

1.

1.1. a
1.2. b
1.3. a, c and d
1.4. b
1.5. a

2.

a) Exothermic
b) Exothermic
c) Endothermic
d) Endothermic

3. No, a chemical reaction cannot be both exothermic and endothermic.

4.

 Teacher will present the following words to the students who have some difficulties to learn:

Thermometers; endothermic; exothermic; energy; temperature; nitrate

In an exothermic reaction energy is released. On the other hand, in an endothermic reaction, energy is taken. One example of an endothermic reaction is the dissolving of ammonium nitrate in water. When this happens the heat taken in by the mixture causes the temperature to change.

Thermometers are used to measure temperature.

When in a chemical reaction temperature decreases, an endothermic reaction is produced.

5. An endothermic reaction is produced because temperature decreases.

6.

a) An exothermic reaction is produced because temperature increases.

b) Hot packs can be made with two separated compartments, one of them containing magnesium sulphate or calcium chloride and the other one containing water. When the hot pack is crushed, water and the other chemical mix together and an exothermic reaction is produced.

EXPERIMENTS[3]

Experiment 1: Heating Copper Sulphate

OBJECTIVE

Observe the changes produced in a chemical reaction.

EQUIPMENT

Bunsen burner	Test tube
Spatula	Test tube tongs
Balance	

MATERIALS

Copper (II) sulphate

Solutions

Questions

1. Answer to this question is free. Students have to write a report of what they did, change the instructions to past tense (e.g. Heat the test-tube……. **We** heat**ed** the test-tube) **and add some of these words: first**; **then**; **after that**; **finally**.

2.

Copper sulphate crystals are **blue**/black. When we heated them we saw **steam**/smoke at the top of the test-tube. The crystals slowly turned into a red/**white powder**/liquid. We found they had **lost**/gained mass. This was because the crystals had lost colour/**water**.

Safety measures:

1. Do not touch the chemical

2. Be careful with fire.

3. Do not touch the test tube when it is hot.

4. Wear safety glasses and a white coat to protect yourself.


When students have answered the questions, they will be corrected on the blackboard. Alternatively, the students correct them one another.

[3] Students work in pairs in the laboratory. It is convenient to change the components of the group when a new experiment begins. On the other hand, it is important that the students who have some difficulty to learn do not work together.

Experiment 2: Chemical Reactions. Microscale Experiments

OBJECTIVE

Observe the changes produced in different chemical reactions. Save chemicals.

EQUIPMENT AND MATERIALS

Microplates	Spatula	Pippete
Diluted sulphuric acid[0]	Water[1]	Diluted sulphuric acid[2]
Copper carbonate[0]	Copper oxide[1]	Copper[2]
Diluted sulphuric acid[0]	Lead nitrate[1]	Diluted sulphuric acid[2]

Sodium hydroxide solution[0]	Potassium iodide[1]	Magnesium[2]
Vinegar[0]	Iron filings[3]	Copper sulphate solution[3]
Sodium hydrogen carbonate[0]	Water[3]	Iron filings[3]

[0]: Reactants for all groups
[1], [2], [3]: Reactants for specific groups (groups 1, 2 and 3)

Procedure:

Students have to follow the instructions given in the student textbook.

Safety measures:

1. Do not touch the chemicals

2. Use small amounts of chemicals

3. Wear safety glasses and a white coat.

Experiment 3: Burning candles

OBJECTIVE

To predict and observe what happen in a combustion reaction when the quantity of oxygen changes.

EQUIPMENT

250 cm^3 beaker 500 cm^3 beaker

Chronometer

MATERIALS

Two candles same size Matches

Procedure:

Students have to follow the instructions given in the textbook.

Safety measures:

Be careful with matches.

Solutions

Questions

1. A candle contains molecules made of carbon and hydrogen. When it burns these elements combine with oxygen in the air. Carbon dioxide and water are formed in the reaction and energy is liberated in the form of heat and/or light.

This question and the other questions will be corrected in common.

Experiment 4: Burning copper

OBJECTIVE

To predict and calculate the mass of product obtained when copper is heated directly over the flame of a Bunsen burner.

EQUIPMENT

Balance	Bunsen burner
Tongs	Ruler
Scissors	

MATERIALS

Copper foil

Procedure:

Students have to follow the instructions given in the textbook.

Safety measures:

1. Be careful with fire.

2. Do not touch the copper foil when it is hot.

3. Wear safety glasses and a white coat.

Solutions

Questions

Considering your results/conclusion

From my results I can see that after I had heated the copper metal the mass had **gone up**.

When students have answered the questions, they will be corrected and commented.

Experiment 5: Displacing metals in salts

OBJECTIVE

Prove how more reactive metals displace less reactive metals in salts. Know if these reactions are endothermic or exothermic. Save chemicals.

EQUIPMENT

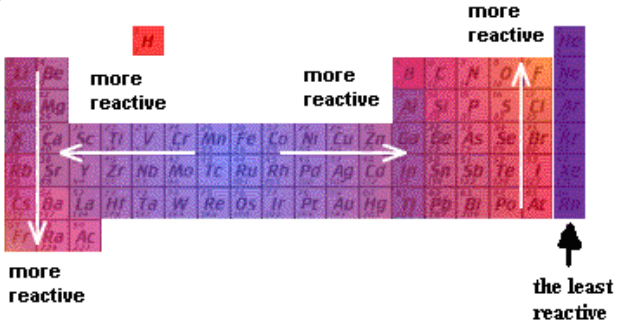
Spatula	Microplates
Thermometer	

MATERIALS

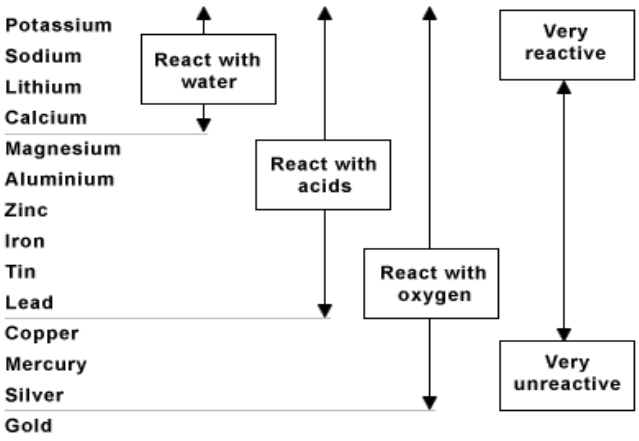
Magnesium	Zinc sulphate
Iron	Magnesium sulphate
Copper	Iron sulphate
Zinc	Copper sulphate

Procedure:

1. The teacher explains how the reactivity of an element depends on its position in the periodic table, using the following graphics:



http://www.nelsonthornes.com/secondary/science/scinet/scinet/reaction/react/periodic.htm



http://www.bbc.co.uk/scotland/education/bitesize/standard/chemistry/metals/reactivity_rev5.shtml

2. Teacher shows the following simulation as an example of reactivity:
http://www.bbc.co.uk/scotland/education/bitesize/standard/chemistry/metals/reactivity_rev5.shtml

3. Students have to:

. Use the Periodic Table to look at the position of the elements.

. Follow the instructions given in the textbook.

Do not fill the boxes in black.

Safety measures:

1. Do not touch the chemicals

2. Use small amounts of chemicals

3. Wear safety glasses and a white coat.

Solutions

Questions

1. **Most reactive displaces least reactive.**
2.
   - Magnesium + zinc sulphate **Yes**/No
   - Iron + magnesium sulphate Yes/**No**
   - Copper + Iron sulphate Yes/**No**
   - Zinc + copper sulphate **Yes**/No
   - Magnesium + copper sulphate **Yes**/No

3.

	Magnesium sulphate (aq)	Zinc sulphate (aq)	Copper sulphate (aq)	Iron sulphate (aq)
Magnesium		**Yes**	**Yes**	**Yes**
Zinc	**No**		**Yes**	**Yes**
Copper	**No**	**No**		**No**
Iron	**No**	**No**	**Yes**	

When students have made predictions, completed the tables and answered the questions, these will be corrected and commented.

4. This is a free answer, where students record on the table with a (Yes) or (No) depending on the experimental results they obtain when performing the chemical reactions.

	Magnesium sulphate (aq)	Zinc sulphate (aq)	Copper sulphate (aq)	Iron sulphate (aq)
Magnesium				
Zinc				
Copper				
Iron				

5.

If we heat a metal with a metal oxide there is sometimes a reaction. E.g. Magnesium can take oxygen from copper oxide because magnesium is more reactive then copper. But if we heat copper with magnesium oxide there is no reaction. The copper cannot take oxygen from the magnesium. More reactive metals displace less reactive metals in a compound.

6.

Magnesium + Zinc Sulphate → Zinc + Magnesium Sulphate

Magnesium + Copper Sulphate → Copper + Magnesium Sulphate

Magnesium + Iron Sulphate → Iron + Magnesium Sulphate

Zinc + Copper Sulphate → Copper + Zinc Sulphate

Zinc + Iron Sulphate → Iron + Zinc Sulphate

Iron + Copper Sulphate → Copper + Iron Sulphate

Experiment 6: Rate of reaction

OBJECTIVE

Know the influence of size of particles in the rate of reaction.

EQUIPMENT

Spatula	Balance
Erlenmeyer flask	Cotton wool
Graduated cylinder	Chronometer

MATERIALS

Diluted hydrochloric acid	calcium carbonate chips
Powder calcium carbonate	

Procedure:

1. Check if the students have labelled correctly the diagram.

2. Students have to:

. Set up the devise showed in the diagram

. Annotate time and total mass of the flask in the table.

. Draw the graph (question **a**) and solve the questions

When students have answered the questions, these will be corrected on the blackboard. Alternatively, the students will correct them one another.

Safety measures:

1. Do not touch the chemical

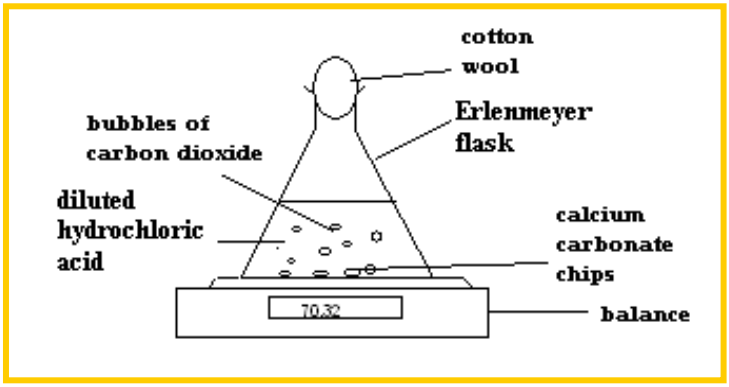
2. Do not spill acid

3. Wear safety glasses and a white coat.

Solutions

Questions

1.



2.

1. The reaction is fast at the start.
2. The mixture is still reacting quickly
3. The mixture is reacting slowly.
4. The reaction has finished. No more carbon dioxide is formed.

3.

The flask and contents lose mass	because carbon dioxide went into the air.
The reaction becomes slow	as the acid or limestone are consumed
Using more diluted acid would	make the reaction go slower.
When the reaction has finished	the mass stops going down.
Stronger acid would	make the reaction go faster.
You could speed up the reaction	by using limestone powder.

 and  **ADDITIONAL EXPERIMENTS (these experiments are not included in the student textbook):**

Enthalpy of an exothermic reaction

Reaction between hydrochloric acid and sodium hydroxide

Enthalpy of an endothermic reaction

1.- Reaction between barium hydroxide and ammonium isothiocyanate

2.- Reaction between citric acid solution and sodium hydrogen carbonate (baking soda)

3.- Endothermic reaction: **http://www.youtube.com/watch?v=qA_OdwIt_tw&hl=es:** This demonstration mixes two solids which react endothermically, taking in enough heat to freeze a wet block of wood to the flask. The chemicals used for this reaction are barium hydroxide octahydrate [$Ba(OH)_2 \cdot 8H_2O$] and ammonium nitrate [$(NH_4)(NO_3)$]. When they react they take in heat energy (which is what freezes the water) and form water and dissolve each other

4.- If you want to perform an easy experiment using the Multilog equipment, go to website **http://www.economatics-education.co.uk/images/additional/Experiments%20%20in%20Chemistry.pdf** where you will find a manual with different experiments very well planned. First of all there is an explanation about how MultiLog works and then you can find the experiments.

Each experiment includes the following parts:

- **Introduction**

  A brief description of the concepts and the theory
- **Equipment**

  The equipment needed for the experiment
- **Equipment setup procedure**

  Illustrated guide to assembling the experiment
- **MultiLog set up**

  Recommended setup
- **Experimental procedure**

  Step by step guide to execute the experiment
- **Data analysis**
- **Questions**
- **Further suggestions**

  Additional experiments you can do

TEACHER'S NOTES

Pupil misconceptions:

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Scientific understanding

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UNIT 7: ACIDS, BASES AND SALTS

Content:

Unit 7 Acids, Bases and Salts

7.1. Definition of acids and bases
7.2. Indicators and pH
7.3. Sulphuric acid, hydrochloric acid and nitric acid
7.4. Acid rain. The effects of acid rain
7.5. Sodium hydroxide and ammonium hydroxide
7.6. Salts

Learning Aims:

At the end of the unit, the student will know:

- What an acid and a base are.
- The characteristics and the difference between and acid and a base.
- The concept of pH.
- When indicators are used.
- What a neutralization reaction is.
- How to write and balance a neutralization reaction.
- How acid rain is produced.
- The causes and effects of acid rain.

Solutions

Initial activities

1. **7**
2.
   a. **True**
   b. **True**
   c. **False**
   d. **False**
   e. **False**
3. **NaCl. Another name for sodium chloride is common salt, table salt, or halite.**

7.1. Definition of acids and bases

1.

a) **False.** Acids and bases react with each other.

b) **True**

c) **False.** Reaction between acid and base **sometimes** releases **water**.

d) **False.** Acids have sour taste and **do not** change the **blue** litmus.

e) **False.** Bases are slippery and change litmus from **blue** to **red**.

f) **False.** When bases ionize, the release **hydroxide** ions.

2.

a) **True**

b) **True**

c) **False.** Bases are electron pair **donors**.

d) **False.** Vinegar, lemon juice and chloride acid are examples of **weak** acids.

e) **True**

f) **False.** A common element to all acids is **hydrogen**.

g) **True**

h) **True**

i) **False.** When bases are dissolved in water they release **hydroxide** ions

j) **False.** The acid used in the storage battery in your car is **sulphuric** acid.

