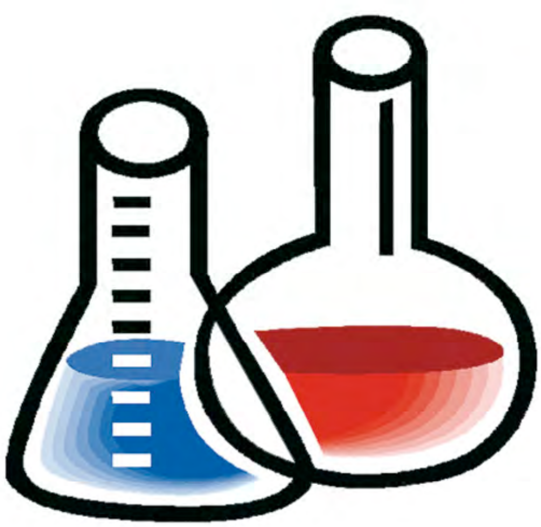
centre de développement pédagogique
pour la formation générale en science et technologie

Working document

FIND THE SOLUTION!



STUDENT BOOKLET

January 2010

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Underhanded invaders!

NOTE This LES was designed within the framework of training sessions. It may require adaptation before being used with students.

Every day you are attacked underhandedly - without your knowledge. Indeed, the objects that surround you are covered in miniscule organisms. By touching these objects, the micro organisms get on your hands. All that's left is for you to take food with your hands, swallow, and there you go. Those little beings can be deposited on the food and find themselves in your digestive system without your knowledge. Most of the time, this intrusion has no ill effect. In fact:

- the beast may be inoffensive or even beneficial to us
- the mucous lining of our digestive system may block the intruder
- our immune system may react efficiently and eliminate the threat.

But sometimes…
The following video shows one way a micro organism may propagate (45 seconds).

http://www.youtube.com/watch?v=nCC40IPg76Q&feature=related

When we're talking of a virus or pathogenic bacteria, ingestion is riskier. If the immune system is not ready to face the danger, the person may become ill.
These micro organisms reproduce very quickly when conditions of temperature and humidity are ideal as is generally the case in the human body (in the lymphatic system, for instance). In the following example, the bacteria multiply rapidly by successively dividing in two. The table indicates the number of bacteria present in relation to time (there is a division every twenty minutes).

Start	20 min.	40 min.	60 min.	2 h	3 h	4 h	5 h	6 h
1	2	4	8	64	512	4 096	32 768	262 144

This next video shows it in an accelerated version (15 seconds).
http://www.youtube.com/watch?v=gEwzDydciWc&feature=PlayList&p=54C80DA513D0D9B2&index=0

One of the most important habits to promote to avoid bacteriological or viral contamination is to wash your hands well. This video shows the correct way to do so. (70 seconds).
http://www.youtube.com/watch?v=XHISh559oho

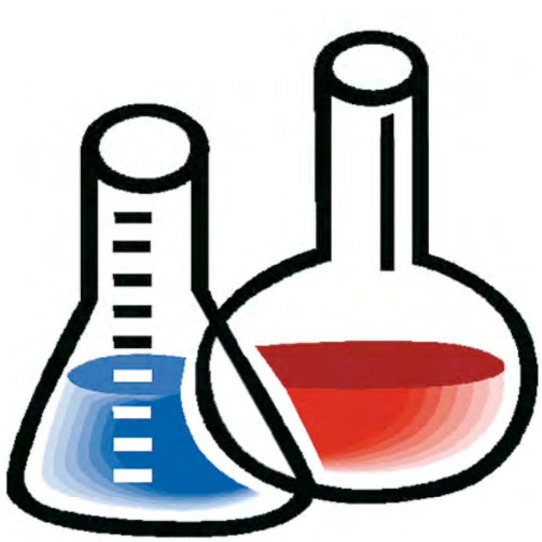
The best way to wash our hands remains soap and water. The soap entirely removes the dirt to which micro organisms cling. When water is unavailable, however, or when we are in a hurry, we often use "hydro alcoholic" antiseptic solutions. We may wonder about several aspects of these solutions.

1. Are all these solutions as efficient one as the other?
2. What is the efficacy of a given solution?
3. What is the composition of a given solution?
4. What are the proportions of each of the components in the solution?

The manner in which the solution is distributed may also have an impact. Indeed, these dispensers are used by a multitude of people. It would be counterproductive to become contaminated when our goal was totally the opposite. The following video shows an ingenious, no contact solution dispenser (13 seconds).
http://www.youtube.com/watch?v=B29h_7F3rz0

That antiseptic solution dispenser works using electronic components. To understand how it works in detail can not be easy. There are, however, much simpler ways to distribute a solution without the user having to touch the device with his hands.

Therein lies one of the challenges set for you in this LES. You will have to design a solution dispenser that can be activated without using your hands. To do so, you will have to use the concepts of simple machines learned in the first cycle of secondary school. In addition, you will must control your mechanism using an electric circuit. That will lead you to study electrical engineering.



But before making your dispenser work, you must be able to fill it up. You will, therefore, be required to perfect an ethyl alcohol based antiseptic solution. It will have to be as effective as those sold commercially. To do so, you need to develop a solution whose concentration is able to destroy these minute invaders.

Let's warm up a bit!

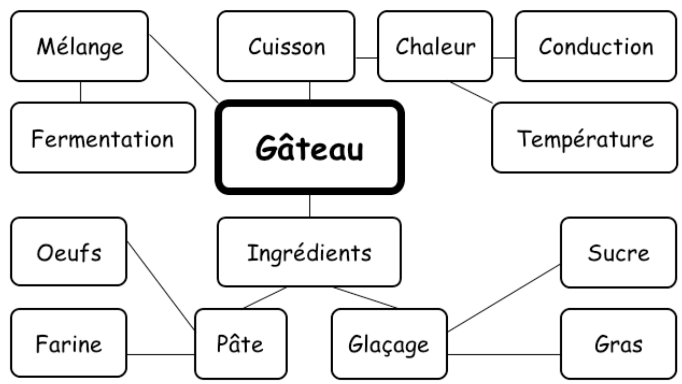
In the last few years, you have had the opportunity of studying several scientic and technological concepts that could be useful in bringing your study to term. Here is a section that will refresh your memory before approaching new concepts that will aid you in preparing your antiseptic solution and designing your dispenser. Building these networks will allow you to organise your knowledge visually.

