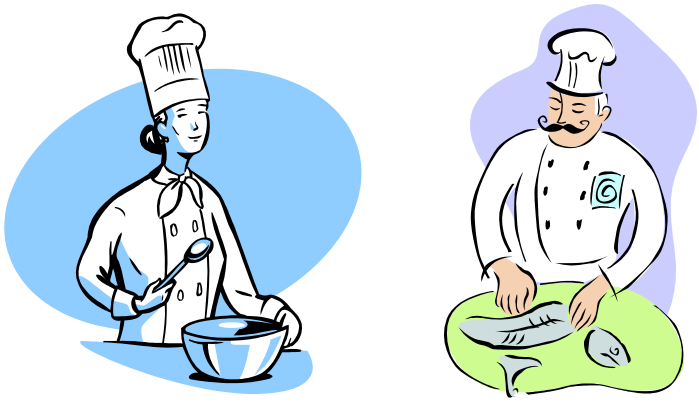
centre de développement pédagogique
pour la formation générale en science et technologie

Working Document

CRYSTALS



STUDENT BOOKLET

December 2007

Global Context

You have worked in the confectionery field for several years. A publishing company approaches you to write the « desserts » section of a new cookbook. This new challenge interests you and you decide to take the plunge.

Among other things, you are asked to work on the preparation of fudge and rock candy. Your personal recipes work, but you carry them out instinctively, without a precise procedure. You must therefore give a complete and scientific procedure in order that the reader might succeed at these recipes every time. In addition, since today's public wants to understand things fully, the publisher requests that you scientifically explain what is going on at a microscopic level.

Objective:

Make an analogy between the formation of crystals in igneous rock and the preparation of the two candies (fudge and rock candy).

Mandate

You must therefore:

- Develop two complete infallible procedures (cooking the fudge must be supported by experimental measures)
- Produce a complete explanation of the microscopic phenomena involved.

Stages

1. **Understand the theoretical concepts involved in the production of the two recipes.** The students must form teams of two people and meet to complete "*Theoretical notions exploration cards*". Several sources are available to bring your research to term (internet, old physical sciences books on the environment, works dealing with geology, crystallography, chemistry, your teacher…)
2. **Establish parallels between crystallography and culinary arts.** Each team must complete the "*Questionnaire on Crystallography*".
3. **Write a complete protocol for the preparation of fudge.** Starting from the summary recipe, the team must write a complete protocol supported by theoretical concepts. The following remarks must be taken into account:
    - The protocol must foresee experimental data gathering in order to follow the cooking process (these data will be analysed by means of a graph).
    - The protocol must take into account that laboratory materials will be used to execute the recipe in very small quantities (there will be no pots or measuring cups…)

4. **Carry out the protocols.**

   For rock candy

   - Carry out the recipe as it is suggested on the internet.
   - Clean dishes must be brought from home.

   For fudge

   - Carry out the protocols in small quantities for validation.
   - Use laboratory materials.
   - Note the experimental data.
   - Rework the entire protocol as necessary.

5. **Treat the data and revise the protocol for fudge.**

   The team must now:

   - Use the data in such a way as to make the execution of the recipe infallible (create a graph in order to interpret the results).
   - Complete and modify the protocol in light of the data interpretation (give pertinent advice and recommendations).

   This protocol then becomes a scientifically guided recipe we will call a procedure.

6. **Execute the fudge protocol for taste testing.**

   The team subsequently carries out the final procedure under real kitchen conditions.

   - Clean dishes are brought from home.
   - The quantities used are real since the result of their work will be evaluated by their peers.
   - **The procedure must succeed on the first attempt.** There will be no chances to try again.