3.

a) Acids and bases **react** when they dissolve in water.

b) HCl and HI are **hydro** acids.

c) Hydroxides of metals of Group 1 of the Periodic Table are strong **bases**.

d) An **acid** turns blue litmus red, carries a current and is corrosive with active metals.

e) Another name for hydrogen ion is **proton**.

f) A **base** turns phenolphthalein pink.

g) A hydrogen ion is the same as a **proton**

h) An acid tastes **sour**.

i) OH^- ions are called **hydroxyl**.

j) Bases are **electron** donors.

7.2. Indicators and pH

To complete the following table, students can consult the website http://www.ch.ic.ac.uk/vchemlib/course/indi/indicator.html.

Indicator	pH Range	Acid colour	Base colour
Thymol Blue (1st change)	1,2 – 2,8	red	yellow
Methyl orange	3,2 – 4,4	red	yellow
Bromocresol Green	3,8 - 5,4	yellow	blue
Methyl red	4,8 -6,0	yellow	red
Bromthymol blue	6,0 – 7,6	yellow	blue
Phenol red	6,8 – 8,4	yellow	red
Thymol Blue (2nd change)	8,0 – 9,6	yellow	blue
Phenolphthalein	8,2 – 10,0	colourless	pink

Questions

1.

a) True

b) False Orange juice has a pH of about 5. It is a **weak** acid.

c) False Acids have a pH **less** than 7.

d) True

e) False Toothpaste has a pH of about 9. It is a weak **base**.

f) True

g) True

h) True

i) True

k) True

l) False A cleaner has a pH of 10 or above, it is **a base**.

m) True

n) True

2.

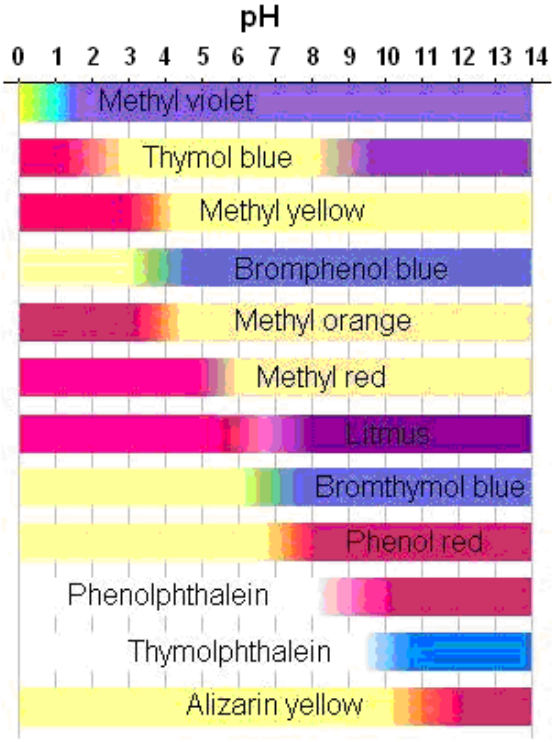
2.1. b

2.2. d

2.3. b

2.4. b

3.



http://www.carlton.srsd119.ca/chemical/equilibrium/Images/indicators.jpg

a) Baking soda, soap, ammonia, bleach and oven cleaner because their pH is higher than 8.

b) Red

c) Blue

d) Red

e)

4.

1. Vinegar has a pH of about 4

d. So, it is a fairly strong acid.

2. Sodium hydroxide is a strong alkali

h. It has a high pH (13 or 14).

3. Sulphuric acid and hydrochloric acid have a pH of 1-2

b. So, they are both strong acids.

4. Toothpaste has a pH of 8 and sodium carbonate has a pH of 9

c. So, they are both weak alkalis.

5. Nitric acid has a pH of 1-2 and vinegar has a pH of about 4

f. Therefore nitric acid is a stronger acid than vinegar.

6. Sodium hydroxide has a pH of 12, but sodium carbonate has a pH of 9

a. Therefore sodium hydroxide is a stronger alkali than sodium carbonate.

7. Water has a pH of 7

e. Therefore it is neutral.

8. The pH of a liquid

k. Tells how acidic or alkaline it is.

9. A very acid solution

j. Has a low pH (1 or 2).

10. A very alkaline solution

g. Has a pH of 12-14.

11. When acid is added to an alkali

i. The pH goes down.

12. When alkali is added to an acid

l. The pH goes up.

5.

$[H_3O^+]$	10^{-5}	$10^{-12.5}$	$10^{-3.2}$	$10^{-4.8}$	$10^{-10.5}$
pH	5 (acid)	12,5 (base)	3,2 (acid)	4,8 (acid)	10,5 (base)

7.3. Sulphuric acid, hydrochloric acid and nitric acid

Students can answer these questions with support of Wikipedia website.

1.

	H_2SO_4 (aq)	HCl (aq)	HNO_3 (aq)
Scientific name	Sulphuric acid	Hydrochloric acid	Nitric acid
Other names	Oil of vitriol	Muriatic acid, Spirit of Salt, Chlorane	Aqua fortis, Spirit of nitre, Salpetre acid Hydrogen Nitrate Azotic acid
Discoverer	Jabir Ibn Hayyan, Muslim alchemist of the 8th century	Jabir Ibn Hayyan, Muslim alchemist of the 8th century	Jabir Ibn Hayyan, Muslim alchemist of the 8th century
Synthesis	$S_{(s)} + O_{2\,(g)} \rightarrow SO_{2\,(g)}$ $2\,SO_{2(g)} + O_{2(g)} \rightarrow 2\,SO_{3(g)}$ $SO_{3(g)} + H_2O_{(l)} \rightarrow H_2SO_{4\,(l)}$	$NaCl_{(s)} + H_2SO_{4\,(aq)} \rightarrow NaHSO_{4\,(aq)} + HCl_{\,(g)}$ $HCl_{\,(g)} + H_2O_{\,(l)} \rightarrow HCl_{\,(aq)}$	$NaNO_{3\,(aq)} + H_2SO_{4\,(aq)} \rightarrow NaHSO_{4\,(aq)} + HNO_{3\,(aq)}$
Molecular Weight	98 g · mol^{-1}	36,5 g · mol^{-1}	63 g · mol^{-1}
State	Liquid	Liquid solution	Liquid
Appearance	Colourless and odourless liquid	Colourless to light-yellow liquid	Colourless
Toxicity. Safety	Sulfuric acid is corrosive and a highly exothermic reaction is produced when is mixed with water. Rubber gloves, goggles and safety clothing should always be used.	Hydrochloric acid is corrosive to human tissue and damage respiratory organs. Rubber gloves, goggles and safety clothing should always be used.	Nitric acid is a powerful oxidizing agent and some reactions are explosive, for example when react with some organic compounds or metallic powders. Rubber gloves, goggles and safety clothing should always be used.
Uses	Sulphuric acid is used in car lead batteries, in the fertilizer manufacture, oil refining, chemical reactions, etc.	hydrochloric acid is used in the chemical industry of plastics, in household cleaning, in food industry, in leather processing, as a catalyst to obtain glucose from starch, etc.	Nitric acid is used as an oxidant and a strong acid in the plastic and perfume industry. It is also used in explosives. Nitrates are very important as fertilizers.

2.

2.1. c

2.2. a

2.3. c

2.4. b

7.4. Acid rain. The effects of acid rain

1. Nitrogen, oxygen and argon are the top 3 substances found in air.

2. Nitrogen oxides are formed during lightning storms, but large amounts of nitrogen oxides are also produced in car engines and power plants.

Small quantities of sulphur oxides are produced naturally from biological decay and volcanic activity, but human activity produced a lot of quantities of sulphur oxides. These oxides are usually produced in the combustion of fossil fuels in power plants.

3. When rain turns acid, the pH is smaller.

4. $CO_2 + H_2O \rightarrow H_2CO_3$

5. When temperature increases, concentration of carbon dioxide in water decreases because carbon dioxide is a gas and it is released of solution.

6. As we said in the previous question, when temperature increases, concentration of carbon dioxide in water decreases, therefore, pH increases.

7. Acid rain is produced in a small proportion in natural processes, but it has a large contribution the oxides produced in the processes of combustion in industries and cars. When these oxides reach the atmosphere, react with water and the respective acids are obtained.

The acid rain has damaged forests and harvests, eroded structures and damaged the life in the lakes of sweet water.

8.

Acid rain is a result of air pollution Power stations, factories and cars all burn fuels and therefore they all produce polluting gases. Some of these gases (especially nitrogen oxides and sulphur dioxide) react with the tiny droplets of water in clouds to form sulphuric and nitric acids. The rain from these clouds then fall as very weak acid - which is why it is known as "acid rain".

Rain is always slightly acidic because it mixes with naturally occurring oxides in the air (such as carbon dioxide). Unpolluted rain would have a pH value of between 5 and 6. When the air becomes more polluted, with nitrogen oxides and sulphur dioxide, the acidity can increase to a pH value of 4. Some rain has even been recorded as a pH = 2.

Acid rain can be carried great distances in the atmosphere, not just between countries but also from continent to continent. The acid can also take the form of snow, mists and dry dusts. The rain sometimes falls many miles from the source of pollution but wherever it falls it can have a serious effect on soil, trees, buildings and water

http://ypte.org.uk/docs/factsheets/env_facts/acid_rain.html

9. This is a free answer question where students have to give at least four examples about what can we do to reduce emissions to the atmosphere.

10. a

Students build a rain gauge with a plastic bottle. They can consult the web page: http://www.rcn27.dial.pipex.com/cloudsrus/measurerain.html

Precaution in case the web site could be eliminated (reproduction of the experiment found in the web site):

Measuring Rainfall

Rainfall is usually measured by first collecting it in a rain gauge. These special drums are then used to record the depth of the water inside. Rain gauges are usually about 50 cm tall and are placed on the ground just high enough to avoid splashes. Rain water that is caught in a funnel on top, runs down into a measuring cylinder below – where it can be recorded.

To make your own rain gauge to keep a record of how much rain falls, follow the instructions below.

You will need:

- a large plastic soft drinks bottle
- scissors
- a ruler
- a waterproof marker pen (or coloured sticky tape)
- a heavy flower pot
- a notepad and pencil (to record the results)

With the help of an adult, carefully cut the top off the plastic bottle with the scissors.

Turn the top upside down and wedge it in the bottle to form a funnel. (If necessary, use sticky tape to hold the top of the bottle in place).

Using a ruler, measure out a scale (in millimetres) on a piece of paper. Either stick this to the side of the bottle, or use the marker pen to mark out the lines instead. Alternatively, cut the coloured tape into strips and stick them a certain distance apart (eg: 10 mm) up the side of the bottle. Make sure that whatever you use, it is waterproof!

To prevent the rain gauge from blowing over, place it outside in a heavy flowerpot. Alternatively, you could dig a hole in the ground for it to stand in. Make sure the rain gauge is placed in an open area. If it is near any trees or buildings, extra water could drip into it and your measurements will not be accurate.

Now you are ready to record how much rainfall is received over a certain time. Check the rain gauge every day, or once a week if you prefer, and record how much water is in the bottle. Use the scale or the marks on the side of the bottle to help you.

Remember, if you are only taking measurements once a week, make sure your rain-gauge does not overflow in between if you get a lot of rain. You could always use a measuring cylinder to store the week's rain before you measure it.

Each time you measure the water, plot the results on a graph or in a table. You could print out the table below to help you if it is easier. Make sure you could draw it yourself as well though.

The answers to the following questions depend on the experimental results:

a) Collect rainwater different days, measure the pHs and complete the following table:

Date / Time	Rainfall (mm)	Rain pH

b) Plot a rainfall/pH graph.

c) Is there any relationship between the rainfall and the rain's pH? Give a reason for your answer.

d) What relationship do you observe between rainfall, pH and the date the observations are made?

7.5. Sodium hydroxide and ammonium hydroxide

Students can answer these questions with support of Wikipedia website.

1. Phenolphthalein turns **violet** in contact with ammonium hydroxide.
2. Sodium hydroxide is a strong base and ammonium hydroxide is a **weak** base.
3. Sodium hydroxide is **solid** at room temperature, but ammonia is a gas at room temperature.
4. pH of a solution of sodium hydroxide or ammonia hydroxide is **higher** than 7.
5.

	NaOH	NH_3
Scientific name	**Sodium hydroxide**	**Ammonia**
Other names	**Caustic soda** **Lye**	**Spirit of Hartshorn** **Nitro-Sil** **Vaporole**
Discoverer	**Jabir Ibn Hayyan, Muslim alchemist of the 8th century**	**Gaseous ammonia was first isolated by Joseph Priestley in 1774.**
Synthesis	**Electrolysis of sodium chloride solution.** $Na_2CO_{3\,(aq)} + Ca(OH)_{2\,(s)} \rightarrow CaCO_{3\,(s)} + NaOH_{(aq)}$	$2\ NH_4Cl + 2\ CaO \rightarrow CaCl_2 + Ca(OH)_2 + 2\ NH_3$ **Haber process:** $3\ H_2 + N_2 \rightarrow 2\ NH_3$
Molecular Weight	$40\ g \cdot mol^{-1}$	$17\ g \cdot mol^{-1}$
State	**Solid**	**Gas**
Appearance	**White solid.**	**Colourless gas with a pungent odour.**

Toxicity. Safety	**Solid sodium hydroxide or solutions of sodium hydroxide will cause burns.** **Rubber gloves, goggles and safety clothing should always be used.**	**Ammonia o ammonia solutions can be irritant, or corrosive depending on concentration. Exposure to very high concentrations of gaseous ammonia can result in lung damage and death.** **Ammonia even at dilute concentrations is highly toxic to aquatic animals, it is *dangerous for the environment* .** **Mixing with chlorine-containing products or strong oxidants, for example household bleach can lead to hazardous compounds such as chloramines.** **Rubber gloves, goggles and safety clothing should always be used.**
Uses	**Sodium hydroxide is the principal strong base used in the chemical industry. It is used to produce alumina, soap, bleach, in the paper industry, for the manufacture of biodiesel, oil refinering, etc.**	**Ammonia is used as a fertilizer, cleaner, refrigerant, fuel, to treat cotton and wool, as a precursor of nitrogen compounds, etc.**

7.6. Salts

1.

a) **Sodium sulphate.**
b) **Barium nitrate.**
c) **Magnesium chloride.**
d) **Iron (III) sulphate.**
e) **Potassium bromide.**
f) **Zinc fluoride.**
g) **Calcium phosphate.**

2.

a) **True**
b) **False** When water solutions of an acid and base are mixed, a salt and **water** are produced.
c) **True**
d) **True**

3. These solutions are electricity conductors because they have free charges.

4.

a)