Take a few minutes to try to complete this card related to mixtures.

Afterwards, a plenary discussion will allow the class as a whole to share their views.

Word bank: heterogeneous mixture, homogeneous mixture, phase, limpidity, separation of mixtures, filtration, sedimentation, decantation, distillation, etc.

Example of a network of concepts



Network of concepts

Mixture

Now take a few minutes to try to complete this card, related to simple machines. This thought process will be useful to you during the design of the mechanism that will activate the solution dispenser. Afterwards, a plenary discussion will allow the class as a whole to share their views.	**Word Bank** • Wheel • Inclined plane • Corner • Screw • Lever • Center force (class 3) lever • Center load (class 2) lever • Center pivot (class 1) lever • Force • Movement

Network of concepts

Simple machines

Time to know more!

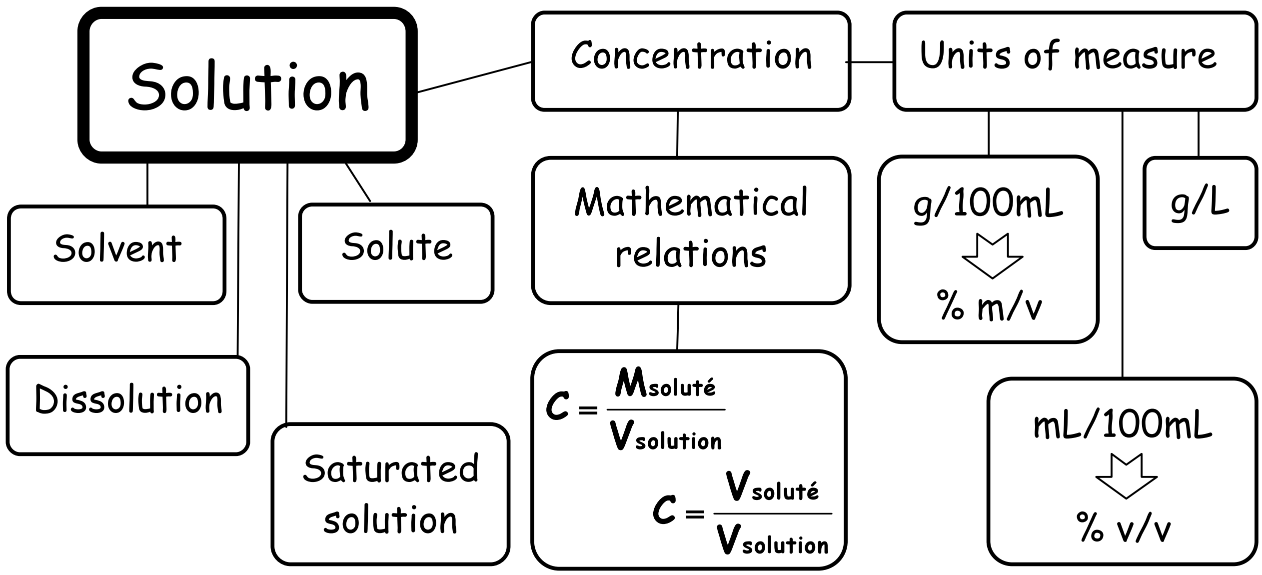
Now it's time to learn something new. Various activities will prepare you to better meet the challenge set for you. Here then, is a list of subjects we will deal with:

1. **Properties of solutions** (preparation of a solution beginning with a pure solute)
2. **Biotechnology** (the concepts of cellular culture and pasteurisation and by extension, antiseptic solutions)
3. **Materials** (mechanical property of a non ferrous alloy: nitinol)
4. **Electrical engineering** (supply, conduction and control)

Properties of solutions

Questions: What mathematical relation unites the quantity of solute, the quantity of solution and the concentration? What units of measure are used for concentration? How do we proceed to prepare a solution of a given concentration? How will we prepare our solution?

Explorations card



Do you remember homogeneous solutions?

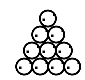
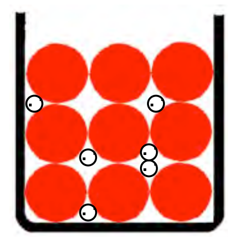
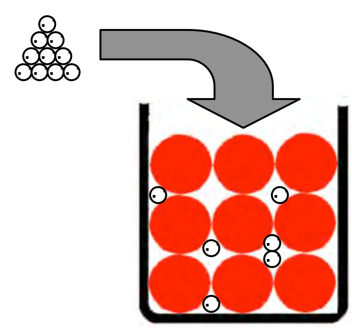
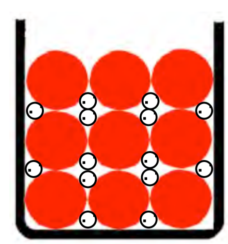
As you surely saw in the first cycle of secondary school, solutions are in fact homogeneous mixtures. They are made up of a single phase. This phase must be totally limpid. There are several types of solutions:

- Gaseous solution (where the solvent is a gas, as is the case with air)
- Solid solution (when the solvent is a solid crystal)
- Liquid solution (when the solvent is a liquid, like tap water)

We will dealt strictly with liquid solutions. In some cases, the solvent used is simply water. We qualify these water based solutions as aqueous solutions. They are very prevalent in the human body.

Here now are some definitions illustrated by a particular model. This model will allow you to better grasp what happens on a microscopic level when we prepare a solution.