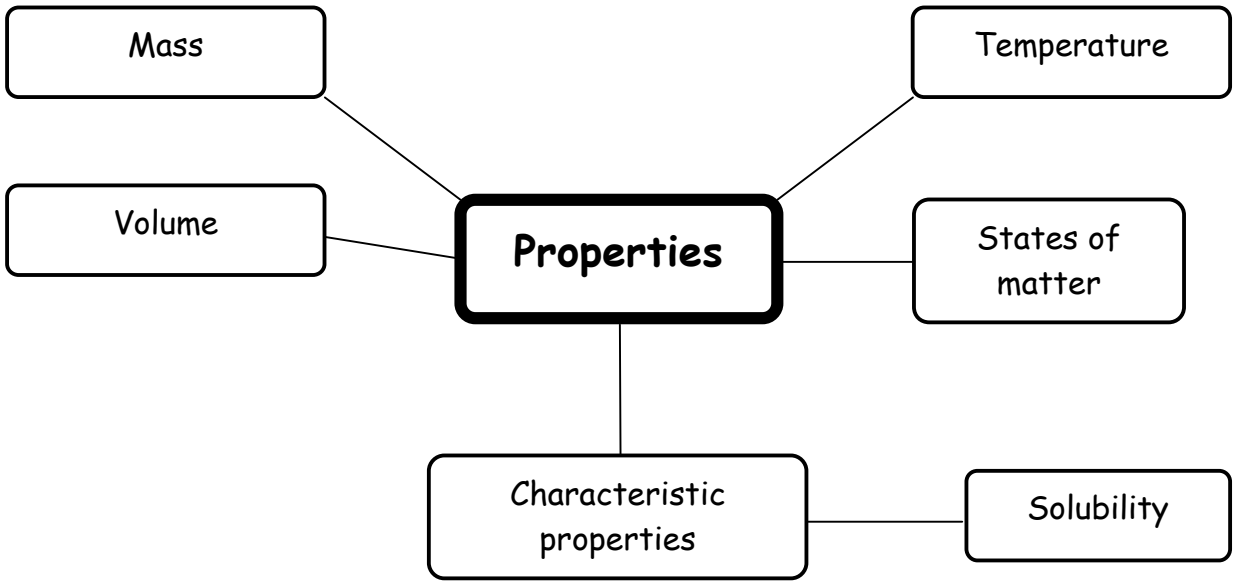
7. **Taste test and evaluate the other teams' goodies.**

   - The students must taste a sample of fudge and rock candy from each team.
   - With the help of the evaluation grids, the students must evaluate the finished products according to several criteria.

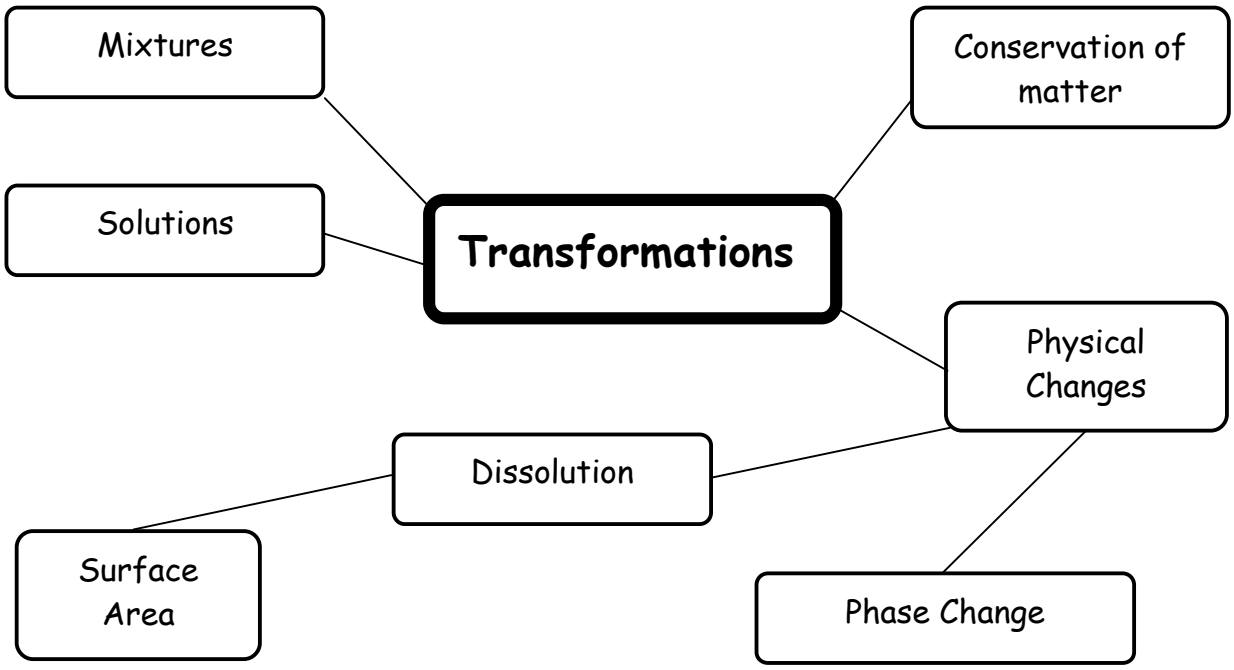
8. **Hand in a detailed report containing the following sections:**