Acid / Base	HCl	HBr	HI	H_2SO_4	HNO_3	$HClO_3$	$HClO_4$
LiOH	$LiCl$ Lithium chloride	$LiBr$ Lithium bromide	LiI Lithium iodide	Li_2SO_4 Lithium sulphate	$LiNO_3$ Lithium nitrate	$LiClO_3$ Lithium chlorate	$LiClO_4$ Lithium perchlorate
NaOH	$NaCl$ Sodium chloride	$NaBr$ Sodium bromide	NaI Sodium iodide	Na_2SO_4 Sodium sulphate	$NaNO_3$ Sodium nitrate	$NaClO_3$ Sodium chlorate	$NaClO_4$ Sodium perchlorate
KOH	KCl Potassium chloride	KBr Potassium bromide	KI Potassium iodide	K_2SO_4 Potassium sulphate	KNO_3 Potassium nitrate	$KClO_3$ Potassium chlorate	$KClO_4$ Potassium perchlorate
RbOH	$RbCl$ Rubidium chloride	$RbBr$ Rubidium bromide	RbI Rubidium iodide	Rb_2SO_4 Rubidium sulphate	$RbNO_3$ Rubidium nitrate	$RbClO_3$ Rubidium chlorate	$RbClO_4$ Rubidium perchlorate
$Ca(OH)_2$	$CaCl_2$ Calcium chloride	$CaBr_2$ Calcium bromide	CaI_2 Calcium iodide	$CaSO_4$ Calcium sulphate	$Ca(NO_3)_2$ Calcium nitrate	$Ca(ClO_3)_2$ Calcium chlorate	$Ca(ClO_4)_2$ Calcium perchlorate
$Sr(OH)_2$	$SrCl_2$ Strontium chloride	$SrBr_2$ Strontium bromide	SrI_2 Strontium iodide	$SrSO_4$ Strontium sulphate	$Sr(NO_3)_2$ Strontium nitrate	$Sr(ClO_3)_2$ Strontium chlorate	$Sr(ClO_4)_2$ Strontium perchlorate
$Ba(OH)_2$	$BaCl_2$ Barium chloride	$BaBr_2$ Potassium chloride	BaI_2 Barium iodide	$BaSO_4$ Barium sulphate	$Ba(NO_3)_2$ Barium nitrate	$Ba(ClO_3)_2$ Barium chlorate	$Ba(ClO_4)_2$ Barium perchlorate

b)  **Procedure:**

Students have to write and do the balance of the equations.

For example:

$$HCl_{(aq)} + LiOH_{(aq)} \rightarrow LiCl_{(aq)} + H_2O_{(l)}$$

$$H_2SO_{4\,(aq)} + 2\,KOH_{(aq)} \rightarrow K_2SO_{4\,(aq)} + 2\,H_2O_{(l)}$$

$$2\,HClO_3 + Ca(OH)_2 \rightarrow Ca(ClO_3)_{2\,(aq)} + 2\,H_2O_{(l)}$$

5.  **Students can answer these questions with support of Wikipedia website.**

a) Other names for sodium chloride are common salt; halite; table salt or rock salt.

b) Sodium chloride is a white solid.

c) Sodium chloride is important to life because it contributes to maintain the electrolyte balances; it is a part of most animal fluids, such as blood, sweat or tears. It provides chlorine, which it is necessary to synthesize the hydrochloric acid, part of the digestive fluid found in the stomach.

d) The composition of a physiological solution is 0.9% (it contains 9.0 grams of sodium chloride in 1 litre solution).

e) **An isotonic saline solution has the same concentration of solutes as the blood.**

f) **Sodium chloride is mainly obtained by evaporation of seawater or by mining rock salt.**

g) **Sodium chloride is used in cooking, to produce soaps and detergents, as a desiccant, in bath products, in food preservation, etc.**

Experiments:

Experiment 1: Making and testing cabbage indicator

OBJECTIVE

Make a pH indicator from red cabbage and test the change of colour when pH changes.

EQUIPMENT

Beaker	Bunsen
4 test tubes	5 pipettes
Stirring rod	knife

MATERIALS

Sliced red cabbage	Vinegar, lemon juice... (an acid)
Water	Ammonia, bleach, baking soda … (a base)
Two unknown solutions	

Procedure:

Students have to follow the instructions given in the student textbook.

Safety measures:

1. Do not touch the chemicals

2. Use small amounts of chemicals

3. Wear safety glasses and a white coat.

Solutions

Questions

1. When vinegar or other acid is added to the cabbage juice, solution has a red colour because cabbage contains a pH indicator pigment.

2. Ammonia or other base turns the cabbage juice pH indicator blue.

3. The colour when the contents of the acid test tube is poured into the ammonia test tube depend on the amount of acid or base, if acid is in excess, colour is red but if base is in excess, colour is blue.

4. If acid is gradually added to the test tube containing the base and cabbage juice, colour of the indicator changes when the base is neutralized by the acid.

5. This question has a free answer, depending on the substance given to the student.

Students work in pairs in the laboratory. It is convenient to change the components of the group when a new experiment begins. On the other hand, it is important that the students who have some difficulty to learn do not work together.

Once the students have answered the questions, and check them with their mate, they will be corrected on the blackboard.

Experiment 2: Neutralizing Acids or Bases Using a pH meter

OBJECTIVE

Observe the variation of pH in an acid-base reaction. Titrate a measured volume of HCl with a solution of NaOH, according to the equation:

$$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$

EQUIPMENT

Erlenmeyer flask	Burette
Beaker	Stand
Clamp	pH meter

MATERIALS

HCl 0,1 mol · dm^{-3}	NaOH 0,1 mol · dm^{-3}
Distilled water	

Procedure:

1. Before starting the experiment, students have to watch the videos: http://www.youtube.com/watch?v=g8jdCWC10vQ&feature=channel_page and http://www.youtube.com/watch?v=r1uEXOOR2nU

2. Students have to follow the instructions given in the student textbook.

3. Repeat this experiment using the Multilog Pro equipment and the Multilab program. In web site: http://www.gwahak.com/pdfs/chemistry/acid_base_titration.pdf you will find all the information to carry out the experiment and also different questions related to the titration process.

Precaution in case the web site could be eliminated (reproduction of the experiment found in the web site):

CHEMISTRY 1

Acid - Base Titration: Reaction of NaOH With HCl

Introduction

In aqueous solutions, addition of bases to water leads to an increase in the pH of the solution, while the addition of acids leads to a decrease in the pH. The changes in the pH can be followed using either specific dyes, called - indicators, or a pH electrode. Acids and bases neutralize, or reverse, the action of one another. By adding a known amount of acid to a basic solution, until it completely reacts with it, the amount of the base can be determined. This procedure is called: acid - base titration. During neutralization, acids and bases react with each other to produce ionic substances, called salts. In this experiment, changes in pH and temperature, occurring while an acid (hydrochloric acid) is added to a base (sodium hydroxide) solution, are followed using a pH electrode and a temperature sensor.

Equipment

- A pH electrode
- A polystyrene coffee cup
- A glass funnel.
- 100 ml NHCl solution
- A MultiLog
- A temperature sensor
- 50 ml Biuret pipette.
- 2 grams NaOH
- Magnetic stirrer

CHEMISTRY 2

Equipment Setup Procedure

1. Connect the MultiLog to the serial port of the computer.

2. Connect the pH electrode to the I/O 1 port and the temperature sensor to I/O port 2 of the MultiLog.

3. Assemble the equipment as illustrated in figure 1 below.

4. Set the MultiLog up according to the setup specified below. You can set up the MultiLog in two different ways:

- use the keyboard of the MultiLog or

- select the **Control Panel** from the **Logger** menu.

MultiLog Set Up

. Input 1: pH
Rate: 1/sec.
. Input 2: temperature -25/110°C
. Samples: 5000.

Experimental Procedure

1. Prepare a polystyrene cover to the polystyrene coffee cup. The cover should be flat and larger than the circumference of the coffee cup (see figure 1).

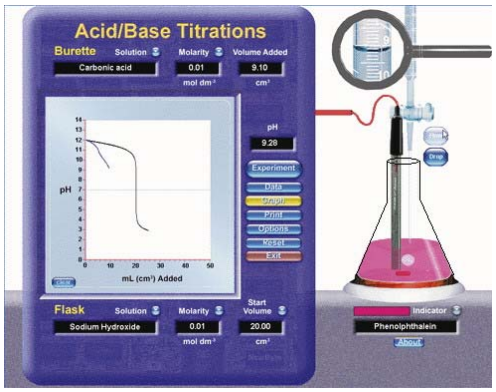
2. Pierce 3 holes in the cover: one for the pH electrode, one for the temperature sensor and one for the glass funnel.

3. Add 50 ml 0.5N NaOH solution to the coffee cup.

4. Place the coffee cup on a magnetic stirrer.

5. Put the cover on the cup.

CHEMISTRY 3



6. Start the MultiLog by pressing the **Run/Stop** key in the MultiLog's keypad. You can also start the MultiLog using the **DB-Lab** software: Press the **Run** button from the c**ontrol Panel,** or the (**Run**) button from the left toolbar.
Wait till readings from the sensors are stable.

7. Start stirring the NaOH solution in the coffee cup.

8. Add dropwise, 1N HCl solution from the biuret, to the cup, through the glass funnel.

9. Follow changes in pH and temperature registered on the monitor.

CHEMISTRY 4

10. As the pH just start to change, stop the flow of HCl. Find the volume of HCl added till that point.

11. Renew dropwise flow of HCl. Follow pH changes very carefully.

12. Stop immediately flow of HCl as the pH stabilizes.

Data Analysis

1. Calculate the change in the pH obtained during the neutralization process:
What was the initial pH value? The final value? The difference between the two values?
*Use the grid to find the appropriate values: choose **View\Display** from the menu.*
*Mark the option **grid** in the **Option Display Window**.*
2. What was the volume of HCl added till the pH started to change? Compare it with the volume of HCl added till a complete neutralization of NaOH was achieved.
3. Find the time interval between the point of "start of change" in pH and the point of pH "start of stabilization".
4. Calculate the change in temperature obtained in the process and the time needed to reach the final temperature value.
5. Calculate the heat of reaction: C- water capacity; □t - temperature change.
Water specific heat capacity at 25□C is 4.18 (J/g□C).*

CHEMISTRY 5

An example of the graph obtained in this experiment, is shown below:

Questions

1. Did you observe a fast pH change? Explain the difference in the short time interval needed for the completion of the drastic changes of pH and that of the whole neutralization process.
2. Is the neutralization reaction an exothermic reaction? Base your conclusions on the experiment you performed.
3. Try to assume the results of acid - base reaction at different concentrations of NaOH added to the coffee cup: What will be the pH change in each case? What will be the extent of change in the temperature?
4. What will be the effect of reacting other acids (like, for example, acetic acid) with NaOH?

CHEMISTRY 6

Further Suggestions

1. React different concentrations of NaOH with a constant concentration of HCl.
2. Calculate unknown concentrations of NaOH (or HCl) titrated: this can be achieved by setting the flow of acid (or base) from the Biuret pipette at a constant rate (from the time interval on X axis multiplied by the flow rate, the volume added, can be calculated).
3. Examine the effect of increasing the water and/or the surroundings temperature, on the reaction.
4. Perform acid - base reaction with different types of acids and/or bases: a weak acid with a strong base and vice versa.

Advantages of Using the MultiLog in Studying Acid - Base Titration

1. Real time measurements of changes in pH, leading to a straight forward analysis of the characteristics typical to acid - base reactions.
2. A very simple experimental system that enables the student to perform various acid - base experiments, leading to improved comprehension of the process

Safety measures:

1. Do not touch the chemicals
2. Use small amounts of chemicals
3. Wear safety glasses and a white coat.

Solutions

Questions

1 and 2 are free answer questions, depending on the results obtained by students.

1. Complete the following table with the titration data:

mL of $NaOH_{(aq)}$	pH	Indicator colour
1		
2		
3		
4		
5		
6		
7		
8		
9		
9,5		
9,6		
9,7		
9.8		
9,9		
10		
10,1		
10,2		
10,3		
10,4		
10,5		
11		
12		

2. Plot a graph of mL of NaOH added versus pH

3. pH increases as more mL of NaOH are added.

4. pH at equivalence point for this titration is 7.

5. An acid-base indicator is a substance that changes colour depending on the degree of acidity or basicity of solution.

Experiment 3: Amphoteric properties of Zinc. Gold Pennies

OBJECTIVE

Show the amphoteric character of zinc.

EQUIPMENT

Beaker	Bunsen
2 test tubes	Pipette
Spatula	Tongs
Goggles	

MATERIALS

$NaOH_{(aq)}$	$HCl_{(aq)}$
Zinc	Distilled water
Vinegar	Saltz
Coin (5 cents)	

Procedure:

1. Reaction of zinc and hydrochloric acid:

Students have to follow the instructions given on the textbook.

2. Reaction of zinc and sodium hydroxide. Gold penny:

Students have to watch this video before starting the experiment: http://www.metacafe.com/watch/1262456/make_a_gold_penny/ and follow the instructions given on the textbook.

Remember **DO NOT TOUCH THE PENNY WITH BARE HANDS**

Safety measures:

1. Do not touch the chemicals

2. Use small amounts of chemicals

3. Wear safety glasses and a white coat.

4. Work with chemicals on the hood.

Solutions

Questions

1.

$$HCl_{(aq)} + Zn_{(s)} \rightarrow ZnCl_{2\,(aq)} + H_{2\,(g)}$$

2. Reaction with diluted hydrochloric is slower than with concentrated hydrochloric acid.

3.

$$2\,H_{2\,(g)} + O_{2\,(g)} \rightarrow H_2O_{(l)}$$

4. No, it isn't because properties of copper and zinc do not change.

5. Students have to consult a web site, for example Wikipedia, and explain some properties and applications of brass.

Brass is an alloy made of copper and zinc. It has a yellow colour, similar to gold. It is more malleable than copper and zinc and relatively resistant to oxidation. Its melting point depends on the composition: 900ºC to 940ºC and the density goes from 8,4 to 8,7 g · cm^{-3}.

It is used in musical instruments, to make coins, in decoration, electrical applications, etc.

Project:

At the end of chemistry students have to do a written report about "Chemistry, society and environment" In this interdisciplinary work a lot of emphasis will be made in the study of the environment: natural resources, waste and pollution, the water as a resource, the greenhouse effect, etc proposing the students a work in group and making debates to put in common the measures they think can be taken.