First and foremost, some definitions

Word	Definition	Particular model
Solvent	Substance which dissolves a solute. It constitutes the greatest quantity of matter in the solution. Example: The (non salty) water in the ocean	
Solute	Substance dissolved in a solvent. It constitutes a smaller fraction of the quantity of matter in the solution. Example: The salt in the ocean	
Solution	Homogeneous mixture comprised of a solvent and one or more solutes. Example: Salt water in the ocean	
Dissolution	The action of dissolving a solute in a solvent.	
Saturated solution	A solution which can no longer dissolve a solute. The interstices (chinks) between the particles of solvent are completely filled by solute particles.	
Concentration symbol: ***C***	Ratio between the quantity of a solute and the quantity of solution. This ratio may be expressed in mass and volume.	$C = \frac{M_{soluté}}{V_{solution}}$ $C = \frac{V_{soluté}}{V_{solution}}$

Now a bit of math

Find the other forms these mathematical relations may take:

Mathematical relations to be used for a **solid** solute.		
$C = \dfrac{M_{soluté}}{V_{solution}}$	$M_{soluté} =$	$V_{solution} =$

Mathematical relations to be used for a **liquid** solute.		
$C = \dfrac{V_{soluté}}{V_{solution}}$	$V_{soluté} =$	$V_{solution} =$

Now let's look at how to convert a unit of measure of concentration. Let's suppose that my concentration is 0.3 g/mL and I want to convert it to g/L.

$$C = 0{,}3\,\frac{g}{mL}$$

The usage of a conversion factor is a simple, structured method that works every time. In this method, the units of measure will guide us toward the right choice...

Step 1 (find the units to replace)

We want the units to change from g/mL to g/L. We therefore want to make the **mL** disappear in favour of a **L.**

$$\frac{g}{mL} \Rightarrow \frac{g}{L}$$

Step 2 (place the units to generate the desired simplification)

We will thus have these two types of units (mL and L) in our factor. Below, we have placed the mLs in such a way as to be able to simplify them, since we want to get rid of them.

$$C = 0{,}3\,\frac{g}{\cancel{mL}} \bullet \frac{?\ \cancel{mL}}{?\ L}$$

Here are the units of the conversion factor

Step 3 (add the numerical values that represent the same quantity)

Since the desired unit here is g/L, we will choose 1L. Because 1L is equivalent to 1000mL, the other numerical value chosen is 1000mL.

$$C = 0{,}3\,\frac{g}{mL} \cdot \frac{1000mL}{1L}$$

Here is the complete conversion

Step 4 (calculate and simplify the units of measure)

The numerical calculation is very simple: 0.3 • 1000 ÷ 1 = **300**
As to the units, the mLs are simplified. Only the g/L remain.

$$C = 0{,}3\,\frac{g}{\cancel{mL}} \cdot \frac{1000\cancel{mL}}{1L}$$

The final answer is therefore C = 300 g/L

If I'm asked to express this in % m/v? Now I have to make a /100 appear in the conversion factor. Numerically you would get: 300 • 0.1 = 30

$$C = 300\,\frac{g}{\cancel{L}} \cdot \frac{0{,}1\,\cancel{L}}{100\ mL} \Rightarrow C = \frac{30\ g}{100\ mL} \Rightarrow C = 30\%\ m/v$$

Example

What is the concentration of a solution prepared using 12 g of salt and 60 mL of water? Express the concentration in g/L and in % m/v.

Data	*Calculation(s)*
C = ?g/L and %m/v *M = 12 g* *V = 60 mL*	$C = \frac{12\ g}{60\ \cancel{mL}} \cdot \frac{1000\ \cancel{mL}}{1L}$
Equation(s) $C = \frac{M_{soluté}}{V_{solution}}$	You have to input: 12÷60x1000÷1 = 200 (everything on the top is multiplied and everything on the bottom, divided) Answer: $C = 200\ g/L$ $C = \frac{200\ g}{1\cancel{L}} \cdot \frac{0{,}1\cancel{L}}{100\ mL} \Rightarrow C = \frac{20\ g}{100\ mL} \Rightarrow C = 20\ \%\ m/v$

Your turn to put your hand to it. Answer the following questions using the complete process.

Question 1

What quantity of salt is necessary to the preparation of 1.18L of saline solution whose concentration is 22 % m/v?

Data	*Calculation(s)*
Equation(s)	Answer:__________________

Question 2

What volume of water (in mL) is necessary to the preparation of a sweet solution containing 253g of sugar and whose concentration is 22g/L?

Data	*Calculation(s)*
Equation(s)	Answer:__________________

Question 3

What is the concentration of a solution prepared using 325mg of solute and 250mL of solvent? Express the concentration in g/L and in % m/v.

Data	*Calculation(s)*
Equation(s)	Answer:_________________

Question 4

What quantity of pure methanol is necessary to the preparation of 750mL of solution whose concentration is 35%v/v?

Data	*Calculation(s)*
Equation(s)	Answer:_________________

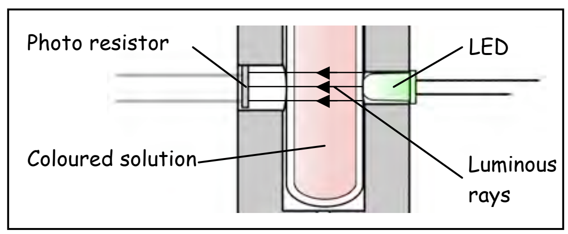
N.B. Your teacher will give you other exercises.

Function of a colorimeter

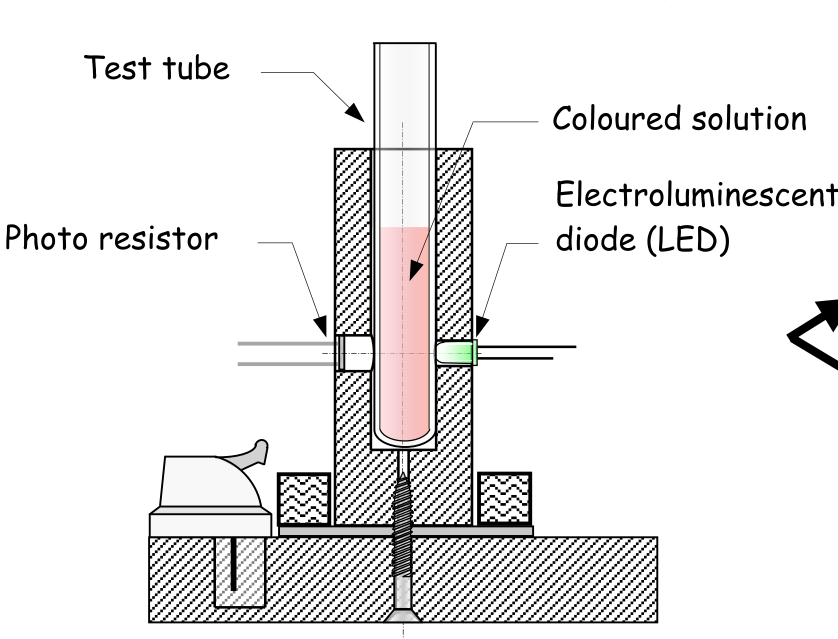
Now's the time to put our knowledge into practise. In the following section, you will have to prepare a solution with a precise concentration. To help you to do this work, we have chosen to use a coloured solute. Like powder based beverages, the more powder is dissolved, the stronger the taste, the greater the concentration, and the darker the solution will be.

