

## Do you need chemistry in order to be a good bone surgeon?



Source:

<http://esporte.ig.com.br/futebol/2009/07/31/medico-do-corinthians-esclarede-demora-para-cirurgia-de-ronaldo+7608931.html>

### A grade 11 science (chemistry) module on oxidation and reduction

#### Abstract:

This module is geared to oxidation-reduction in metals. Students build on their previous learning on the properties of different metals, and the differences between them. In particular they build on their prior learning of a reactivity series in which more reactive metals will reduce the oxide of less reactive metals and that more reactive metals react at a much faster rate with oxygen or air than less reactive metals. Through the activities in this script, students learn about the depositing of metals using electrolysis and the effects of structural changes on the reactivity of metals (especially the rusting of iron nails) and the meaning of alloys, especially stainless steel.

Sections included		
1.	<a href="#">Student activities</a> (for the students)	Describes the scenario in more detail and the tasks the students should perform
2.	<a href="#">Teaching guide</a>	Suggests a teaching approach
3.	<a href="#">Assessment</a>	Gives suggested formative assessment strategies
4.	<a href="#">Teacher notes</a>	States the theoretical physics and gives the expected calculations/results

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Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science

## Acknowledgement

This module has been adapted from that developed under the PARSEL project ([www.parsel.eu](http://www.parsel.eu)) as part of an EC FP6 funded project (SAS6-CT-2006-042922-PARSEL) on Popularity and Relevance of Science Education for scientific Literacy

## Overall Objectives/Competencies/Goals:

The students are expected to:

- \* understand the goals and rationale of the unit of oxidation-reduction.
- \* devise the electrochemical series, based on experimental evidence.
- \* read an article critically.
- \* perform a virtual experiment
- \* perform a real experiment
- \* collect data
- \* explain the results
- \* compare the results obtained virtually with those obtained in real laboratory activity
- \* participate in a group discussion and a class discussion

**Curriculum content:** Mechanical strength, toxicity, density, chemical stability and the electrochemical series. In Portugal, this part of the curriculum is embedded in the unit 2 – “From the atmosphere to the ocean: solutions on Earth and to the Earth“. The sub-titles are: 2.3 - acid rain; 2.3.2. - Impact on some materials, oxidation reduction reactions and experimental activity (AL 2.4 - Electrochemical Series: the case of metals)

**Kind of activity:** Critical reading and group activity, guided inquiry virtual laboratory, critical report of the laboratory activity.

**Anticipated time:** 6 lessons

**Prior Learning:** Electronic structure of the atom, configuration quantum electronics.

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This unique teaching-learning material is intended to guide the teacher towards promoting students' scientific literacy by recognising learning in 4 domains – intellectual development, the process and nature of science, personal development and social development.

Its uniqueness extends to an approach to science lessons which is designed to follow a 3 stage model. For this the approach is intentionally from society to science and attempts to specifically meet student learning needs.

This uniqueness is specifically exhibited by:

1. a motivational, society-related and issue-based title (supported in the student guide by a motivational, socio-scientific, real life scenario);
2. forming a bridge from the scenario to the scientific learning to be undertaken;
3. student-centred emphasis on scientific problem solving, encompassing the learning of a range of educational and scientific goals;
4. utilising the new science by including in socio-scientific decision making to relate the science acquired to societal needs for responsible citizenship.

## Do you need to know chemistry in order to be a good bone surgeon?

### Student Guide

#### Scenario

The following note was published in the sport sections of one of the online newspapers:

“On July 26, 2009, in a match for Corinthians, Ronaldo after a play in midfield, was pushed by an opponent and fell to the ground, supporting the entire body on his left hand. Because there has not been much of an impact in the fall, his injury was lessened. However, he suffered a fracture in the third and fourth metatarsal of his left hand and was forced to have surgery. Were placed two metal plates and screws 5 fix the lesion. Ronaldo was two months without playing.”

#### Task description

Discuss the following main question:

- Question: If you had accompanied the injured player to hospital, which questions would you make to the surgeon about the fixation of bones?

Also discuss the following ancillary questions:

- What metal would be good to use for the surgery?
- Would it matter if the nails and the plate were of different metals?
- To create nails, the metal is machined into shape so that the head is flat and the other end pointed. Does this affect the properties of the metal?

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- Should a plastic be used instead of metal?

Are these good questions to ask the surgeon who is performing the operation?

In order to choose the best metal to be used in bone surgery, we suggest that examine the reactivity of different metals. In the following experimental virtual activity you will be able to search the reactivity of metals.

Enters link: <http://stwww.weizmann.ac.il/G-CHEM/animationsindex/Redox/home.html>

What other questions would you ask?

## Virtual Activity

Question: If you had accompanied the injured player to hospital, what questions would you make to the surgeon about the fixation of bones?

### Perform activity No. 1.

On the screen you will see a series of beakers each contains a solution of metal ions, you can also see a list of solid metals.

1. Choose one of the metals and insert it into the different solutions, wait until a message tells you to remove the metal from the solutions.
2. Write your observations.
3. In which of the beakers does a chemical reaction occur?
4. Repeat steps 1-3 for all the different metals.
5. Summary all your observations in the table.

	Mg <sup>2+</sup> (aq)	Zn <sup>2+</sup> (aq)	Cu <sup>2+</sup> (aq)	Ag <sup>+</sup> (aq)
Mg				
Zn				
Cu				
Ag				

6. In order to observe the reactions in a molecular level, click on "Molecular Scale Reaction" and follow the directions.
7. Write the chemical equation for two reactions that happened.
8. Would you be able to organize the electrochemical series of metals by reducing power increasing.