TEACHER'S NOTES

Pupil misconceptions:

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Scientific understanding

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UNIT 8: RADIOACTIVITY AND THE ATOM

Content:

Unit 8 Radioactivity and the atom

8.1. Nuclear Reactions.
8.2. Types of radiations.
8.3. Ionization by radiation.
8.4. Half-life
8.5. Nuclear fission.
8.6. Nuclear fusion
8.7. Radiation effects.
8.8. Applications of radioactive nuclei

Learning Aims:

At the end of the unit, the student will know:

- To identify a nuclear reaction.
- The difference between an alpha and beta particles.
- The characteristics of gamma rays.
- How to solve questions related to the half-life of an isotope.
- The difference between nuclear fission and fusion.
- Some applications of radioactive isotopes.
- To use the appropriate language to answer questions and to communicate with teacher and classmates.

Solutions

Initial activities

1.

1.1. a and c

1.2. b

1.3. c

1.4. b

1.5. b

2.

In a fission reaction nucleus splits into two or more lighter nuclei and in a fusion reaction a two light nucleus combine and a heavier nucleus is formed.

3.

In nuclear reactions nucleus release energy by either a combination of light atoms or the splitting of heavy atoms and in a "normal" chemical reaction nucleus remains the same.

8.2. Types of radiations

1.- The new nucleus has two protons and two neutrons less than the original nucleus.

2.- The new nucleus has one more proton than the original nucleus.

3.- In nuclear reactions nucleus release energy by either a combination of light atoms or the splitting of heavy atoms and in an ordinary chemical reaction nucleus remains the same.

4.-

a) $^{7}_{3}Li + {}^{1}_{1}H \rightarrow {}^{4}_{2}He + {}^{4}_{2}He$

b) $^{3}_{1}H + {}^{2}_{1}H \rightarrow {}^{1}_{0}n + {}^{4}_{2}He$

c) $^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$

d) $^{9}_{4}Be + {}^{4}_{2}He \rightarrow {}^{12}_{6}C + {}^{1}_{o}n$

e) $^{26}_{12}Mg + {}^{1}_{0}n \rightarrow {}^{0}_{-1}e + {}^{27}_{13}Al$

5.-

a) $^{214}_{82}Pb \rightarrow {}^{214}_{83}Bi + {}^{0}_{-1}e$

b) $^{214}_{83}Bi \rightarrow {}^{214}_{84}Po + {}^{0}_{-1}e$

c) $^{214}_{84}Pb \rightarrow {}^{210}_{82}Pb + {}^{4}_{2}He$

8.3. Ionization by radiation

1.-

a) α **particles gets rid of its energy quickest.**
b) α **particles could not get trough skin very easily.**
c) γ **rays could go furthest through the air.**

2.-:

Type	Paper	3 mm aluminium	3 cm lead
Alpha	X	X	X
Beta	√	X	X
Gamma	√	√	X

3.-

a) $^{131}_{53}I$ **has 53 protons and 78 neutrons.**

b) $^{131}_{53}I \rightarrow {}^{0}_{-1}e + {}^{131}_{54}Xe + \gamma$

c) 2,86 mL

8.4. Half-life

1.- 1,25 g

2.- $6{,}25 \cdot 10^{18}$ **atoms**

3.- b

4.- c

5.- c

6.- a

8.5. Nuclear fission

8.6. Nuclear fusion

1.-

In a fission reaction nucleus splits into two or more lighter nuclei and in a fusion reaction a two light nucleus combine and a heavier nucleus is formed.

2.-

In a nuclear fusion reaction is released a large amount of energy than in a nuclear fission reaction.

3.-

a) **The reaction of** $^{3}_{1}H$ **and** $^{2}_{1}H$ **to form** $^{4}_{2}He$ **and a neutron is an example of a nuclear a nuclear fusion reaction.**

b) $^{3}_{1}H + {}^{2}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$

4.- 

$$1\ g\ ^{235}U \cdot \frac{1\ mol}{235{,}05\ g} \cdot \frac{6{,}02 \cdot 10^{23}\ nuclides}{1\ mol} \cdot \frac{200\ MeV}{1\ nuclide} = 5{,}12 \cdot 10^{23}\ MeV$$

$$5{,}12 \cdot 10^{23}\ MeV \cdot \frac{10^{6}\ eV}{1\ MeV} \cdot \frac{1.6 \cdot 10^{-19}\ J}{1\ eV} \cdot \frac{1\ kJ}{10^{3}\ J} = 8{,}19 \cdot 10^{7}\ kJ$$

$$8{,}19 \cdot 10^{7}\ kJ \cdot \frac{1\ g\ of\ coal}{34\ kJ} = 2{,}41 \cdot 10^{6}\ g\ of\ coal$$

Conclusion: 2,41 · 10^6 g (2,41 tones) of coal are needed to generate the same quantity of energy than the energy produced in the fission of 1 gram of ^{235}U.

5.- a

As we have seen in the previous question, 5,12 · 10^{23} MeV are released in the fission of 1 gram of ^{235}U.

Energy released in the fusion of 1 g of deuterium:

$$1\ g\ of\ {}^{2}_{1}H \cdot \frac{1\ mol}{2{,}01\ g} \cdot \frac{6{,}02 \cdot 10^{23}\ nuclides}{1\ mol} \cdot \frac{3{,}27\ MeV}{2\ nuclides} = 4{,}90 \cdot 10^{23}\ Mev$$

Conclusion: The fission of 1 gram of ^{235}U releases 1,04 times the energy released by 1 g of deuterium-

6.-

a) 1 eV = 1,78 · 10^{-36} kg

b) 1 kJ = 1,11 · 10^{--14} kg

c) 1 cal = 4,64 · 10^{-17} kg

d) 1 MeV = 1,78 · 10^{-30} kg

8.7. Radiation effects

1.- body

2.- alpha

3.- If a cell's DNA is damaged by radiation mutations of DNA occur.

4.- Yes, they can.

5.- Gamma particles cause more damage than beta particles.

6.- Gamma particles does not directly damage me by ionisation.

7.- Alpha particles

8.8. Applications of radioactive nuclei

1.- d

2.- 0,00625 g of ^{99}Tc will remain in the organism after 24 hours.

3.- Students work with computers to look for information to answer the following questions:

3.1. Enrico Fermi was an Italian physicist who worked in the United States on the Manhattan Project for the development of nuclear energy and the atomic bomb. **This is a free answer question were student have to write an abstract about the biography of Fermi (where he was born, studied, his work, etc.)**

3.2. Fermi gets the Nobel Prize in 1938.

3.3. A Geiger counter is used for detecting ionizing radiation (usually beta particles and gamma rays).

3.4. Explain how a chain fission nuclear reaction is produced when a nucleus reacts with a particle giving more of these particles than react with other nucleus and so on.

3.5. The first atomic bomb detonated near Alamagordo, New Mexico, on July 16, 1945. Hiroshima and Nagasaki were the Japanese cities where the Americans threw the two atomic bombs in the Second World War.

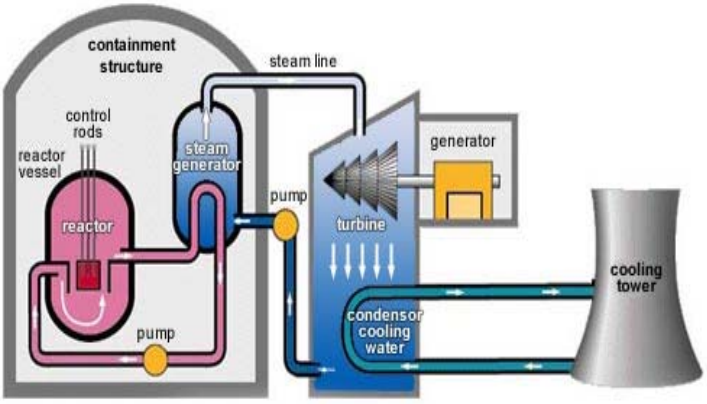
3.6. Yes, Fermi participated in the preliminary work on the hydrogen fusion.

3.7. Radiations damage the organ tissue. A high level of radiation can produce tumours, cancer and genetic changes.

4.- This is a question of free answer where students have to explain, in ten lines, all what they think about the advantages and disadvantages of nuclear energy.

Extra exercise

Cut out the pieces of this nuclear reactor (you can use Photoshop to make a jigsaw or use a free jigsaw maker download program in web page **http://www.spintop-games.com/jigsaw_game_download/jigsaw_platinum.html**). Give it to each student with some difficulty to learn. Students have to fit the pieces and then stick them down onto a piece of paper.



Source: http://www.cameco.com/common/images/content/u101/reactor2.jpg

TEACHER'S NOTES

Pupil misconceptions:

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UNIT 9: ELECTRICITY

Content:

Unit 9 Electricity

9.1. The electric charge
9.2. Types of electrification
9.3. Conductors and non-conductors
9.4. Electroscope
9.5. Electrophorus
9.6. The van der Graaff generator

Annex: History of electricity

Learning Aims:

At the end of the unit, the student will know:

- The different kinds of electricity and how are produced.
- The differences between conductors and non-conductors of electricity.
- How to describe some devices used in electrostatics.
- How an electroscope works.
- How an electrophorus works.
- How the van der Graaf generator works
- To use the appropriate language to answer questions and to communicate with teacher and classmates.

Solutions

Initial activities

1.

1.1. b

1.2. b

1.3. a

1.4. a

2. Electrons are responsible for electric conduction

3. Because their charge has the same sign.

9.1. The electric charge

1.

a) **True.**

b) **False.** Like charges **repel** each other.

c) **False.** Protons and electrons **attract** each other.

d) **False.** In a neutral atom the number of protons is equal to the number of **electrons**.

e) **False.** A negatively charged object must have an excess of **electrons**.

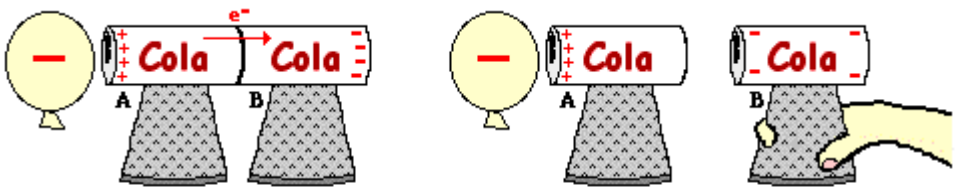
2.- **A positively charged object has more protons than electrons and a negatively charged object has excess of electrons.**

3.- **Charges to be attracted need to have the same sign.**

9.2. Types of electrification

In webpage http://www.glenbrook.k12.il.us/GBSSCI/PHYS/CLASS/estatics/u8l2c.html students will find a curious way of charging by induction

Precaution in case the web site could be eliminated (reproduction of the experiment found in the web site):



The negatively charged balloon induces movement of electrons within the two pop cans. With electrons moving from Can A to Can B, the two-can sytem becomes polarized. Once the two cans are separated using the insulating handle, Can A has a + charge and Can B has a - charge.

1.-

a) **False.** When a neutral object is charged by friction, there is a transfer of **electrons** between the two insulating objects.

b) **True.**

c) **True.**

d) **True.**

e) **True.**

2.- **The process of charging a neutral body by touching it with a charged body is called induction.**

3.- **The charge of the hair is positive.**

4.- When an object is charging by conduction, charges of the charged object distribute between the two objects.

When the object is charged by induction, their charges separate when the charged object is approached (without contact).

5.- Silk would end up with a negative charge because it has a greater affinity for electrons than glass.

6.- Because rubber has more affinity for electrons than fur.

7.-.
a) The can closer to the negatively plastic rod will be charged positively and the other can negatively.

b) The cans will be charged with an opposite charge than in the previous process.

8.- The sphere can be charged by induction, approaching (without contact) a negatively charged object. When the negatively object is approached, a separation of charges in the insulating sphere occur. A ground wire is used to transport negative charges to ground.

9.-
a) Charges of the negatively charged rod distribute between the rod and the metal.

b) Charges of the positively charged rod distribute between the rod and the metal.

9.3 Conductors and non-conductors

1.- A conductor has free charges and an insulator has not.

2.- Solid salts have not free charges but when they are dissolved in water their ions (cations and anions) can move freely through the solution.

3.- Because metals have free electrons.

9.4. Electroscope
9.5. Electrophorus
9.6. The van der Graaff generator

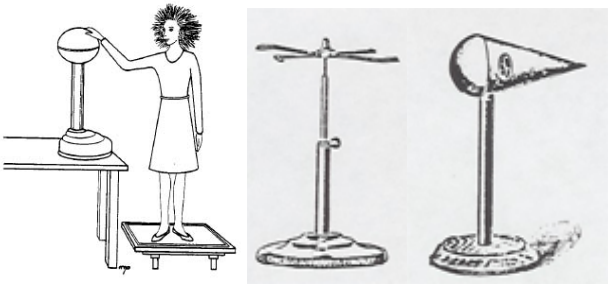
3.-

http://www.physics.ucla.edu/demoweb/demomanual/electricity_and_magnetism/electrostatics/van_der_graaff_experiments.html: This is a very interesting web site with explanations and simulations using different accessories: electric whirl, electroscope, smoke precipitator (when smoke is blown into a tube (for example, from a cigarette) rapidly disappears when the electrodes on the ends of the tube are connected to the generator), Styrofoam balls, etc.

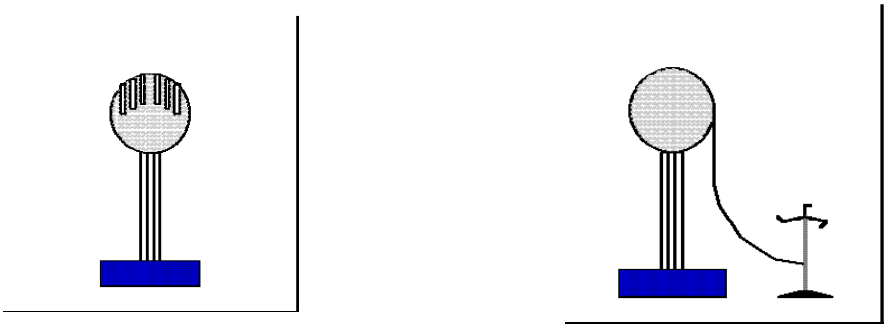
Precaution in case the web site could be eliminated (reproduction of the experiment found in the web site):

E.1.2 Experiments with Van de Graaff Generators

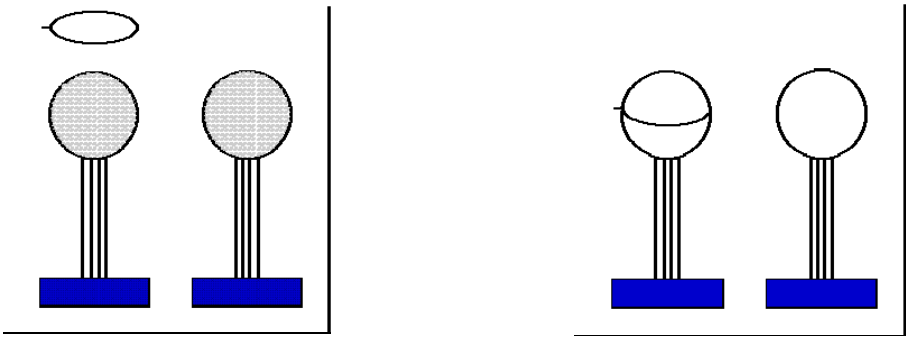
Note: All electrostatic demos work better on cold, dry days.