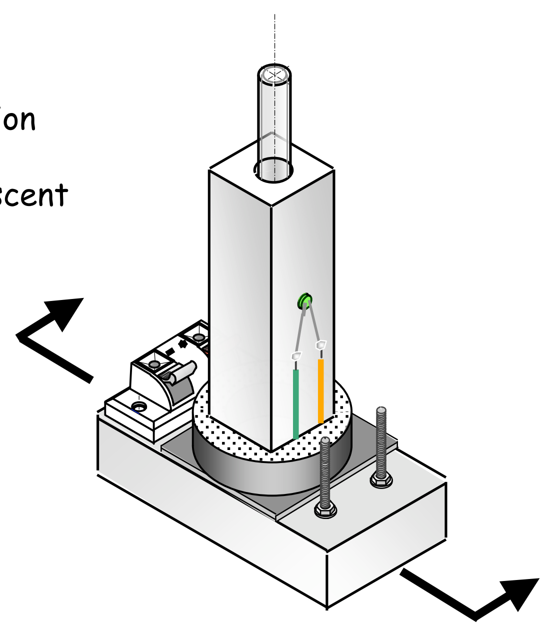
It is therefore possible to evaluate the concentration by evaluating the hue of the prepared solution. This appreciation may be judged by eye alone, without great precision. If, however, we want to verify the concentration of the solution with a greater degree of precision, we can use a colorimeter. Indeed, this device can detect small variations in the hue of a prepared solution. Here is how this laboratory instrument works.

The colorimeter we will use is composed of two principal components: an electroluminescent diode (LED) and a photo resistor (see drawing below). LEDs are little red or green luminous sources like we see on our electronic devices. In the colorimeter, we simply use a green LED to produce light. As to the photo resistor, it is an electronic component sensitive to light. During a test, the light rays from the LED will be blocked by the colouring present in the solution. The greater the concentration of the solution, the darker its hue and the less light will reach the photo resistor. By analysing the ease with which the photo resistor allows an electrical current by, we can deduce the concentration of the solution.



Cut view drawing of colorimeter





Directed laboratory: Preparing a solution

Problem

Prepare 25 mL of solution with a concentration of 200m/L, using a solid solute.
Validate the concentration of your coloured solution using the colorimeter.

Materiel

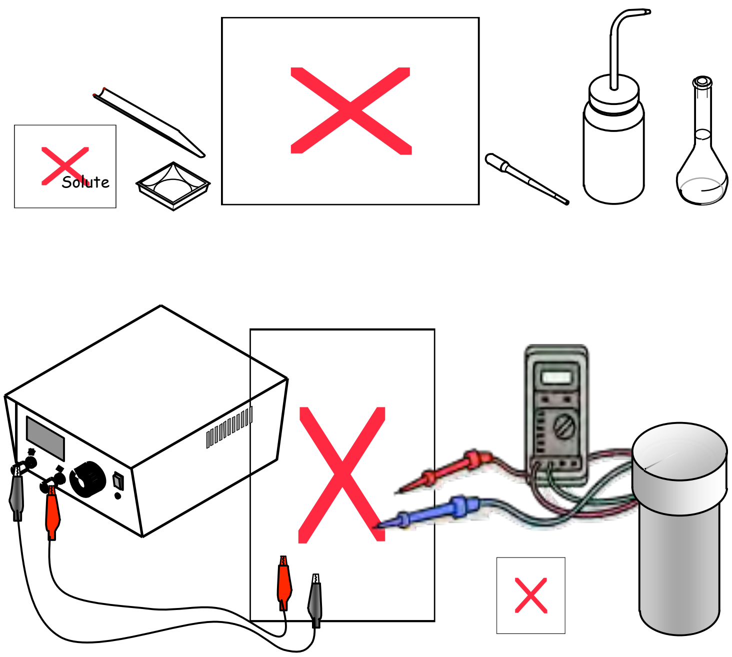
Preparing the solution

- 1 solid solute
- 1 spatula
- 1 weighing pan
- 1 scale
- 1 - 25 mL gauged balloon
- 1 wash bottle (distilled water)
- 1 eye-dropper

Validation of the concentration

- 1 - 50 mL beaker
- 1 - 5 mL test tube
- 1 source of continuous stable current adjusted to 9 volts
- 2 alligator clips
- 1 colorimeter with dark room
- 1 multi metre in resistance mode
- 1 calibration graph

Assembly diagram



Manipulations

Preparation of the solution

1. Calculate the quantity of solute necessary.
2. Weigh this quantity of solute using the scale.
3. Add a small quantity of water in the gauged balloon in order to cover the bottom.
4. Transfer the solute into the gauged balloon.
5. Shake the balloon to begin dissolving the solute.
6. Complete the volume, coming close to the mark by adding distilled water with the wash bottle.
7. Shake the balloon to completely dissolve the solute.
8. Complete the precise volume right to the mark (watch the bottom of the meniscus) adding water with the eye-dropper.
9. Shake again and proceed to the validation of the concentration, following the next steps.