   - The purpose of the activity
   - A summary of the important theoretical notions
   - The similarities between the formation of igneous rock and sugar crystals
   - The procedure for the preparation of fudge (the revised protocol)

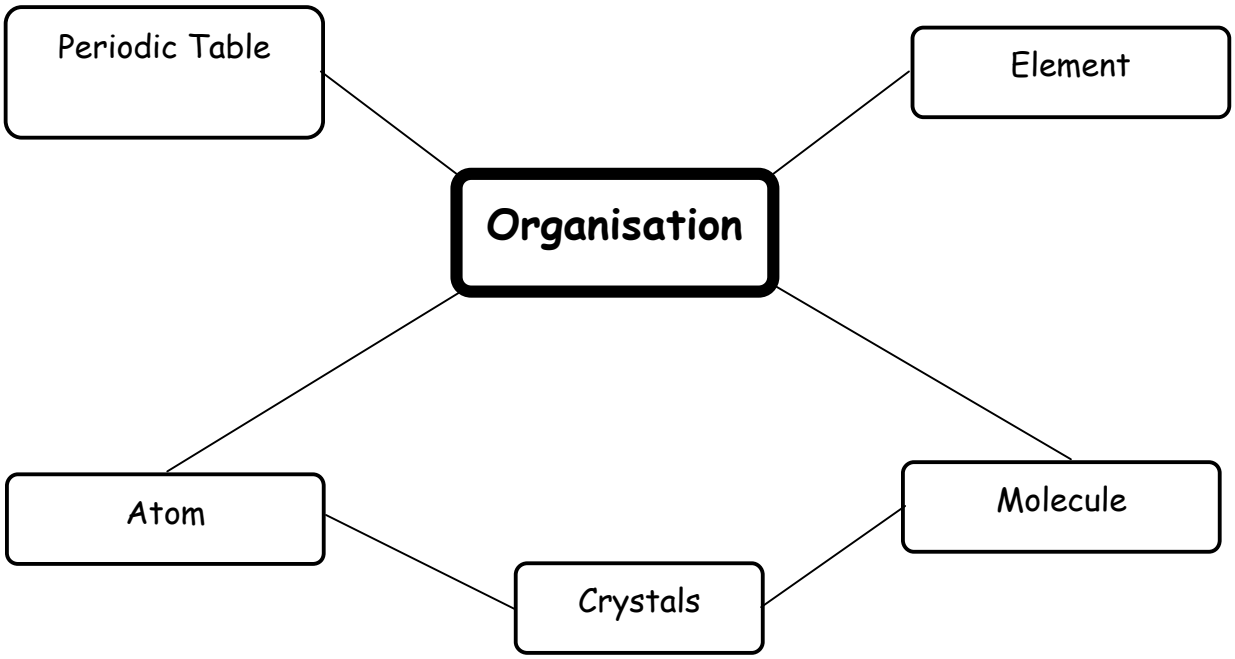
THEORETICAL NOTIONS EXPLORATION CARDS



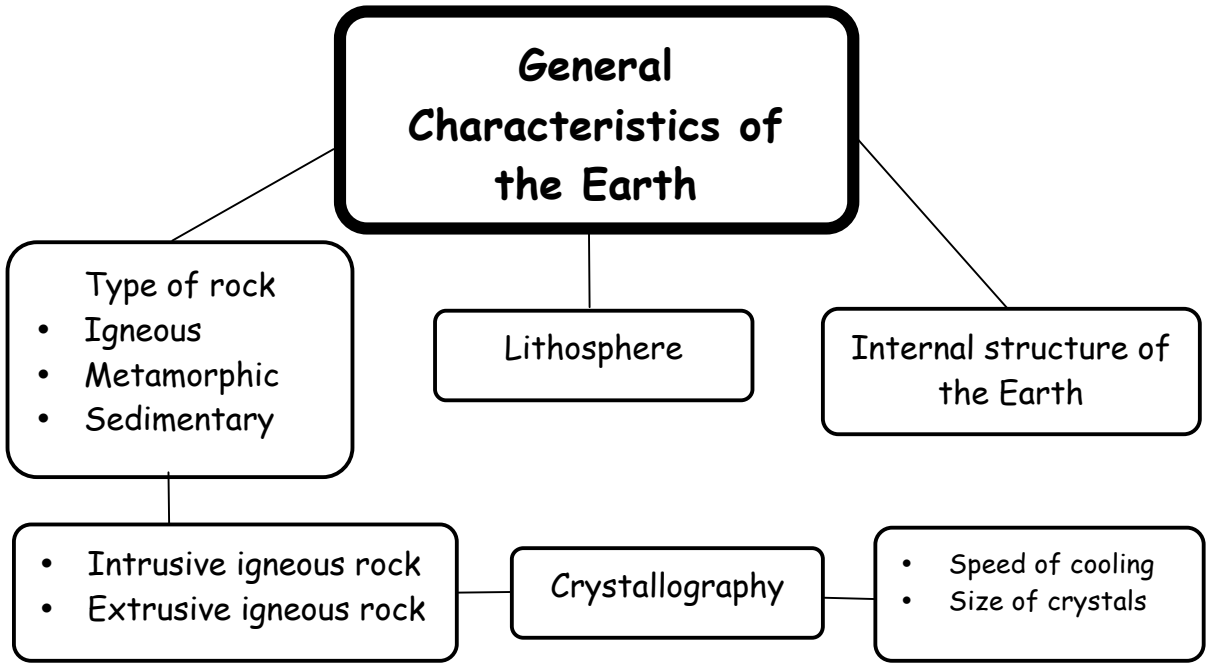
The results of my research (what I need to remember)



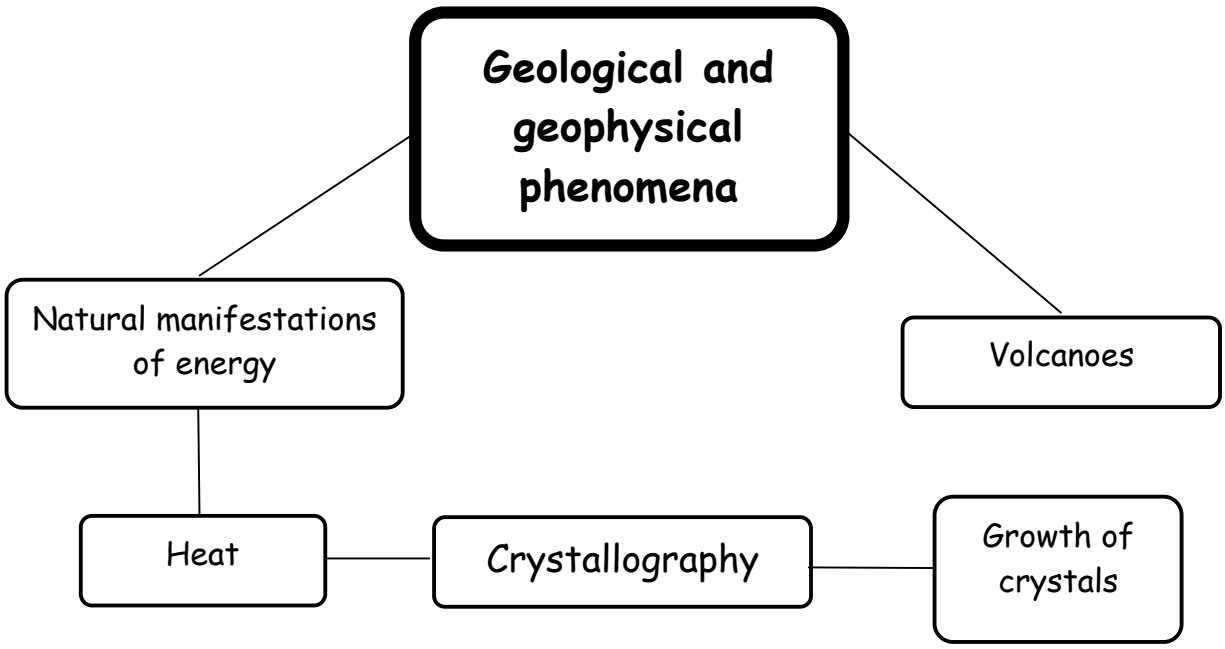
The results of my research (what I need to remember)