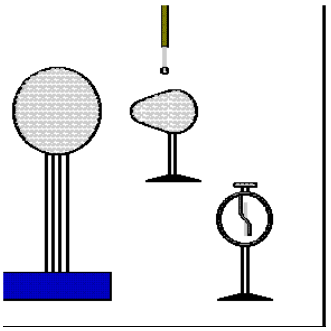
a. Charge flows to the points and sprays off. In this classic demonstration, the professor or a student volunteer stands on the insulated base and places his/her hand on the sphere of the generator. An assistant turns the generator on, and the demonstrator's hair stands on end. The demonstrator should have a key or other pointed object concealed on his person to hold up and spray off the excess charge when the demonstration is over.
A similar effect can by demonstrated by placing a wig on the sphere, or by connecting the sphere to a paper plume. The electric flier shown below will spin by spraying off charge when connected to the sphere.

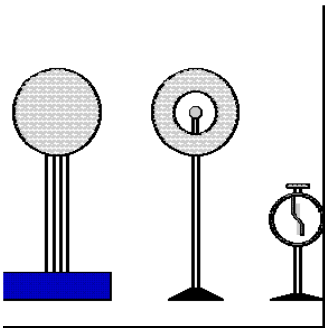


b. Action of a lightning rod. Two Van de Graaffs are provided, one of which charges its sphere positive, and the other negative. When both are turned on, they will spark to each other over 8 -12" distance. However, if a small point is placed on one sphere, aimed in any direction, even at the other sphere, no sparks will jump, because the point dissipates the charge into the air preventing the potential from building up.



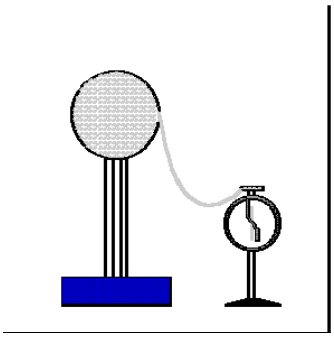
c. Charge density is Greatest at the areas of highest curvature. When the pear-shaped metal sphere is charged by touching it to the Van de Graaff, a larger charge can be removed from the narrow end than from the fat end. The amount of charge is tested by the deflection of an electroscope. To produce a noticeable effect this demonstration must be done carefully.

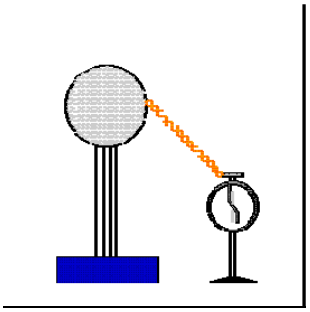




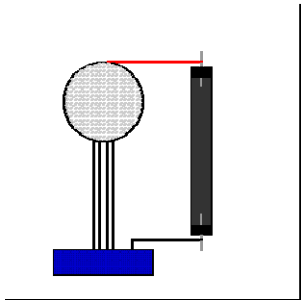
d. Gauss' Law --charge is on the outside of a conductor. Several demonstrations of these effects are described in E.1.8

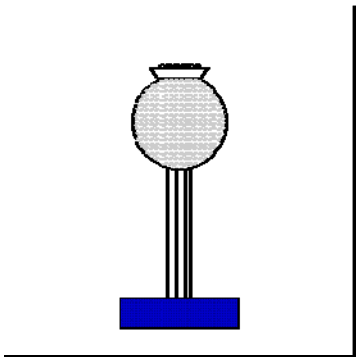
e. Conductors and non-conductors. A string connected between an electrostatic generator and an electroscope will not conduct charge, but a metal wire will.





f. Smoke precipitator. Smoke blown into a tube (from a cigarette) rapidly disappears when the electrodes on the ends of the tube are connected to the generator.





g. "Shot from guns" A paper cup full of puffed wheat or small Styrofoam chips placed on top of the generator produces a spectacular effect. Bring your own puffed wheat.

Click on the images below to see movies

http://www.mercury.co.nz/education/education_whatisenergy_historyofelectricity.asp

1.

a) True

b) False. An electroscope, positively charged, is touched by a negatively charged balloon. **Separation of the electroscope leaves decreases**.

c) True.

d) False. We discharge a positively charged electroscope touching it because **electrons enter the electroscope from the ground** through our body.

e) False. The leaves of a charged electroscope will deflect even more when we touch it with a charged rod, **with the same** sign of charges.

2.- Electrophorus is charged by induction. Steps to charge an electrophorus:

1. **With an animal fur rub a plastic surface (this surface becomes negatively charged).**
2. **Place the metallic disc of electrophorus onto the negatively charged plastic. Charges in metal will be distributed, the positive charges will be attracted by the negative charges of plastic and the electrons in the metal will occupy the opposite place.**
3. **Remove the electrophorus from the plastic surface, then eliminate the negative charge with a ground wire or touching the metal disc briefly (the negative charges will flows to earth through the wire or your body)**
4. **The electrophorus will be charged positively.**

3.- Balloon will be charged negatively because rubber has a greater affinity for electrons than fur.

4.-

a) **Sparks are produced between the two spheres because they have accumulated a great quantity of charge.**

b) **The electric whirl spins in a direction that is away from the points due to the action and reaction principle: the electrons leave the whirl by the points and points move in an opposite direction.**

c) **Styrofoam balls jump inside the glass jar because they have the same sign of charge, so they repel each other.**

d) **The sheets of paper are pulling apart because they have the same sign of charge, so they repel each other.**

e) **When the sphere is touched with an electroscope, the electroscope leaves separate because metal leaves acquire the same charge as the sphere.**

f) **Because smoke charged particles are attracted by the pole with an opposite charge.**

g) **When an insulated person touches the sphere their hair stand up and separate because they have the same sign of charge, so they repel each other.**

Project:

The following three projects are proposed to student. They can work individually or in groups of two, Students can choose one of them, or any other related to electrostatics:

1. Build a Leyden jar: Web pages to consult:

[1] **http://video.google.com/videoplay?docid=-7547972370900128124**

http://www.alaska.net/~natnkell/leyden.htm

http://home.earthlink.net/~lenyr/stat-gen.htm

2. Build an Electroscope: Web pages to consult:

http://www.charlesedisonfund.org/Experiments/HTMLexperiments/Chapter9/9-Expt3/p1.html

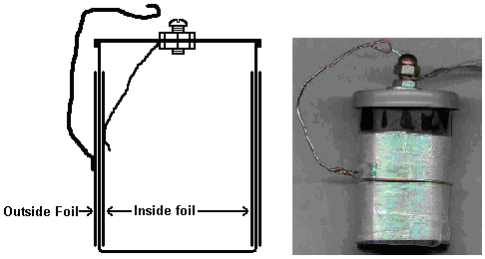
3. Build a Van der Graaf generator: Web pages to consult:

http://scitoys.com/scitoys/scitoys/electro/electro6.html

[1] Show the following video to students which explain the construction of a Leyden jar, how to charge it with a screen TV and how to discharge the Leyden jar (a spark is produced): **http://video.google.com/videoplay?docid=-7547972370900128124**.

Precaution in case the web site could be eliminated (reproduction of the experiment found in the web site):

Film Can Capacitor (Leyden Jar)



The picture of the film can Leyden jar is self explanatory. Now days, a film "can" is really plastic but it is a kind of plastic that makes a great capacitor. The inside foil can be taped to the wall or secured any way you want, so long as it makes good contact with the wall. One person wrote back and reported that the film can exploded as a result of using rubber cement to glue the inside foil to the wall. Rubber cement is highly flammable and explosive and was set off by sparking inside.

A Leyden jar is a device that early experimenters used to help build and store electric energy. It was also referred to as a "condenser" because many people thought of electricity as fluid or matter that could be condensed. Nowadays someone familiar with electrical terminology would call it a capacitor.

Basically, the Leyden jar is a cylindrical container made of a dielectric (that's an insulator, like plastic or glass) with a layer of metal foil on the inside and on the outside. With the outside surface grounded, a charge is given to the inside surface. This gives the outside an equal but opposite charge. When the outside and inside surfaces are connected by a conductor...*SNAP!* *You get a spark and everything returns to normal.*

: In the following web pages you will find information about different electrostatic experiments to perform with students:

1. http://www.jpimentel.com/ciencias_experimentales/pagwebciencias/pagweb/Los_talleres_de_ciencias/electricidad_y_magnetismo/electrostatica_experiencias_vdg.htm -: Experiments with the Van der Graaf generator.

2. http://www.arborsci.com/CoolStuff/cool18.htm: Easy and interesting electrostatic experiments, using balloons, tape, a homemade electroscope, charging by contact, etc) .

3. http://education.jlab.org/frost/: Videos about Van der Graaf generator and more.

4. http://www.execulink.com/~ekimmel/biofax15.htm: Quiz, including answers, about electrostatics.

5. http://www.sciences.univ-nantes.fr/physique/perso/maussion/statelec/: easy electrostatic experiments (Attraction and repulsion of light objects. Attracted balloon. Trickle of water. Electroscope and versorium. Charging and discharging by contact. Charging by induction. Points power. Two types of electric charges. Two types of electric charges. Conduction. Sign of charges. Electrostatic chime. Electrophorus. Faraday's cage)

6. http://www.phy.olemiss.edu/~thomas/weblab/222%20Lab%20Manual/Exp16_Electrostatics_fall01.pdf: basic electrostatic experiments.

Experiments:

Experiment 1: Conductors and insulators

OBJECTIVE

Test the electrical conductivity of different materials.

EQUIPMENT

Battery	Light bulb
Three Cables	Multimeter

MATERIALS

Paper clips	Aluminium foil
Sulphur	Running water
Distilled water	Rubber
Plastic	Copper
Etc.	

Procedure:

Students have to follow the instructions given on the textbook.

Safety measures:

Do not touch the two poles of battery

Solutions

Questions

The answer of these questions depends on the results obtained by students.

1. Annotate your observations in the below table:

Material	Bulk's Brightness

2. Divide the materials you have used in good conductors, poor conductors and insulators. Which criterion have you used to do this classification?

3. Record the data (in volts) indicated by the multimeter:

Material	Voltage

Experiment 2: Attraction and repulsion of charges

OBJECTIVE

Observe the attraction between opposite charges and repulsion between like charges.

EQUIPMENT

Electroscope	Pith ball pendulum
Animal fur	Ebonite or plastic rod
Silk cloth	Glass rod
Balloon	Comb

Procedure:

Students have to follow the instructions given on the textbook.

Solutions

Questions

1.

a) **False.** When the plastic rod is rubbed with animal fur the plastic rod **became negatively charged** and the animal fur became positively charged.

b) **False.** When the electroscope is touched with the charged plastic rod, their leaves separate because they both acquire **negative** charges.

c) **True.**

d) **False.** The type of charging that occurs when a glass rod is rubbed with a silk cloth is called electrification by **friction**.

e) **True.**

f) **False.** In electrification by friction objects acquired **different** kind of charge.

2. **When a comb is rubbed with fur it acquires negative charge because plastic has a greater affinity for electrons than fur.**

3. **In the beginning, an attraction between opposite charges takes place, but when the pith ball and rod are in contact, charges of rod distribute and the sign of charges of the two objects have the same sign, therefore, repulsion between the two objects occurs.**

4. **No, they haven't. The rubbed glass rod has positive charges and the rubbed plastic rod has negative charges because plastic has a greater affinity for electrons than fur and fur has a greater affinity for electrons than glass.**

TEACHER'S NOTES

Pupil misconceptions:

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UNIT 10: ELECTRIC CURRENT

Content:

Unit 10 Electric Current

10.1. Coulomb's law
10.2. Electric current intensity
10.3. Voltage
10.4. Resistance. Ohm's law
10.5. Joule's law
10.6. Electric circuits
10.7. Parallel and series circuits

Learning Aims:

At the end of the unit, the student will know:

- How to calculate forces between charges from Coulomb's law.
- The meaning of electric current intensity.
- How to calculate voltage, current and resistance using Ohm's law.
- The relationship between resistance and heat.
- How to analyze circuit diagrams for series circuits and parallel circuits.
- The different parts of an electric circuit.
- How to assemble components in an electric circuit.
- To use the appropriate language to answer questions and to communicate with teacher and classmates.

Solutions

Initial activities

1.

1.1. **c**

1.2. **a**

1.3. **a**

1.4. **a**

1.5. **b**

1.6. **c**

2.

a) **True.**
b) **True.**
c) **False.**

3.

Force: **newton**
Charge: **coulomb**
Electric current: **ampere**
Heat: **joule**
Resistance: **ohm**
Voltage: **volt**

10.1. Coulomb's law

1.

Force: **Newton**
Charge: **Coulomb**
Distance: **Meter**

2. **$6{,}25 \cdot 10^{18}$ electrons have a total charge of 1 C.**

3.

a) **There is an attraction force between the two objects.**
b) **$1{,}35 \cdot 10^{-3}$ N**

4.

a) **The three charges exert the same force.**

b) **A exerts the biggest force.**

5. **If one of the charges is tripled, force also is tripled.**

6. **22,5 N**

7.

a) **0,21 m**

b) **When the two charges are situated twice as far apart, force reduces four times (5 N)**

8. **$6{,}75 \cdot 10^{-7}$ N**

9. **a** or **b**

10. **d**

11.

a) **Force will be four times bigger.**

b) **Force will be four times bigger.**

10.2. Electric current intensity

1.

a) **True.**

b) **False.** A charge of 5 mC takes to flow through a copper 0,1 seconds if the current intensity is **50** mA.

c) **False.** The current intensity unit in the International System is the **ampere**.

d) **False.** The devise used to measure intensity is called **ammeter**.

e) **True.**

2. **20 mC.**

3.

a) **0,8 A.**

b) **$3{,}125 \cdot 10^{11}$ electrons**

4. **$1{,}44 \cdot 10^{-3}$ C.**

10.4. Resistance. Ohm's law

1. **15 V**

2. **15 Ω**

3. **0,75 V**

4. **0,33 A**

5. **3 A**

6.

a) **False.** The formula that relates intensity and resistance is: **I = V/ R**

b) **False.** The current flow in a conducting wire will increase as the length of that wire is **decreased**.

c) **True.**

d) **False.** The resistance in a conducting wire will increase as the diameter of that wire is **decreased**.

e) **True.**

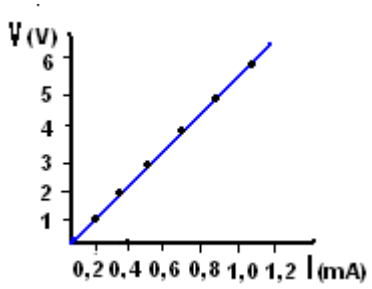
f) **False.** Unit of voltage in the IS is **volt**.

g) **False.** Unit of resistance in the IS is ohm and it is symbolized by an "Ω"

7. Graph d represents the Ohm's law because voltage across two points in an electrical circuit is directly proportional to the electrical current flowing in the circuit.