Validating the concentration

1. Transfer about 15 mL of your solution in a 50 mL beaker.
2. Go to the validation station with your sample (50mL beaker).
3. Withdraw the dark room from the colorimeter.
4. Withdraw the test tube from the colorimeter.
5. <u>If the test tube is clean and dry</u>, transfer your sample into it.
   Careful: A wet or dirty test tube must first be rinsed with a part of your solution.
6. Place the test tube inside the colorimeter, orienting it according to the marks.
7. Place the dark room onto the colorimeter in such a way as to completely prevent the ambient light from lighting the sample.
8. Read and note the resistance indicated by the multi meter in the data table.
9. Consult the calibration graph and note the resistance in order to validate your work.

In one sentence, resume your objective:

____

____

____

What are the constant factors during this experiment (quantity of solute, solvent or solution, tension, resistance, colour, ambient light)?

____

____

____

Resume your protocol in the form of a diagram.

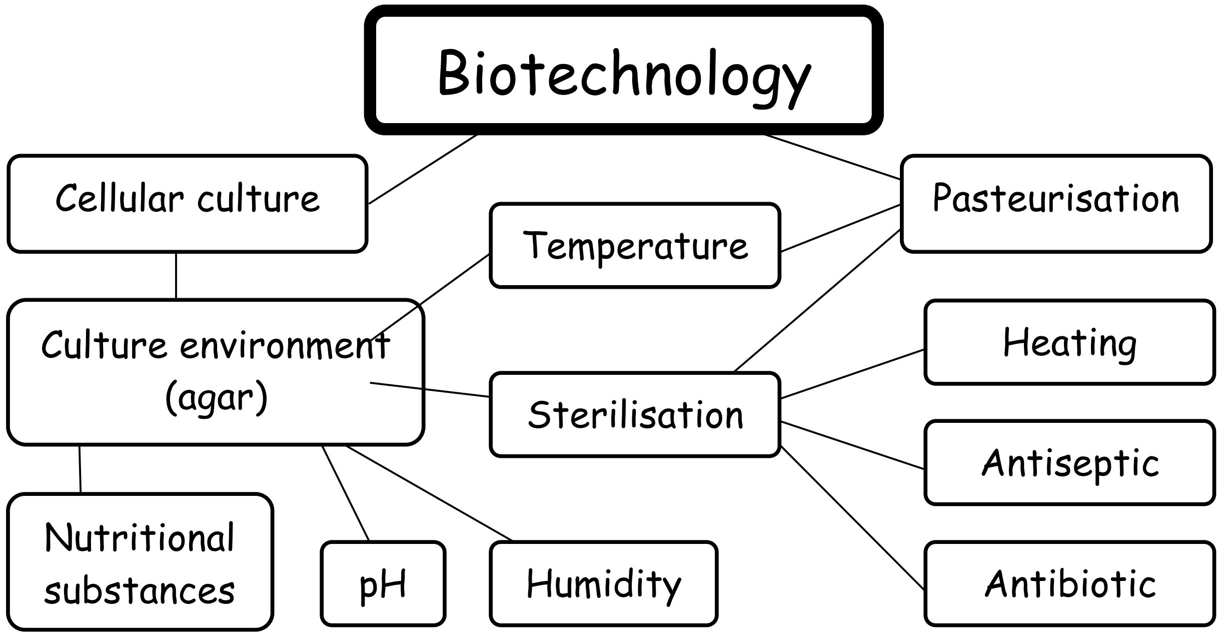
Calculation of the required quantity of solute.

Data	*Calculation(s)*
Equation(s)	Answer:________________

Data table		
	Resistance (kΩ)	**Concentration (g/L)**
Analysed sample		

Analyse your results and draw your conclusions.
Question 1 Is the concentration found during validation similar to that which was required in the problem? ________ ________ ________ **Question 2** Name the sources of imprecision related to manipulations carried out during the preparation of the solution. ________ ________ ________ **Question 3** Name the sources of imprecision related to the function of the colorimeter. ________ ________ ________

« Biotechnology » explorations card



What I need to remember

Non ferrous alloy: « nitinol »

Where its name comes from

"Nitinol" is a non ferrous alloy composed of nickel and titanium. Its name is composed of the symbols of the periodic table of elements, studied in the first cycle of secondary school: Ni for nickel and Ti for titanium. As to the "nol" syllable, it is an acronym meaning: **N**aval, **O**rdnance, **L**aboratory. Indeed, this is a research laboratory run by the American Navy which discovered the alloy in the nineteen sixties. Its mandate was to study various nickel based alloys.

Its fantastic properties

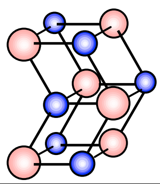
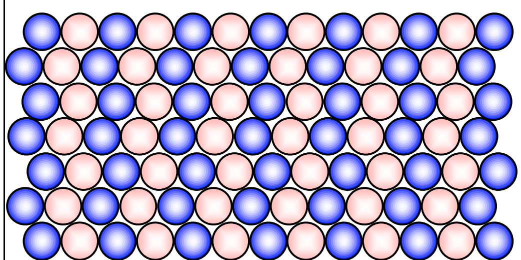
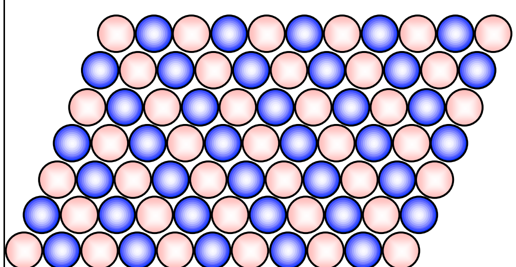
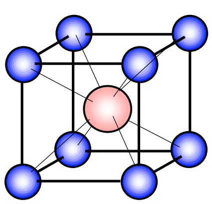
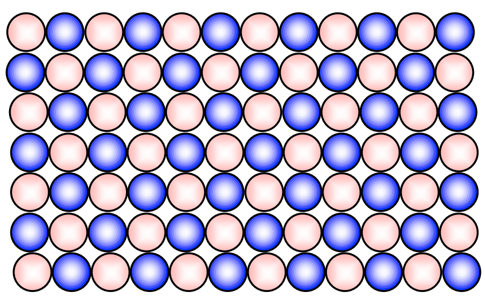
One of the researchers mandated to study the nickel titanium alloy was a smoker. This alloy is very malleable and ductile. Probably during a break, he had rolled some nitinol wire around his finger. Then, he accidentally touched the wire to the lit end of the cigarette. The wire immediately contracted. He had just discovered a metal with memory.
Here is a short video showing nitinol in action:
http://www.youtube.com/watch?v=Y7jjqXh7bB4

How is it possible?