The results of my research (what I need to remember)



The results of my research (what I need to remember)



The results of my research (what I need to remember)

QUESTIONNAIRE ON CRYSTALLOGRAPHY

This questionnaire will help you to make the necessary links between the theoretical notions and the knowledge required for the realisation of your goodies. Use your exploration cards; they should be a treasure trove of information.

FORMATION OF A CRYSTAL

Question 1

Describe a crystal (touch on its appearance, state and shape).

Question 2

Draw what a crystal looks like on an atomic level in this frame.

Question 3

Give an example when a crystal forms from a gaseous solution.

Question 4

Give an example when a crystal forms from a liquid solution.

Question 5

Atomically, what is a diamond made from?

Question 6

In what particular conditions are diamonds formed? (Place, temperature, pressure)

Question 7

An extrusive igneous rock is formed outside the soil and is made up of fine crystals. During its formation, the atoms that make up the rock didn't have time to place themselves correctly to form large crystals. Was the cooling of this type of rock fast or slow?

Question 8

An intrusive igneous rock forms within the soil. It thus cools a little more slowly. What will its crystals' dimensions be?

Question 9

During the formation of a diamond, is the cooling fast or slow? Why?

Question 10

At a microscopic level, what does a small grain of sugar look like?

Question 11

Rock candy can be used to sweeten coffee. It is a large crystal similar to that of a diamond. During its fabrication, must its growth be slow or fast? Why?

Question 12
What dimensions must the crystals of fudge be for it to be smooth and creamy?

Question 13
Given your answer, will the cooling of your fudge have to be fast or slow? Why?

Question 14
Practically, during the execution of a fudge recipe, what can be done so that the cooling happens at the ideal speed?

Question 15
Practically, during the execution of a fudge recipe, it is possible to cheat a little. Indeed, some recipes recommend the addition of powdered sugar in the final phase. In your opinion, what does such an addition instantaneously provoke?

DESTRUCTION OF A CRYSTAL

Question 16
What can one do to transform a diamond into a pencil lead?

Question 17
What can you do that involves neither grinding nor heating to break a grain of salt (NaCl) into tiny pieces?

Question 18
What is the solubility of a substance?

Question 19
What can be done to increase the solubility of sugar in water?

Question 20
During the preparation of rock candy and fudge, why is it necessary to completely dissolve the brown and white sugars completely before provoking the final crystallisation?

Question 21
Why is fudge better when it is made up of extremely fine crystals? (Think of the size of the crystals, of their solubility in saliva).

COMPLETE PROTOCOLS

To begin with, here are two very simple recipes from which all your work must be done. All the teams must use the same recipes for comparison's sake. The ingredients will be identical for all - only the manner in which the recipes are executed will reveal the great chefs! The use of a microwave is prohibited. Only a laboratory hot plate is allowed. The recipes must be adapted to suit the materials available.