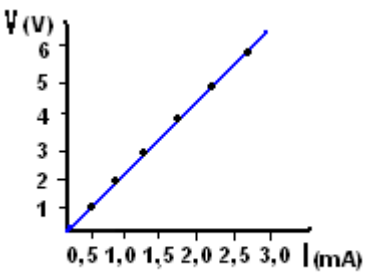
8.

a)



b) **5.000 Ω**

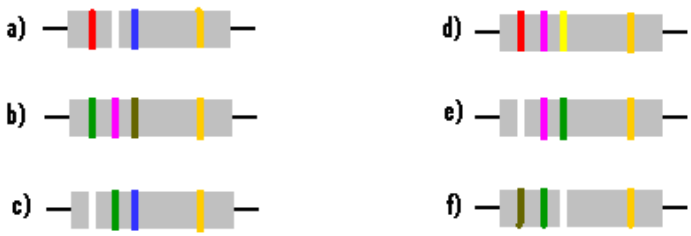
c)



d) **2.000 Ω**

9. There are different web pages with applets to calculate the total resistance. For example: http://www.dannyg.com/examples/res2/resistor.htm or http://www.resistor-color-code.com/ .

Students consult the web page: http://www.kpsec.freeuk.com/components/resist.htm to calculate the resistance of:



a) **$29 \cdot 10^6$ Ω** **b)** **570 Ω** **c)** **$95 \cdot 10^6$ Ω**

d) **$27 \cdot 10^4$ Ω** **e)** **$97 \cdot 10^5$ Ω** **f)** **$15 \cdot 10^9$ Ω**

Precaution in case the web site could be eliminated (reproduction of the experiment found in the web site):

Resistor values - the resistor colour code

Resistance is measured in ohms, the symbol for ohm is an omega Ω.
1 Ωis quite small so resistor values are often given in kΩ and MΩ.
1 kΩ = 1000 Ω 1 MΩ = 1000000 Ω.

Resistor values are normally shown using coloured bands.
Each colour represents a number as shown in the table.

Most resistors have 4 bands:

- The **first band** gives the **first digit**.
- The **second band** gives the **second digit**.
- The **third band** indicates the **number of zeros**.
- *The fourth band is used to shows the tolerance (precision) of the resistor, this may be ignored for almost all circuits but further details are given below.*

This resistor has red (2), violet (7), yellow (4 zeros) and gold bands.
So its value is 270000 Ω= 270 kΩ.
On circuit diagrams the Ωis usually omitted and the value is written 270K.

Find out how to make your own Resistor Colour Code Calculator

Small value resistors (less than 10 ohm)

The standard colour code cannot show values of less than 10Ω. To show these small values two special colours are used for the **third band**: **gold** which means × 0.1 and **silver** which means × 0.01. The first and second bands represent the digits as normal.

For example:
red, **violet**, **gold** bands represent 27 × 0.1 = 2.7 Ω
green, **blue**, **silver** bands represent 56 × 0.01 = 0.56 Ω

Tolerance of resistors (fourth band of colour code)

The tolerance of a resistor is shown by the **fourth band** of the colour code. Tolerance is the **precision** of the resistor and it is given as a percentage. For example a 390Ω resistor with a tolerance of ±10% will have a value within 10% of 390Ω, between 390 - 39 = 351Ω and 390 + 39 = 429Ω (39 is 10% of 390).

A special colour code is used for the **fourth band** tolerance:
silver ±10%, **gold** ±5%, **red** ±2%, **brown** ±1%.
If no fourth band is shown the tolerance is ±20%.

Tolerance may be ignored for almost all circuits because precise resistor values are rarely required.

10.5. Joule's law

1.

1.1. b

1.2. c

1.3. a

1.4. b

2.

a) Light bulb of 60 W has the highest resistance.

b) Light bulb of 100 W carries the greatest current.

c) A 100 W bulb is brighter than a 60 W light bulb.

A very interesting demonstration to your students is to show that a 100 W bulb is brighter than a 60 W light bulb. when they are connected in parallel (this is the way we have our domestic electrical installation) but when the two bulbs are connected in series, the 60 watt bulb is then brighter because its resistance is higher than the 100 W resistance (remember that in this case the current through the two bulbs is the same).

3.

a) $1{,}08 \cdot 10^7$ J

b) 6,52 A

4. $7{,}2 \cdot 10^6$ J

5.

Magnitude	**Symbol**	**IS unit** (name and symbol)
Voltage	**V**	**volt, V**
Electric charge	**Q**	**coulomb, C**
Current intensity	**I**	**ampere, A**
Resistance	**R**	**ohm, Ω**
Energy / Heat	**E**	**joule, J**
Power	**P**	**watt, W**

6. **3,33 W**

7. **0,67 A**

8. **P = 0,6 W**
W = 6 J

9. **E = 540 J**

10.6. Electric circuits

1. **a**

2.

Battery:

Lamp:

Voltmeter:

Motor:

Resistor:

Ammeter:

Switch:

Ohmmeter:

10.7. Parallel and series circuits

1.

1.1. b

1.2. a

1.3. b

1.4. b

1.5. c

1.6.

1.6.1. d

1.6.2. d

1.6.3. b

1.6.4. a

1.6.5. c

1.7. b

1.8.

1.8.1. b

1.8.2. a

1.8.3. d

1.8.4. d

1.8.5. a

2.

a) Equivalent resistance:

a.1) 9 Ω

a.2) 3,33 Ω

b) A: 1,11 A

A_1: 1,8 A

A_2: 1,2 A

A_3: 0,6 A

3. 

Resistor	**It control current by providing resistance**
Motor	**It transforms electric energy into kinetic energy**
Ammeter	**It is used to measure current intensity**
Voltmeter	**It is used to measure voltage**
Battery	**It provides direct current**
Ohmmeter	**It is used to measure resistance**
Switch	**It breaks or opens an electric circuit**

4. 

a)