Let's now try to better understand this surprising kind of metal. You surely know about different states of matter: solid, liquid and gas. These states are intimately linked to the position of the atoms in the matter. For an ordinary metal, here is how we can describe the position of the atoms in the different states:

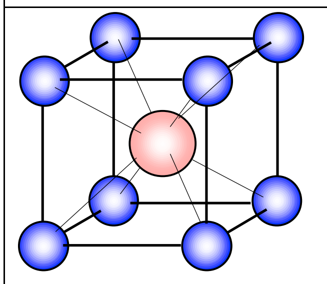
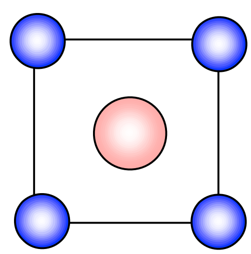
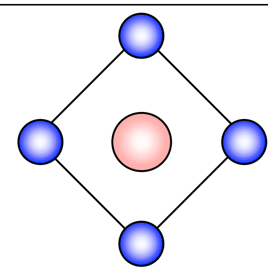
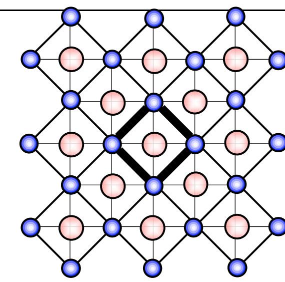
1. Gaseous: The atoms are very far from one another and completely free to move.
2. Liquid: The atoms are closer to one another and are not completely linked. They "slide" in relation to each other.
3. Solid: The atoms are linked to neighbouring atoms by chemical links.

In the case of nitinol, there are three different states of the solid. In each of the three states, the atoms are linked to each other in a different way. These three states carry hard to remember names: austenite, distorted martensite and non distorted martensite. As is the case with other changes of state, a temperature change will generate a state change. The temperature at which the change of state occurs may vary by modifying the proportions of titanium and nickel in the alloy. This critical temperature could be -10°C, 37°C or 50°C depending on different applications. The following table resumes the properties of nitinol depending on the temperature.

Three solid states of a titanium nickel alloy (nitinol) (Examples for a critical temperature set at 50°C)			
Type of solid state	2D Representation of the crystalline structure	Temperature	Properties
Martensite (non distorted) 		At low temperature (ex. 20°C)	The alloy is very **malleable and ductile.** It can easily be distorted, but so far, hasn't been.
Martensite (distorted)		At low temperature (ex. 20°C)	The alloy is still very **malleable and ductile**. Here, it has been distorted (examples: by folding or stretching).
Austenite 		At high temperature (ex. 60°C)	The alloy becomes much more **rigid.** It comes back to a previously chosen shape.

Representing a real crystal in 2 dimensions allows us to simplify things. That is precisely what we did in the table above.

It is nonetheless interesting to observe, from the point of view of technical drawing, to observe the way in which we go from a three dimensional (3D) representation to a two dimensional (2D) representation. Here is an example for the simplest solid state of nitinol, namely the Austenite state.

3D and 2D Representations of the solid state (Austenite)			
3D Representation	Right side view (2D)	45° Rotation of the 2D	Adding atoms to the crystal
			

The right hand representation above is similar to the 2D representation of austenite on the preceding page. Let's now look at what we can do with this marvellous metal.

The applications of nitinol

The following videos show in a very concrete fashion how nitinol behaves. When it is heated beyond a certain critical temperature, it take on a specific, predetermined form.

1. http://www.youtube.com/watch?v=8nnNBVmfHpM
2. http://www.youtube.com/watch?v=-Z96s-lYabM

The applications for nitinol are extremely varied. Several of these applications are in the field of biotechnology: artery dilators, braces for orthodontics, surgical instruments, frames for unbreakable glasses.
Here are some medical applications: http://www.memry.com/applications/index.php

Note that it is also possible to elevate the temperature of nitinol by passing an electrical current through it. The electricity heats it the same way it would an electric radiator. http://www.youtube.com/watch?v=38meyct_nbw

Here too, are some mechanical applications:
http://www.dynalloy.com/index.html
http://www.holbrookandcompany.com/sub_insight/GroupStudents/movinghand.html

Do you think nitinol could be useful to you during the design of your antiseptic solution dispenser?

Questionnaire about nitinol

The following questions will allow you to better understand the way in which solid state changes occur in nitinol. Afterwards, it will be easier to use it in the design of your solution dispenser.

Question 1
From which metals is nitinol made?

Question 2
Name the five states possible for nitinol.

Question 3
Under what conditions is nitinol malleable and ductile?