Recipe for rock candy as found on the internet.

http://www.momes.net/education/technologie/documents/cristauxdesucre.html

Ingredients

- 700 grams of sugar
- 1 glass container of approximately 250 ml
- 1 small pot
- 1 pencil
- 1 cotton sewing thread
- 1 clean paper clip

What to do

- Pour 150 ml water into the pot.
- Heat until the water simmers.
- Completely dissolve as much sugar as possible (about 600 grams)
- Do not boil too long then pour this liquid into the glass container.
- Tie the thread to the pencil and weight the thread with the paper clip.
- Place the pencil on the edge of the glass container so that the paper clip hangs in the sweet water.
- Place everything in a quiet spot for several days.

Fudge recipe (supplied by a colleague)

Ingredients

- 1 cup 35% cream
- 1 cup granulated (white) sugar
- 1 cup brown sugar
- 2 tablespoons butter

What to do

- Heat for the necessary time (it's up to you to find it).
- Add a bit of vanilla.
- Beat with electric beaters for 5 minutes.
- Spread in pan.

From the fudge recipe, you must now write a complete protocol. The only materials available will be those usually used in the laboratory. (Beaker, test tube, graduated cylinder, Erlenmeyer flask, hot plate…) The only exception will be the use of a candy thermometer which attains a higher temperature than those normally used in the laboratory.
As we are in the experimental phase, the quantities used must be very small to avoid waste. The order of magnitude to keep in mind is enough to make a single piece of fudge.
Laboratory materials are not intended for culinary arts and are not cleaned in view of such a use. You must therefore not taste the results of your work at this time.

And now, to your pencils:

Fudge
THEORETICAL CONCEPTS TO KEEP IN MIND • Complete dissolution of the preparation at the very beginning. • Speed of cooling of the final mixture. • Let the final preparation sit or mix it?
I must pay attention to:

Fudge
OBJECTIVE
Write your objective here:

Fudge
PROTOCOL (Equipment assembly diagram)
Draw your assembly here:

Fudge
PROTOCOL (equipment)
Here, enumerate your list of materials as well as the precise quantities of ingredients used. **(Careful, use small quantities to avoid waste).**
List your materials and your ingredients:

Fudge

PROTOCOL (manipulations)

At this stage the purpose is not to simply recopy what is found in the recipe. You must also plan to take temperatures and record cooking times. It is preferable to overcook the fudge in order that it not turn out. Indeed, this will allow you to better follow the evolution of the cooking and to properly identify the point which must not be exceeded when you make the real recipe. Rewrite the protocol as necessary.

You will also have to take regular samples during cooking.

- Place them on a cold object to verify how it solidifies (our grandmothers let a drop fall into cold water).
- Note your observations in order to be able to interpret your graph.

List your manipulations in detail here:

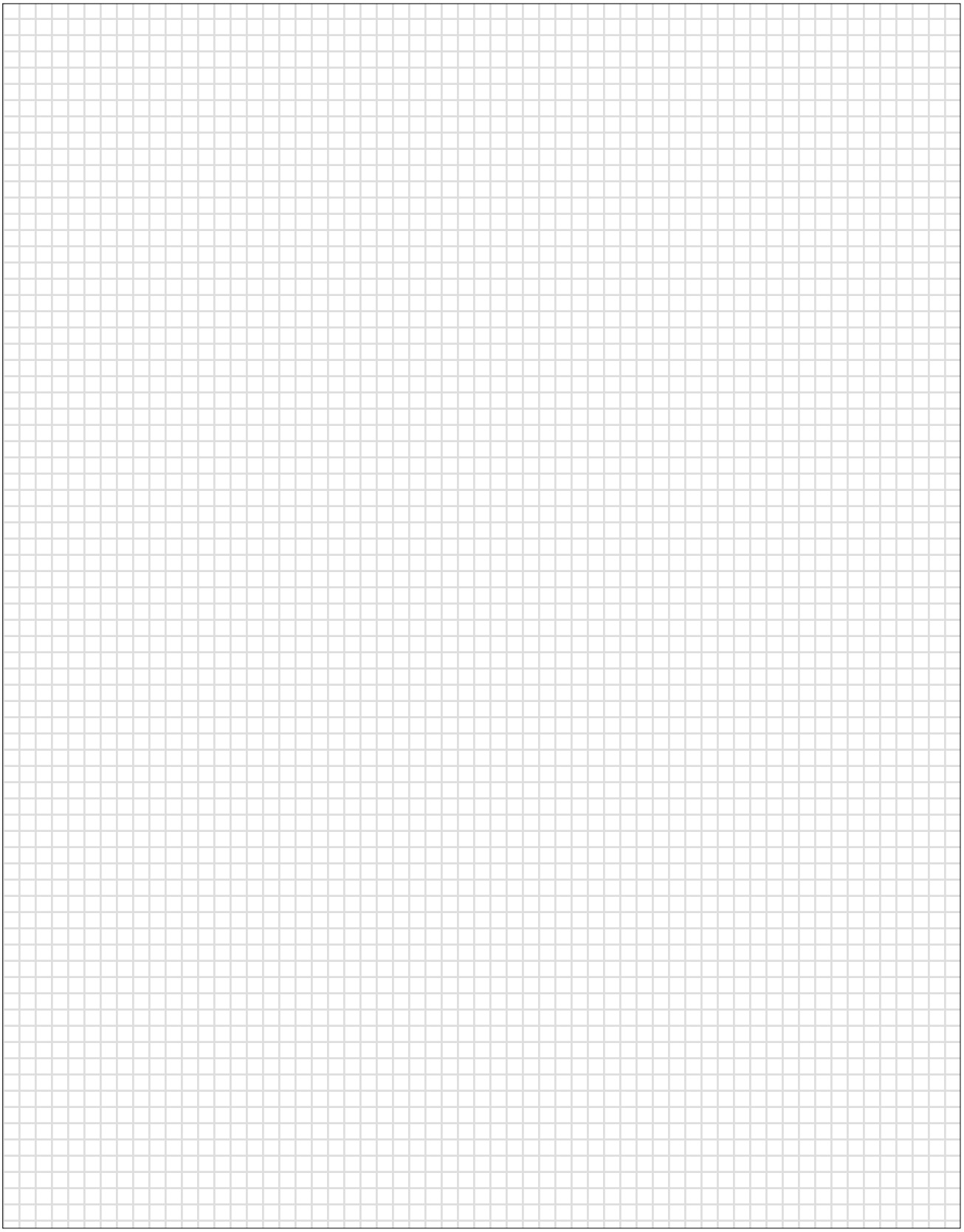
Fudge

PROTOCOL (manipulations - continued)

List your manipulations in detail here:

Fudge			
DATA TABLE			
These data will allow you to analyse the cooking by creating a graph.			

GRAPH OF TEMPERATURE VERSUS TIME
FUDGE



REVISED PROTOCOLS

Fudge
PROTOCOL (manipulations)
Write the manipulations you will perform in the recipe for taste testing here. **The recipe must succeed on the first attempt!** Your peers will judge your performance. You must take into account your graph as well as your previous experiments. You need not rewrite the data or create a new graph.
List your manipulations in detail here:

Fudge

PROTOCOL (manipulations - continued)

List your manipulations in detail here:

ANNEX 1

Rock candy taste test evaluation

NAMES OF TEAM MEMBERS : _____

_____

Team Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Appearance (5 points)	• Shape of candy • Colour of candy • Transparency																
Sensation (5 points)	• Sensation on the tongue • Surface roughness																
Taste (5 points)	• Softness of taste • Solubility of crystal • After-taste																
Total on 15 points																	

ANNEX 2

Fudge taste test evaluation

NAMES OF TEAM MEMBERS : _____

_____

Team number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Appearance (5 points)	• Shape of piece • Colour of piece • Texture (smooth, granular, mushy)																
Sensation (5 points)	• In-mouth sensation • Hardness, viscosity, solubility • Size of crystals																
Taste (5 points)	• Softness of taste • Solubility of crystals • After-taste																
Total on 15 points																	