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+ + C U R R E N T + + +
+ + + + + E L + I + + C
R E S I S T A N C E H +
C + + + + T I + I A C +
I N S U L A T O R S T +
R + + A + B N G T + I +
C + M + + + E + C + W +
U P + + + + T + E + S +
I + + M O T O R L + + +
T + + + + + P + E + + +
+ + + + + + + + + + + +
```

BATTERY; CHARGE; CIRCUIT; CURRENT; ELECTRICITY; INSULATORS; LAMP; MOTOR; PETENTIAL; RESISTANCE; SWITCH.

b)

Electricity is the flow of **charge** around a **circuit** carrying energy from the **battery** (or power supply) to components such as a **lamp** or a **motor**.

We say that **electricity** flows from the positive (+) terminal of a **battery** to the negative (-) terminal of the **battery**.

This flow of electric **charge** is called conventional **current**.

In a **circuit** there is at least a **switch**. If the **switch** is opened the **circuit** is broken - so **electricity** cannot flow, but if the **switch** is closed the **circuit** is complete - allowing **electricity** to flow.

Opposition of a **circuit** to the flow of electric **current** is called **resistance**. Ohm's law states that the **current**, **I**, flowing in a **circuit** is proportional to the applied **potential** difference, **V**. **Insulators** have extremely high **resistance** to the flow of **charge** through them.

5.

Across

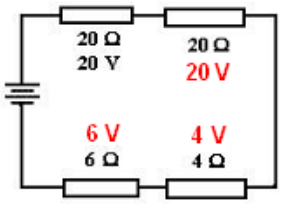
1. **Ampere**
4. **Circuit**
6. **Series**
7. **Volt**
8. **Ohm**

Down

2. **Parallel**
3. **Conductor**
5. **Current**

6. 

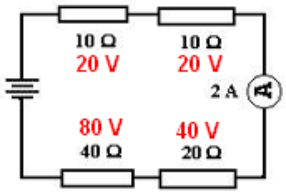
a)



This is a series circuit, so, the same current, 1 A, passes through each resistor.

The total voltage is 50 V

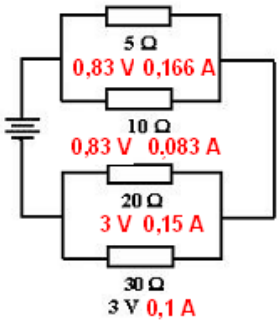
b)



This is a series circuit, so, the same current, 2 A, passes through each resistor.

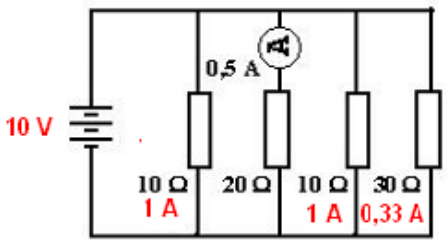
The total voltage is 160 V

c)



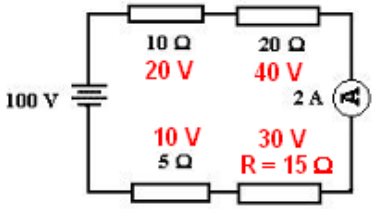
The total voltage is 3,83 V

d)



This is a parallel circuit, so, the potential difference across the ends of each resistor and the total voltage is the same voltage, 10 V.

7. a



This is a series circuit, so, the same current, 2 A, passes through each resistor.

The resistance of the unknown resistor, R, is 15 Ω

Project 1: The following projects are thinking to work individually. Each student has to choose one of them:

1. Natural electrical phenomena
2. Cells, Batteries
3. Power stations: hydroelectric, thermal, solar, nuclear, aeolian
4. Uses of the electrical energy
5. Electricity at home
6. Saving energy

Project 2: The following projects are thinking to work individually or in groups of two. Students have to choose one of them, or any other related to electricity:

1. Build a Burglar Alarm: Consult the webpage:

http://www.charlesedisonfund.org/Experiments/HTMLexperiments/Chapter7/7-Expt4/p1.html

2. Build an electrical motor: Consult the webpage:

http://scitoys.com/scitoys/scitoys/electro/electro4.html

Suggested rules

Projects are though to practice written and oral language and also to work accurately. Projects will be done as homework of an approximately fifteen day's duration. When students have finished the different projects, they have to give a written document to the teacher and it is important to expose them to the rest of the class in approximately ten or fifteen minutes.

Teacher's strategies

- Create the right atmosphere.
- Provide support
- Ask some easy questions to know if students understand the information they are giving us.
- Show interest.
- Encourage contributions from other students
- Revise the language
- Give the students time to think before answering
- Allow students to consult one another
- Set a time limit for the discussion

Student's rules

- Do not interrupt your classmate
- Listen to each other
- Be responsible for what you do
- Respect each other's opinions

Experiments: DC Circuits

Experiment 1: Series batteries

OBJECTIVES

- Learn how to connect batteries in series.
- Calculate the total voltage in series batteries.

EQUIPMENT

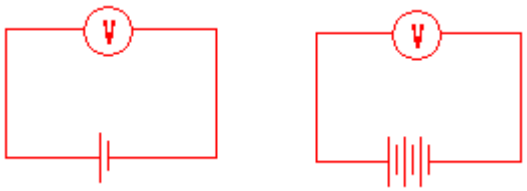
Three 1,5 volts batteries
One 4,5 volts battery
Cables
Voltmeter

Procedure:

Students have to follow the instructions given on the textbook.

Solutions

Questions

1. 
2. **When the terminal connexions to the batteries are reversed, voltage has a negative value.**
3. **The total voltage of two 1,5 volts series batteries is 3,0 volts.**
4. **The total voltage of the three 1,5 volts series batteries is 4,5 volts**.
5. **The total voltage of the three 1,5 volts series batteries is the same as the voltage of an isolated 4,5 volts battery.**
6. **When opening a 4,5 volts battery we can observe three 1,5 volts batteries connected in series.**
7. **The total voltage of five 1,5 volts batteries connected in series is 7,5 volts**.

Experiment 2: Parallel batteries

OBJECTIVES

- Learn how to connect batteries in parallel.
- Calculate the total voltage in parallel batteries.

EQUIPMENT

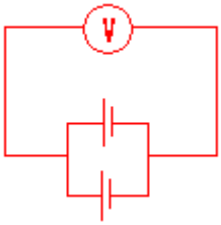
- Two 6 volts batteries
- A 12 volts bulb
- A socket
- Cables
- Voltmeter

Procedure:

Students have to follow the instructions given on the textbook.

Solutions

Questions

1. 

2. **The lamp glows dimly because it needs more voltage than the applied voltage.**

3. **The total voltage of the two 6 volts parallel batteries is the same than the voltage of an isolated 6 volts battery because when batteries are connected in parallel the voltage of each battery is the same.**

4. **The total voltage of four 6 volts batteries connected in parallel is 6 volts.**

Experiment 3: Ohm's law

OBJECTIVES

- To know how to use a voltmeter
- To know how to use an ammeter
- To prove the Ohm's law

EQUIPMENT

- 6 volts battery
- Different resistors between 100 Ω and 1000 Ω
- Cables
- Polimeter

Procedure:

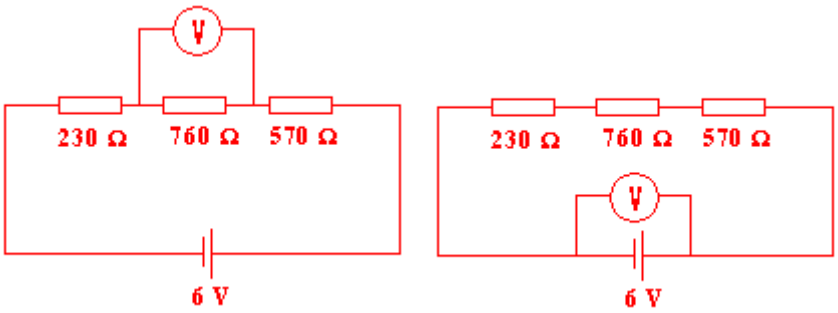
Students have to follow the instructions given on the textbook.

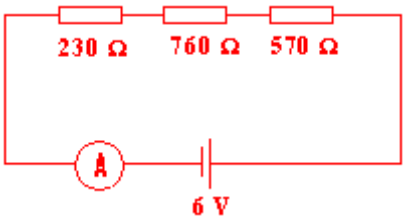
Solutions

Questions

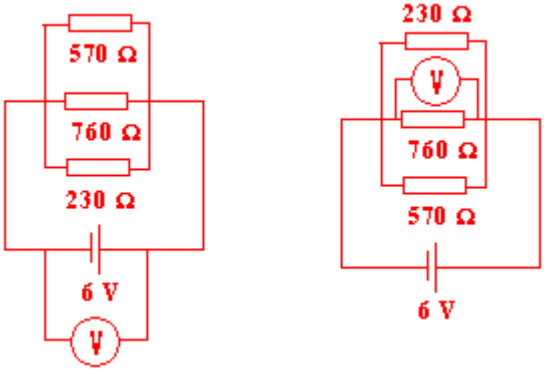
1.

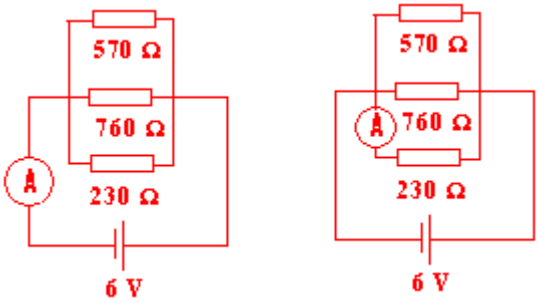
Series circuit:





Parallel circuit:





2.

Series Circuit			
	Resistance (Ω)	Voltage (V)	Current (mA)
1	230	0,88	3,85
2	760	2,93	3,85
3	570	2,19	3,85
Total	1.560	6	3,85
Parallel Circuit			
	Resistance (Ω)	Voltage (V)	Current (mA)
1	230	6	26,09
2	760	6	7,89
3	570	6	10,53
Total	134,80	6	44,51

Note: **You can use the web site: http://www.dannyg.com/examples/res2/resistor.htm to calculate the resistance of each resistor.**

3.

a) **In a series connexion the total voltage is equal to the sum of the voltages across all the components.**

b) **In a parallel connexion the voltage across each of the components is the same.**

4.

a) **In a series connexion the current across each of the components is the same**.

b) **In a parallel connexion the total current is equal to the sum of the current across all the components**.

5. This question has been calculated in question 2. To calculate the resistance of each resistor using the Ohm's law we have to divide the voltage between the current.

6. This question has been calculated in question 2.

7. If the number of resistors in the series circuit increases, current decreases.

8. If the number of resistors in the series circuit increases the total voltage is the same but the voltage across each resistor decreases.

9. If the number of resistors in the parallel circuit increases the current through each resistor is the same as they have before connecting the other resistors.

10. If the number of resistors in the parallel circuit increases, the voltage does not change.

11. When we approach the red probe to the black one, voltage decreases. The greatest voltage indication is obtained when the red and black probes are situated on the ends of the rod.

Experiment 4: Thermocouples

OBJECTIVE

Observe the how a variation of temperature affect conduction in thermocouples.

EQUIPMENT

- Copper wire
- Iron wire
- Voltmeter
- Lighter
- Ice cubes

Procedure:

Students have to follow the instructions given on the textbook.

Solutions

Questions

1. **The voltmeter indicates a zero voltage when we connect it to the ends of thermocouple in the beginning of the experiment because the two ends are not at a different temperature.**
2. **The maximum value of voltage obtained with the flame is higher than the maximum value of voltage obtained with the ice cubes because of the highest difference of temperature.**
3.  **Thomas Johann Seebeck discovered in 1821 the Thermocouple principle, known as the thermoelectric effect or Seebeck effect. He demonstrated that a voltage is obtained between the two ends of a conductor when these two ends are at different temperature and the voltage is proportional to the temperature difference.**

   Thermocouples are used as temperature sensors or to generate electric power.

References:

http://www.dataforth.com/catalog/pdf/an106.pdf

http://www.egr.msu.edu/classes/me412/ljgenik/thermocouple.pdf

http://en.wikipedia.org/wiki/Thermocouple

Experiment 4: Lemon battery

OBJECTIVE

- Prove that some chemical reactions produce electricity

EQUIPMENT

- A lemon
- Lamina of zinc
- Lamina of copper
- Voltmeter

Procedure:

Students have to follow the instructions given on the textbook and answer the questions according the results they have obtained.

In the following web pages you will find information about different experiments related to this unit to perform with students:

1.- http://www.walter-fendt.de/ph14e/combres.htm Applet. It is possible to combine resistors and change the total voltage. Voltage and current in each resistor can be known.

2.- http://www.lon-capa.org/~mmp/kap20/RR506a.htm In this applet you can select several configurations of resistors in parallel or in series or in combination of both, change their individual resistances, and know the total resistance.

3.- http://www.educypedia.be/electronics/javacollectors.htm Different Physics Java applets and animations.

4.- http://www.ngsir.netfirms.com/englishVersion.htm Interesting Java applets

5.- http://people.clarkson.edu/~svoboda/ihp.html Different exercises about circuits. A calculator is included.

6.- http://webphysics.davidson.edu/physlet_resources/bu_semester2/menu_semester2.html Different Java applets and animations.

7.- http://library.thinkquest.org/10796/ch15/ch15.htm Applet to design a circuit

8.- http://ourworld.compuserve.com/homepages/g_knott/elect27.htm

9.- http://www.hyperstaffs.info/work/physics/child/index.html (In this applet there is a brief introduction to circuits. Interesting

10.- http://www.andythelwell.com/blobz/ Interactive theory and questions about circuits.

11.- http://puzzlemaker.discoveryeducation.com/ Puzzle maker

12.- http://www.authorstream.com/Presentation/AscotEdu-37770-ELECTRIC-CIRCUIT-Conductor-Insulator-Simple-Conventional-as-Education-ppt-powerpoint/ Circuit Power Point

13.- http://www.kpsec.freeuk.com/electron.htm Theory about circuits

14.- http://www.hunkinsexperiments.com/themes/themes_electricity.htm Cartoons. Funny experiments with a TV set, making a battery and static electricity

TEACHER'S NOTES

Pupil misconceptions:

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Scientific understanding

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UNIT 11: ELECTROMAGNETISM

Content:

Unit 8 Electromagnetism

11.1. Magnets: natural and artificial
11.2. Magnetization
11.3. Poles: magnetic properties
11.4. Magnetic field
11.5. The compass
11.6. Electromagnet
11.7. The electric engine
11.8. The dynamo

Learning Aims:

At the end of the unit, the student will know:

- Different substances that present magnetic properties.
- How a substance can be magnetized.
- Properties of the magnetic poles.
- What happen to iron fillings when they are situated over a magnet.
- What is a compass and what is used for.
- The difference between ferromagnetic, paramagnetic and diamagnetic substances.
- How and electromagnet works.

Solutions

Initial activities

1. Choose the correct answer:

1.1. c
1.2. b
1.3. b
1.4. a
1.5. d
1.6. b
1.7. a
1.8. a

2. **A magnet can separate iron filings from sawdust.**

3.

a) **180º,90º, 270º.**

b) **electric**

4. **iron, direct, ceases.**

5. **The name of a magnet that can be turned on and off is electromagnet.**

11.1. Magnets: natural and artificial

1.

a) nickel, iron, cobalt, gadolinium, samarium, neodymium, boron

b) Sm , Co , Fe , Nd , B , Al , Ni

c)

Gadolinium is used for making magnetic refrigerators.

Samarium Cobalt magnets are used in computer disc drives, sensors, satellite systems, etc.

Neodymium magnets are used in the music, electronic, automotive, in the toy and jewellery industry amongst other applications.

Plastic magnets have many applications in industry and in home appliances.

d)

Gadolinium heats up when exposed to a magnetic field and cools down when the magnetic field is removed.

Samarium Cobalt magnets are extremely strong for their small size and high resistance to demagnetization.

Neodymium are the strongest type of permanent magnets made, but are also mechanically fragile (it can be crushed with a mixer)

Ceramic magnets are very hard and brittle and have a higher resistance to demagnetization and oxidation compared to other non-rare earth magnets.

Plastic magnets have a high elasticity and flexibility.

2. **A magnetic refrigerator works due to the special magnetic properties of gadolinium. Gadolinium heats up when exposed to a magnetic field and cools down when the magnetic field is removed. That means that a magnetic refrigerator requires no so much electrical energy and causes little harm to the environment.**

To answer this question you can use the following wed pages:

1.- http://en.wikipedia.org/wiki/Magnetic_refrigeration

2.- http://www.eurekalert.org/features/doe/2002-01/dl-nmr061702.php

3.

Colloidal mixture: **Mixture in which very small particles, approximately 10 to 10.000 Å in size, are dispersed within a continuous medium.**

Surfactant: **Substance that, when dissolved in water, lowers the surface tension of the water and increases the solubility of compounds.**

Carrier: **Neutral material used to support other substances.**

4. **When a magnet is approached to a ferrofluid the density of ferrofluid changes because the volume occupied by particles increases.**

5. **Ferrofluids have different applications:**

- **In medicine, they are used to detect cancer. They can also be used to treat cancer because when a ferrofluid is placed in an alternative magnetic field heat is released.**
- **Due to their refractive properties, they are used in optics.**
- **Loudspeakers use ferrofluids to eliminate the heat produced between the coil and the magnet.**
