TEACHING IDEAS SHARED FROM SAILS TEACHER EDUCATION PROGRAMME

Chemical reaction speed

This resource has been developed through the SAILS Teacher Education Programmes (2012-2015) but was not developed as a finalized SAILS Inquiry and Assessment Unit. These materials are shared to inspire further use of inquiry and assessment of inquiry skills in the science classroom.

SAILS
Strategies for Assessment of Inquiry Learning in Science

Author[s]	Katalin Radnóti
Organisation	University of Szeged
Project Coordinator	Dr. Odilla Finlayson, Dublin City University.
Website	www.sails-project.eu
Email	info@sails-project.eu

This resource has been produced within the scope of the SAILS Project. The utilisation and release of this document is subject to the conditions of the contract within the Seventh Framework Programme. The SAILS Project has received funding from the European Union's Seventh Framework Programme for research technological development and demonstration under grant agreement no 289085.

Roland Eotvos University
Faculty of Science
Institute of Physics

Chemical reaction speed

Section 1: Topic

Studying the temperature dependence of chemical reactions
For physics and chemistry subjects
Chemical reactions, temperature dependent reactions
For ages 17-18 years old, working in groups of 3-4
Time to process: 2x45minutes
Demonstrating scientific inquiry process shown through a particular example; developing scientific thinking
Most chemical reactions proceed at different speeds, at different temperatures. Biochemical processes in living organisms are typical examples of this. During the experiment, we will observe a reaction where temperature dependence is clearly visible.

The students should make a protocol during the experiment that shows:

- the planning of the experiment and prior thoughts,
- problems that may have occurred during the experiment and their solutions,
- observations, measurements, conclusions gathered during the experiment ,
- graphs developed using the measurement data,
- overall conclusions

Pictures and charts should also be included!

Section 2: Content - Key concepts and ideas

The rapidity of chemical reactions may differ. There are reactions that are instantaneous (10^{-3} s).like the reaction of limestone and hydrochloric acid:

$$CaCO_3 + 2HCl = CaCl_2 + H_2O + CO_2,$$

Where effervescence may be observed due to the release of carbon-dioxide
Other reactions take longer. Examples are biochemical reactions in living organisms. Our example is the reaction of sodium thiosulfate and hydrochloric acid:

$$Na_2S_2O_3 + 2HCl = 2NaCl + H_2O + SO_2 + \underline{S}$$

During the reaction, non water soluble, sulphate colloids develop that allow for time measurement. To describe the speed of chemical reactions we use the term reaction velocity.
Reaction velocity describes the concentration change of a component of a solution at a given amount of time.
Reaction velocity is proportional to the effective particle collisions when the chemical reaction takes place. The number of effective collisions is proportional to the concentration. Reaction velocity also depends on how many particles have the necessary energy to react.

Section 3: Inquiry and reasoning skills and scientific literacy

Skills to be developed:

- Competencies in the subject, both considering chemical reactions and scientific thinking:
  - hypothesis
  - planning the measurement
  - safe use of equipment
  - collecting data
  - recording data
  - illustrating the data in the required form
  - IKT competence
  - conclusions

- Communication skills
  - the students must discuss the entire measurement process
  - then they must communicate their results with the other groups

- Attitudes towards science
  - Natural regularities are observable and laws can be deduced from them
  - There must be laws in nature
  - Natural regularities are not always linear!
  - Creativity in measurement.
  - Creativity in answering questions and realizing that science is interesting.

Section 4: Suggested Learning Sequence

2x45 minutes, double lesson

Student Learning activity	**Supportive Teacher activity**	**Inquiry skills and processes**
Assessing prior knowledge of the topic to be dealt with (chemical reactions)	What group of substances is called - salt - -acid - base? What kind of reactions can take place in case of the group of substances mentioned above? What is their reaction rate? Find examples of reactions which take place -really slow In fractions of a second! What methods can be used to speed up chemical reactions? How do you think the reaction rate changes if	Spoken formulation of students' prior knowledge. Finding relation equations between different quantities. Formulating the expected relationship equation using a mathematical expression

	temperature is increased? What is the relation equation between temperature and rate of reaction?	
Observing the reaction of fixing salt (hypo/ Sodium thiosulphate/ Ammonium thiosulphate) and hydrochloric acid at room temperature	What type of substances take part in the reaction? (What types of reagents are involved?) What products are yielded? When can you claim that a reaction is complete?	Using laboratory equipment accident-free In case of chemical reactions, defining their findings clearly
Planning an experiment to observe temperature dependence in the above process	What equipment do you need for measurement? What volume solutions are worth working with? What vessel is suitable to create a reaction? How will you ensure constant temperature during the reaction? How will you ensure - cold - warm environment? For example, you can use a beaker/canister (big enough for test-tubes) to contain a greater quantity of water. How long will you keep the test tubes with the reagents in the water before mixing them? How would you simplify the process? For example using the same quantity of substances at different temperatures (!) What quantities will you measure? Where will you measure temperature? What will you use for measuring reaction time? At which phase will you stop measuring time	Planning an experiment to solve a problem Putting theoretical knowledge into practice. Choosing the appropriate materials and planning their arrangement Making plans how to collect data and how record them Creative thinking Communication: reasoning, arguing, consensus. The role a student takes in the group, cooperation with the others .