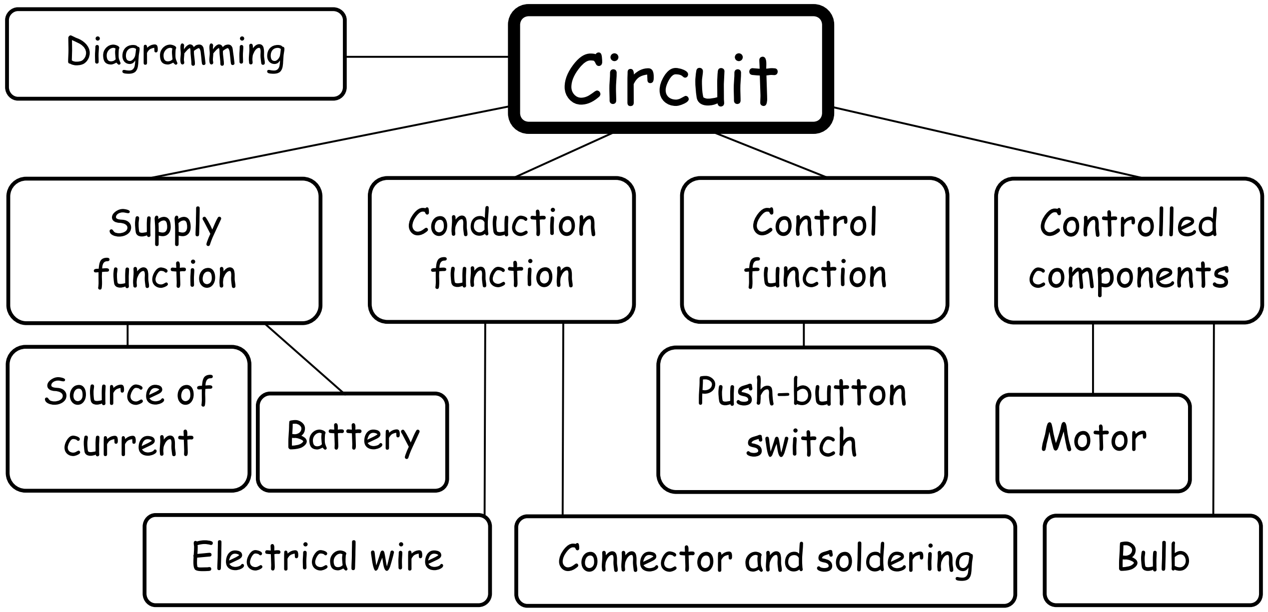
Question 4
Name three ways in which nitinol takes on a pre-defined shape.

Question 5
What critical temperature would you choose if you were using nitinol to make a frame for glasses (-10°C, 37°C or 50°C)? **Why?**

Question 6
What critical temperature would you choose if you were using nitinol to make an artery dilator (-10°C, 37°C or 50°C)? **Why?**

Question 7
What critical temperature would you choose if you were using nitinol so that it contracts using an electrical current (-10°C, 37°C or 50°C)?

« Circuit » explorations card



What I need to remember

Specifications booklet

Global function
Using the assembly panel described on the next page, each team must design an electrically controlled dispenser while respecting the following parameters:

a) In terms of the *physical aspect (nature of the elements)* the dispenser must be solely made from the elements made available to you in class.

b) In terms of the *technical aspect* the dispenser must:

- Generate a sufficiently large force so as to produce an efficient translation of the bottle's pump.
- Be activated without contact with the hands.
- Distribute an antiseptic solution whose concentration is identical to commercial solutions.
- Reinitialise itself after the nitinol spring cools.

c) In terms of the *human aspect (security),* the dispenser must:

- Not have any sharp edges.
- Not propagate infections between humans.

d) In terms of the *industrial aspect (production),* the dispenser must:

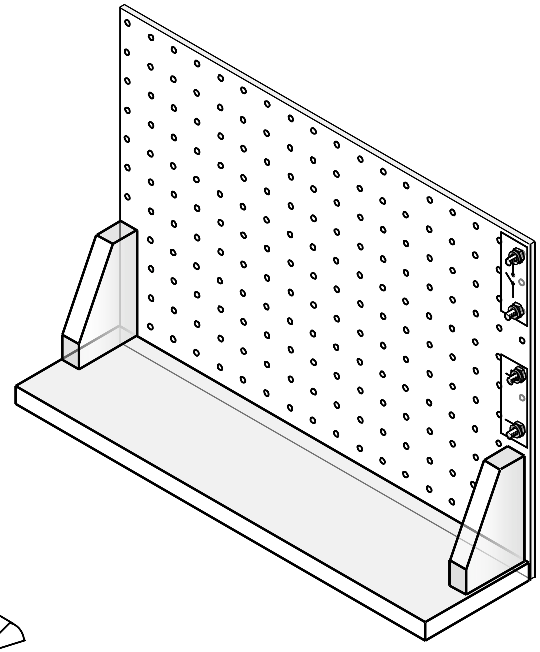
- Be assembled on the lever assembly panel.
- Be made from the mechanical materials supplied in class (elastic, mass, lever, fasteners, pivot).
- Be made from the electrical materials supplied in class (10 volt source of current, wire, connectors, push-button switch).
- Be made with a single nitinol spring that contracts when its temperature is elevated due to the passage of an electrical current.
- Be made solely with the tools available in class (laboratory or workshop).
- Be made in teams of two students.

e) In terms of the *economic aspect (cost price),* the dispenser must:

- Be constituted of reusable elements in order to minimise costs.

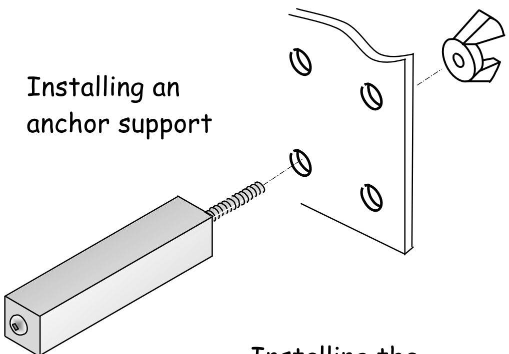
Description of the assembly panel

The right hand panel allows for easy mounting of a lever mechanism as well as an electrical circuit. The components below are easily affixed to the panel using nuts and bolts.