### Perform activity No. 2.

Undertake an internet search on the metal titanium.

Seek information on titanium and its alloys when in contact with human bone and with several real applications.

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## Do you need to know chemistry in order to be a good bone surgeon?

### Teaching guide

The activity is dealing with metal properties: Mechanical strength, toxicity, density, chemical stability and the electrochemical series. It introduces the goals and rationale of the unit of oxidation-reduction, enables constructive building of the electrochemical series, and gives an example to the use of chemistry outside school.

- A. In the first lesson we suggest group working. Each student read the short text and the small group discuss it. The group should pose as much questions as they can (a list of students questions is given in the teacher notes).

The group work is followed with a class discussion (scientific background is available in the teacher notes). The goals for the discussion are:

- To rise the connections between chemistry and medicine.
- To create the students "need to know" – which metal is less reactive.

- B. The students enter to the site:

<http://stwww.weizmann.ac.il/G-CHEM/animationsindex/Redox/home.html>

This site offers to perform virtual experiments, to inquire the relative reactivity of metals.

It is possible to conduct these experiments in the lab, instead of using the web site, as the teacher prefers, but this will take more then one lesson.

After the virtual experiment, the students have the ability to construct the electrochemistry series. After the laboratory experiments, the students can criticize more fully the experimental results.

It is recommended to have a class discussion regarding the next questions:

1. How can you explain the results?
2. What are possible conclusions?
3. In all the experiments we used metals and solutions of metal ions, can you rank the metal by their reactivity order?
4. What is the chemical process in the molecular level?

This discussion can be at the beginning of the second lesson.

Usually, after this discussion we focus in the scientific concept of oxidation-reduction.

- We define: Oxidation and Reduction.
- After we build a concept map, which lists all of the concepts inherent in this balancing redox.

In the link

<http://stwww.weizmann.ac.il/G-CHEM/center/animationsindex/Redox/home.html>

there are more activities. Activities 2 and 3 can be used in order to verify the electrochemistry series that was built by the students. They usually make them in the homework or test preparation. Repeating the simulation at home, generate the possibility to self assess.

The concepts of redox:

After the previous introduction the students should have an authentic "need to know" the concept of Redox. We suggest each teacher to teach Redox as he/she are used to teach. In the end, We build a concept map, which lists all of the concepts inherent in this redox balance.

We suggest closing the last lesson by the same questions that opened the first lesson – Do you need chemistry in order to be a good bones surgeon?

It is possible to give the students information regarding the "real solution" of the starting question (information is given in the teacher notes). We also can give them several supplementary texts to spread / respond to matters of interest (eg, the interconnection between Science - Physics, Chemistry, Medicine, Biology and Geology)



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### Assessments

#### First lesson:

It is possible to count the number of the questions proposed by the students, in order to follow their involvement in the activity.

We suggest that the important thing in this part of the lesson is the involvement of all students in the group work. Teachers can use rubrics, as shown in table 1 as an assessment tool of the group work.

#### Student Evaluation Tool Based on the Teacher's Observations

Group's subject: \_\_\_\_\_

Date: \_\_\_\_\_

Dimension	Criteria for evaluation The student:	Students' name in the group (scale 1 to 5)				
		1	2	3	4	5
Functioning in 50%	Contributes to the group discussion during the learning the subject					
	Has patience for the group's members					
	Knows and understands the objectives of the activity (active observation)					
	Thinks in a creative manner and exhibits vision					
	Average					
Presenting the experiment orally- 50%	Presents the activity in a clear and practical manner					
	Presents knowledge and understanding of the subject					
	Uses precise and proper scientific language					
	Average					

**Table 1** – Student Evaluation Tool Based on the Teacher's Observations assessment tool.

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## **Assessing the learning of the Redox concept:**

The most important learning goal for this lesson is to construct the electrochemistry series. We suggest giving the students to answer written exercises regarding this subject. We also believe that every teacher will use the instrument s/he prefers.



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## Do you need to know chemistry in order to be a good bone surgeon?

### Teacher Notes

#### Students questions after the critical reading exercise:

1. What kinds of materials are suitable for bone affixing?
2. Why do the surgeons use metals?
3. Will the metals rust?
4. How will the metals fixed in the bones, influence the patient's life?
5. What are the criteria for choosing the metals?
6. Why don't the surgeons use plaster?
7. Will the patient who has undergone such a surgery, be able to go through a metals detector checkup?
8. When the bone will knit, will it be able to remove the metal?
9. Will the body reject the metal?

#### Scientific answer to the question

A breakthrough regarding bone affixing occurred during the 1960. Suitable synthesized materials started to be used for bone stitching and even for joint replacement. Those alloys of metals such as: Steel; Cobalt and Chrome and Titanium alloys. The production of those materials has enormously developed – the alloys were modified and improved according to the specifications and in addition, the physicians started to use ceramic materials. It was found, that the human body does not reject these alloys and ceramic materials, and there's no danger in using them, as long as they remain in one piece and do not break.

The latest innovation is the use of unbreakable ceramic materials in combination with Titanium alloys. This combination enables on one side the matching of the ceramic materials to the bone segment of the patient (the join, for example), and its binding to the implanted part (composed of Titanium alloys). The Titanium alloys are fixed in the bone, and in this way, the bone grows into the surface of the Titanium alloys.

#### Why Titanium alloys?

Titanium (Ti) is an element which atomic number is 22. It is a light and strong metal, and has a few properties which contribute to the technological needs:

- A high ratio between strength and weight.
- A good resistance in high temperatures.
- Malleable.
- Its alloys resist corrosion due to the protective layer of Titanium Oxide which covers its surface.

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