- **For military proposes, The USA Air Force uses a paint made with ferrofluid and non-magnetic substances to reduce the reflection of electromagnetic waves, so the radar cross section is reduced.**
- **In electronic devices, ferrofluids are used between the magnet and the rotating shaft to prevent particles enters the inside of the hard drive.**

For more information you can consult the web page:
http://en.wikipedia.org/wiki/Ferrofluid

6.

a) **770 ºC**

b) **Curie temperature is the temperature above which ferromagnetic materials lose their magnetism.**

c) **Lava has not magnetic properties because its temperature is higher than the Curie temperature.**

11.2. Magnetization

1. **Paramagnetic materials only have magnetic properties when a permanent magnet is closed to them.**
2. **Diamagnetic materials that are slightly repelled by a magnet.**

3. **Ferromagnetic materials that are strongly attracted by a magnet.**

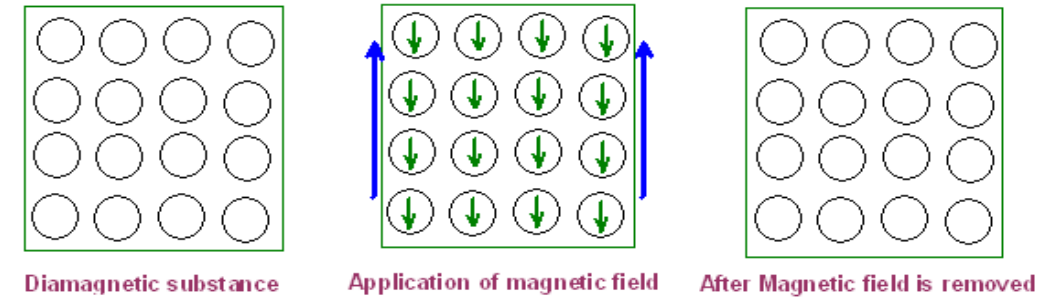
4. **Electrons spin around its axis in either a clockwise or anti-clockwise direction.**

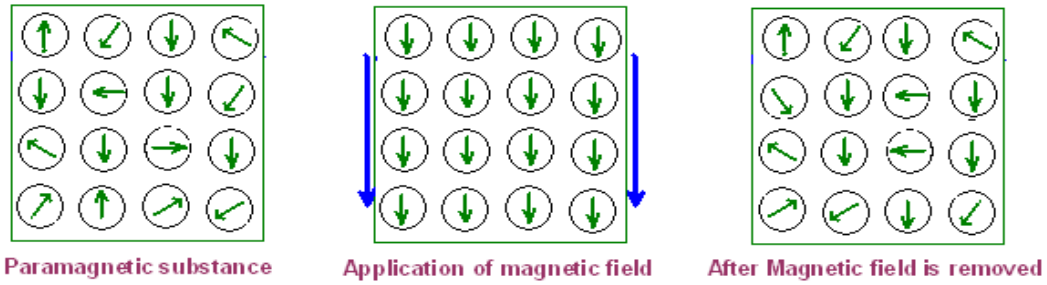
5. **Paramagnetic materials only have magnetic properties when a permanent magnet is closed to them and ferromagnetic materials can be magnetized by their insertion in a magnetic field.**

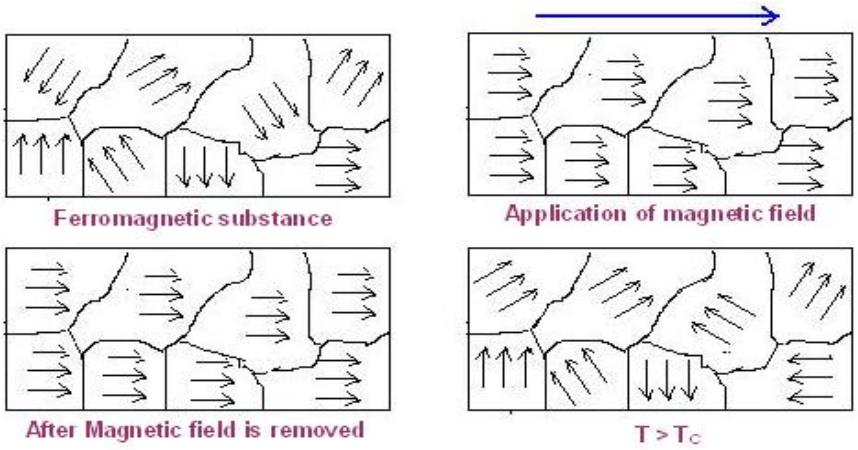
6. **A magnetic domain is a small region of material in which the magnetic fields of atoms are aligned.**

7. **When you rubbed a magnet across a needle, the needle becomes magnetized.**

8.







In diamagnetic substances all the electrons are paired and when they are placed in a magnetic field, a slight magnetic field is produced, but this field is opposed to the magnetic field applied.

In paramagnetic substances the atoms have unpaired electrons. Initially, the atom magnetic fields are aligned randomly, and the total magnetic field is zero. When an external magnetic field is applied to this kind of substances, the magnetic field realign in the same direction that the external magnetic field, but these magnetic properties disappear when the external magnetic field is removed.

Ferromagnetic substances also have unpaired electrons. They behave as paramagnetic substances when an external magnetic field is applied to them, but when the magnetic field is removed, the magnetic properties remain.

The arrows represent the direction of magnetic fields.

9. Electrons are paired when a half of electrons spin in a direction and the other half in the opposite direction, therefore, the total magnetic field is zero. An orbital electron for which there is no other electron in the same atom with the same energy but opposite spin presents unpaired electrons.

10. Atoms have magnetic field when they have unpaired electrons and the total magnetic field is different from zero.

11. Not all materials with unpaired electrons have magnetic properties because sometimes the atom magnetic fields are aligned randomly, and the total magnetic field is zero.

12. A permanent magnet retains its magnetic properties but a temporary magnet loses the magnetic properties.

13. When a magnet is heated above the Curie temperature, it loses the magnetic properties.

14.

14.1. b and d

14.2. c

14.3. b

14.4. a

15.

a) In domains, large numbers of atom's moments (10^{12} to 10^{15}) are aligned. Their volume is of order 10^{-15} m^3.

b) Magnetic domains can be detected using Magnetic Force Microscopy (MFM)

11.3. Poles: magnetic properties

1.

a) **True**

b) **False.** A magnet has two poles called **north** and **south**.

c) **False.** Like poles **repel** each other.

d) **False.** Opposite poles **attract** one to another.

e) **False.** The magnetic force between two magnets is stronger the **closer** the magnets are from one another.

f) **True.**

g) **False.** The ends of magnets are called **magnetic** poles.

h) **True.**

2. **Magnet B is the strongest.**

3. **Near an electric charge or the magnet poles, the field is stronger.**

4.

a) **When a magnet is cut in 5 pieces, each piece has two poles.**

b) **There will be 10 poles in total.**

5.

5.1. **b** **and** **d**

5.2. **a** **and** **c**

5.3. **b**

6.

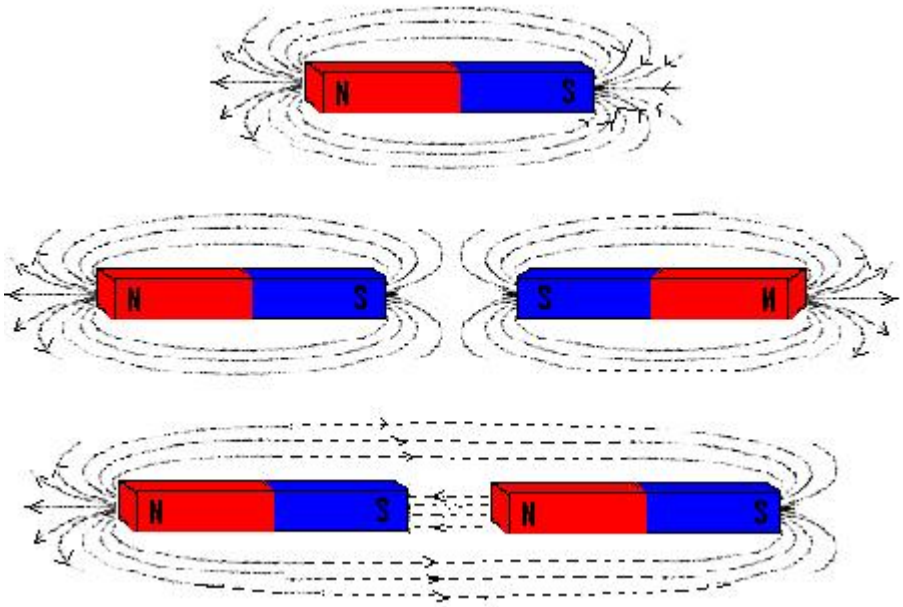
a)

Opposite poles attract each other and like poles repel one to another.

b) **Yes, it is possible to do another drawing changing the position of magnetic poles:**

11.4. Magnetic field

1. In the following picture we can see the differences between the magnetic lines of force created by:



a) **One magnet: The magnetic field is stronger in the magnetic poles.**

b) **Two magnets with the two like poles close to one another: There are not lines of force between the two closest like poles.**

c) **Two magnets with the two different poles close to one another: Lines of force are very similar to the lines created by only one magnet.**

2.

2.1. a

2.2. a, c or d.

2.3. a

2.4. b and c

.

3. When iron particles are sprinkled over a magnet they are placed around the field magnetic lines.

4. When small compasses are situated around a magnet they are placed around the field magnetic lines. The north pole of compass points to the south pole of magnet and viceversa.

You can observe the orientation of compass around a magnet in the web page:

http://www.windows.ucar.edu/tour/link=/physical_science/magnetism/bar_magnet_interactive.html

5. **The magnetic forces around a magnet are stronger at the two poles.**

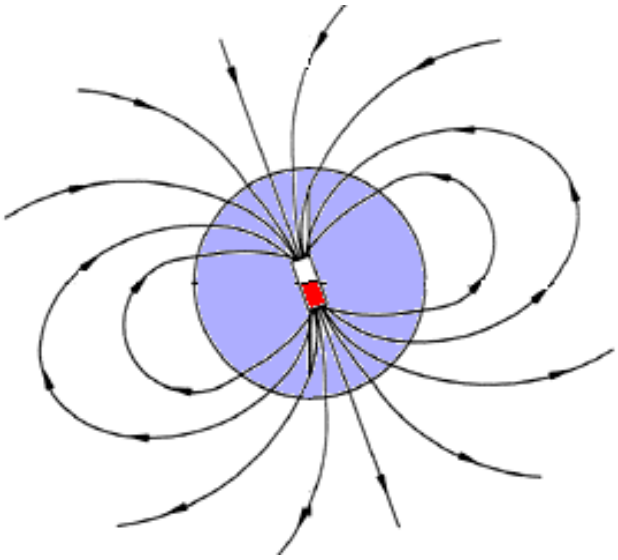
6. **The magnetic forces around a magnet are weaker when the distance to poles increases.**

7. **The magnetic lines of force around a magnet indicate the magnetic field, region in which the force of the magnet can be detected.**

8. **The poles of each iron filing point to the opposite pole of magnet when they are situated in the magnetic field created by the magnet.**

9. **Earth is a magnet, the real magnetic north pole is situated on the south hemisphere and the south magnetic pole is situated on the north hemisphere. Earth's magnetic poles and its geographic poles are actually pretty far apart. In 2005, the South Magnetic Pole was located about 810 km from the Geographic North Pole and the North Magnetic Pole was situated about 2,826 km from the Geographic South Pole. However, this location is moving continually.**

10.



11.5. The compass

1. **A compass is a magnetic device that indicates the direction of the magnetic poles of Earth.**

2. **When a compass is situated around a magnet if follows the direction of magnetic field and the north pole points to the south pole of magnet.**

3. **Compasses are used in navigation because it points to the north-south direction of Earth.**

4. **In ancient China, sailors carried a lodestone to magnetize needles by rubbing the needles with the lodestone.**

5. **The north pole of compass points to the north geographic of Earth.**

11.6. Electromagnet

1.

1.1. a and b

1.2. b

1.3. b and c

2.

a) **False.** A compass situated close to an electrified wire, experiment a movement because of the **magnetic force**.

b) **True.**

c) **False.** If we sprinkle iron filing close to an electrified wire, they will be **placed on the lines of force around a magnet that represents the strength and direction of the magnetic force.**

3. An electromagnet can be made coiling a wire several times (solenoid) around a soft iron core and connecting the ends of solenoid to a battery. When the current is turn on, the solenoid become a magnet, but if the current is turn off, magnetism disappear.

4. Magnetism and electricity are so closely related: The magnetic field is produced by the motion of electric charges (electricity flowing through a wire produce a magnetic field). A changing magnetic field produces an electric field (moving a magnet inside a solenoid, electric current is produced).

11.7. The electric engine

1.

1.1. a and b

1.2. a and b

1.3. a (heat is also produced)

2.

a) **False.** A motor can work with alternating current. In this case is **not** necessary **the** commutator.

b) **False.** In a motor, the electromagnet moves in response to the attracting force of **unlike** poles and the repelling force of **like** poles.

c) **False.** Direct current **does not change** the direction of flow, so a commutator divided in two halves is needed.

d) **True.**

3. The main parts in a motor are: the coil or rotor, the permanent magnets, the brushes and the commutator.

4. In a motor, permanent magnets provide a steady magnetic field.

5. The commutator is divided in two halves, so the current in the coil change the direction, which means that the electromagnet poles are inverted, and will be repelled by the poles of the permanent magnets; consequently, the coil keeps spinning while the battery is on.

6. When an electric current flow through the coil, it becomes an electromagnet.

7. Examples of devises in which motors are used: **fans, electric vehicles, washing machine, hairdryer, dishwasher**

8.

a) **Unlike poles attract each other.**

b) **Like poles repel each other.**

9. The attraction and repulsion magnetic forces are responsible of the engine spinning.

10. In a direct current motor, if the commutator is not divided in two halves, the motor spinning ceases.

11.8. The dynamo

1. The voltmeter needle moves when the magnetic lines of force from the magnet interact with the electrical coil.

2.

2.1. True.

2.2. True.

2.3. False. In a dynamo, **kinetic** energy changes to **electrical** energy.

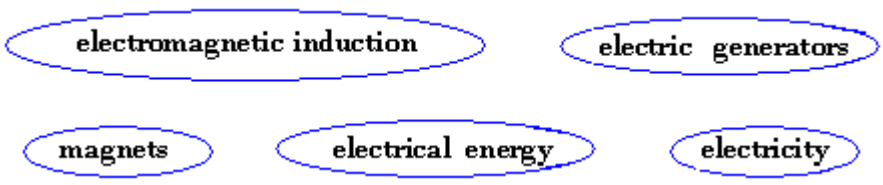
2.4. **True.**

3. **Dynamos are used to generate electricity in lamps, clockwork radios, to recharge batteries, to feed the Light system in bicycles, to transform the wind power in electrical energy, etc.**

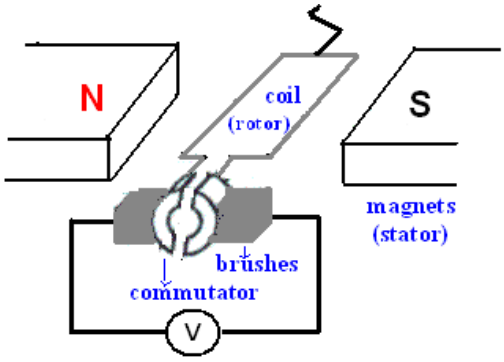
4.

you move your legs to peddle a bicycle

a rushing wave of water hits a boat



5. **A dynamo can be made with electric wire, magnets and strips of metal.**



6.

Compass	Instrument for determining direction, with a magnetized needle which points to magnetic north.
Dynamo	Devise that transforms mechanical rotation into direct electric current through the use of a commutator
Lodestone	Rock with magnetic properties and attracts iron, cobalt, nickel, …
Magnetism	Property of attraction displayed by magnets to some materials.
Electron	Subatomic negatively charged particle.
Electromagnet	Magnet in which an iron or steel core is magnetized by the electric current going through the coil of insulated wire wound around it.
Commutator	A cylindrical arrangement of insulated metal bars connected to the coils of a direct-current electric motor or generator, providing a unidirectional current from the generator or a reversal of current into the coils of the motor.
Battery	Device that generates electricity by means of chemical reactions.
Magnetic poles	Either of two regions of a magnet, designated north and south, where the magnetic field is strongest.

7. Examples of common items that rely on magnetism to work: **speakers, TV, credit cards, video tapes, floppy and hard computer disks, magnetic toys, electric motors, etc.**

Experiments:

Experiment 1: Properties of magnets

OBJECTIVES

Test the magnetic force.

Visualize magnetic lines.

Magnetize objects.

MATERIALS

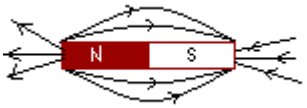
Magnets	Iron filings
Sheet of paper	Metal objects (paper clips, nails, coins, etc.)

Procedure:

Students have to follow the instructions given on the textbook.

Solutions

Questions

1. 

2. **This is a free answer, depending on the objects the students have used.**
3. **A metal becomes a magnet when their atom magnetic fields are aligned and the total magnetic field is zero**

Experiment 2: The magnetic pendulum

OBJECTIVES

Test how magnetic properties change with temperature.

MATERIALS

A Magnet	Nickel coin (1, 2 or 5 cent of euro)
Support	Metallic wire

Source of heat (a candle, alcohol or Bunsen burner)

Procedure:

Students have to follow the instructions given on the textbook.

Solutions

Questions

1. **Curie temperature is the temperature at which a metal loses the magnetic properties.**

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2. **Curie temperature of nickel is 358ºC.**
3. **The flame heat up the coin until it loses its magnetic properties. Gravity pulls the pendulum away from the magnet. The coin cool down a little bit once it is away from the flame. Once it is a little cool, it regains its ability to stick to the magnet. The magnet attracts the coin again into the flame, and the whole process repeats.**
4. **When coins of 10, 20 or 50 cent of euro are used, they are not attracted by the magnet, because metals of these coins do not have magnetic properties.**

Note: Remember that a rare earth magnet will work a little better because it loses its magnetic properties at a lower temperature.

Experiment 3: Building a DC motor

OBJECTIVES

Know some applications of electromagnetism.

MATERIALS

A ceramic disc magnet	Battery
Isolated copper wire	2 paper clips o safety pins
Tape	Board

Procedure:

Students have to follow the instructions given on the textbook.

Solutions

Questions

1. **The motor run due to repulsion and attraction forces between the permanent magnet and the magnet created when the electric current goes through the coil.**
2. **The motor spin can be faster increasing the number o magnets, increasing the number of loops of rotor, increasing the number of batteries and using better wire conductors of electricity in rotors.**
3. Motors are devices that convert **electric** energy into **mechanical** energy.
4. **a and c.**
5. Examples of devises that need a motor to work: **hairdryer; vacuum cleaner; dishwasher; washing machine; fan.**

Experiment 4: Building an electromagnet

OBJECTIVES

Know the relationship between electricity and magnetism.

MATERIALS

A long nail	4,5 V and 9 V batteries
Isolated copper wire	Iron filings or paper clips

Procedure:

Students have to follow the instructions given on the textbook.

Solutions

Questions

1. **An electromagnet works when the electric current goes through the wire due to the magnetic field created by the current.**
2. **If the 4,5 V battery is changed for a 9 V battery, more quantity of iron filing are attracted because the magnetic force increases.**
3. **If the nail is removed, less quantity of iron filing is attracted because the magnetic force decreases.**
4. **b**
5. **Electromagnets are used to generate magnetic fields. Electromagnets are used for example in door bells, loudspeakers, tape recorders, etc.**

TEACHER'S NOTES

Pupil misconceptions:

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Scientific understanding

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