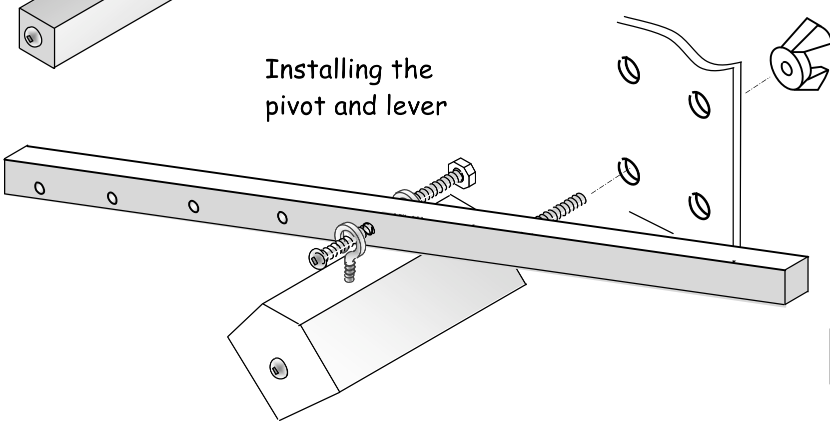


Components affixed directly to the panel

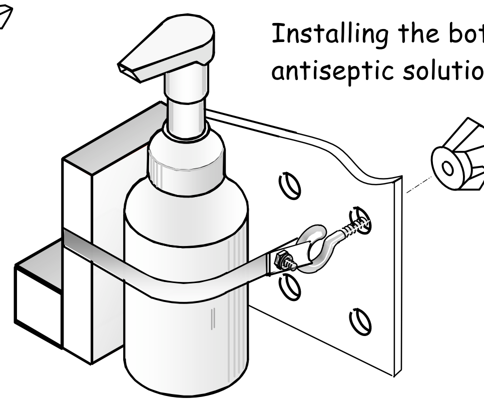
Installing an anchor support



Installing the pivot and lever

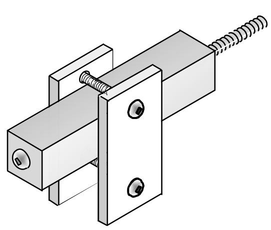


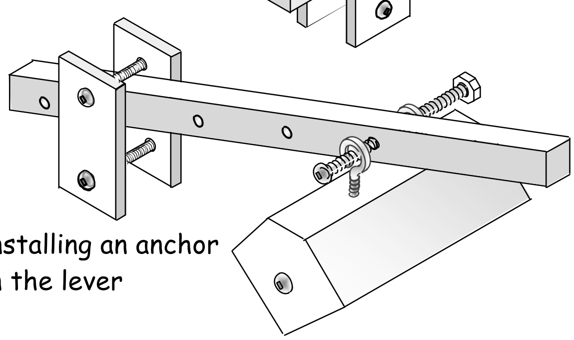
Installing the bottle of antiseptic solution



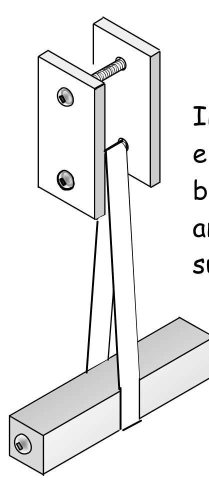
Some examples of anchor usage

Installing an anchor on a support

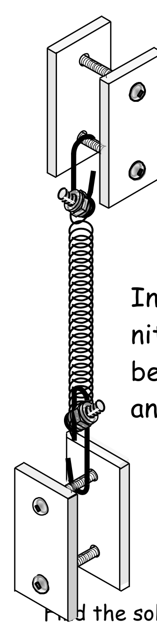




Installing an anchor on the lever



Installing an elastic band between an anchor and a support



Installing the nitinol spring between two anchors

Outlining the mandate following learning activities, while respecting the specifications booklet.

What do you have to do to produce an efficient antiseptic foam dispenser?
(Make a complete working plan of your entire process)

Preparing the antiseptic solution

Questions: How do we prepare 25mL of a solution with a concentration identical to commercial antiseptic solutions (62% v/v) beginning with 100% v/v alcohol? How do we validate the concentration obtained to ensure the efficacy of the solution?

OUTLINING THE PROBLEM

Resume the problem to be resolved:

ELABORATION OF AN ACTION PLAN (Protocol)

Materials

Manipulations

Manipulations (continued)

IMPLEMENTING THE ACTION PLAN

(Execute the protocol, gather the data)

ANALYSE THE RESULTS

Conclusion (result, tendency, link, answer to the problem)

Designing your antiseptic solution dispenser

1. Outline the problem in relation to the specifications booklet.
Take into account the available resources.

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2. Simmer your ideas (mechanism and electrical circuit).

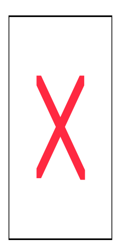
Lever mechanism

- 1 elastic band
- 1 lever
- 1 pivot point
- 1 nitinol spring
- 1 pump bottle

Electrical circuit

- 1 source of current
- Electrical conductors
- 1 push-button switch

N.B. The motor organ is the nitinol spring. The force generated by the spring is not sufficient to activate the bottle pump directly.



3. Evaluate your ideas and choose (justify your choice). Draw (diagram) the chosen solution (mechanism and circuit).

Your choice and justification

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Principles diagram (indicate movements, forces, links and guidance)

4. Carry out a prototype of the retained solution

Note all decisions made.

Design or construction problems	**Adjustments or modifications**

5. Carry out a test and evaluate the efficacy.

Improve on the solution.

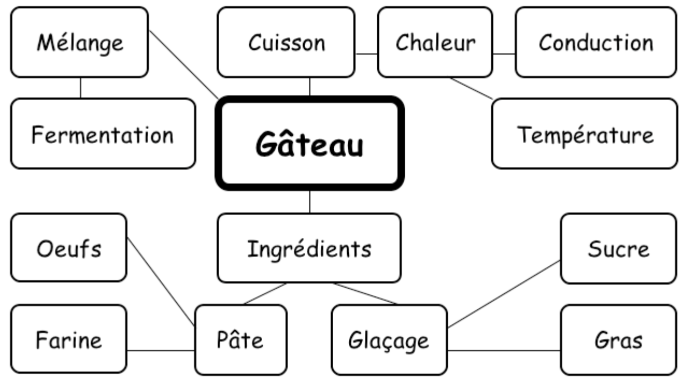
Tests carried out and results obtained (illustrate your solution on the panel)

Improvements

Integration and reinvestment

Following the creation of the antiseptic solution dispenser, build a network of concepts related to the properties of solutions. This new network completes the one made at the beginning of the LES dealing with mixtures. This exercise will allow you to appreciate how far you have come.

Example of a network of concepts



Network of concepts

Solution

Synthesis activity

We now invite you to use your acquired competencies to push your thinking a little further. To do so, you must produce a document that may take the form of a PowerPoint presentation, a poster or simply a text. The document must summarily address the 3 following subjects:

1. **The methods of propagation of illness.**
2. **Safe behaviours and personal hygiene habits to adopt.**
3. **The efficacy of commercially sold antiseptic solutions.**

Work plan