	- when the solution starts to become opalescent - when the solution has a yellowish color? How many monitoring points would you like to have? How many different temperatures will you check the reaction at? How will you take data? How will you record data?	
Accomplishing a series of measurement .	Monitoring experiments Observing group work and the role of individual students Helping groups/students meeting obstacles.	Observing. Measuring. Manual skills. Experimenting in an orderly and safe way. Accuracy. Stamina.
Showing data on paper or on computer using a spreadsheet program .	How will you represent the data collected? How will you convert data? Is the reciprocal of the measured reaction time proportional to the reaction rate? <u>Individual differences approach:</u> What other data can be defined using the collected data?	Mathematical skills. Handling collected data. Using DBMS
Analyzing the results (graphs, diagrams), comparing them to the hypothesis	Is the connection found what you expected?	Students who expected to find a linear connection should be able to accept that the preliminary hypothesis has not been proved.
Making records Making records actually starts during the planning phase Groups present their work	Records include • planning the experiment and the expectations, • problems arising during the experiment and their solutions, • observations, results, collected data, • graphs showing the collected data,	Communication: spoken and written report The role a student takes in the group, cooperation with the others

	• conclusions. At the end of the record you should state your part in your group's work. Answer the following questions: - what was your assignment and how did you complete it, - did you have any problems and how were they solved, - how could you cooperate with your peers, - to what extent did you find these tasks interesting, - did you get results you expected, - what did you learn during the whole process, - what would you do differently next time?	.
Why is the new knowledge gained important in everyday life?	Find examples of such processes which should be - slowed down so cooling is used - quickened so warming is used	Applying knowledge gained transference among the different fields such as biology, chemistry, geography.

Materials: hot water, thermometers, beakers, test tubes, test tube rack, refrigerator for cooling water, stopwatch, fixing salt and hydrochloric acid solutions, measuring tube

The experiment requires 0,1 mol HCl solution and 0,1 mol thiosulphate.
A fixing salt solution (thiosulphate): 1 mol thiosulphate crystallizes with 5 moles of water.
Molar weight: 158 + 90 = 248 g.
One tenth, 24,8g should be dissolved in 1liter of water.

Worksheet if needed.

Pour **5 cm^3** of fixing salt and **5 cm^3 of** hydrochloric acid into the test tubes placed on the test tube rack. Pour water of the same quantity but with different temperatures into big beakers. (In laboratories this is called ……..) Pour as much water into the beakers so that it would cover the solutions in the test tubes but it should not get into them. Put into each beaker a test tube containing fixing salt and one containing hydrochloric acid for 2-3 minutes so that they reach the required temperature. Then pour the hydrochloric acid into the fixing salt. During the chemical process a substance gets precipitated (sulphur), which small grains make the liquid opalescent. This shows us that the process is complete.
Handle solutions carefully! Be sure to prevent its squirting on your skin or into your eyes!

Section 5: Assessment opportunities

Student Learning activity	**Inquiry skills and processes**	**Assessment (concepts, inquiry skills, reasoning and scientific literacy)**
Summing up the previous knowledge in connection with the conceptual content of the text (chemical reactions)	Oral presentation of students' previous knowledge Looking for function relations between different quantities Mathematical framing of the excepted function relations	Evaluation of the students' previous knowledge, its quantity and quality from the aspect of the elaborated topic Do students know the groups of the main inorganic compounds and their reactions? What kind of mathematical function relations do they know? Do they know the exponential functions? (on advanced level)
Observing the reaction between sodium thiosulfate and hidrochloric acid in room temperature	Safe use of lab tools and equipment. Exact presentation of expreiences in connection with chemical reactions	Level of use of lab tools and equipment by students Appropriate description of experiences concerning chemical reactions

Planning investigation in order to observ the temperature dependence of reaction speed	Planning investigation in ored to solve a problem Implementing the conceptual knowledge Necessary equipment for the investigation and their appropriate use Making plans in order to collect and record data Creative thinking Communication: arguing, debate, agreement The students' role in the group, cooperation and collaboration	The teacher's assesment on the base of observing within the group Do student choose appropriate tools for investigation? Do they want to measure suitable data? Do they want to record the data properly? Is the communication appropriate within the group?
Carrying out the measure series	Observing Measuring Hands-on skills Safe and disciplined experimenting Accuracy Steadiness	Do students carry out properly the measure series allowed by the teacher? Do the use the tools properly? Do they measure the data properly? Do the record the data properly?
Representation of data in awritten way, or by computer with the help of table editor software	Math skills Handling data Use of database handling software	Do students describe the data properly? Do they choose the axis of the frame of reference properly? In advenced level: Do they change the data in order to describe them properly
Analyse the emerged graphs, comparing with teh hypothesis	Accepted, that the provious hypothesis hasn't been justified (by the students who expect a linear relationship)	Do the students approach towards the non-linear relationship properly?

Making report Making report actually begins in the planning phase Groups presentation about their work	Communication: presentation in written form and oral way as well The students' role in the group, cooperation and collaboration	Assessment on the base of students' completed reports Are there the following: Hypothesis, investigation plan, desciption of the measuring process, the appropriate arrengement of data, representation and explanation of the data, comparing to the hypothesis Evaluation of individual and gruopwork according to the given aspects in advance
Why is the acquired knowledge important in the everyday life?	Implementation of new knowledge, transfer between the defferent subjects as biology, chemisrty, geography	How can students use their knowledge in the connection with everyday life phenomena

Section 6: Case studies- Evaluation of evidence of learning

The above described task has been carryed out several times. The student usually think about linear relationship in their previous hypothesis. Contrary to this statement the reaction speed increases in exponential way. The reason is that the reaction speed influenced by the number of the particules wich have enough energy so that to happen effective collision.
Carrying out the series of measurement is very simple, it needs only a few equipment, but it is very spectacular. It can be observed clearly that in cool environment for example on 10 degree Celsius the process is going on very slowly, but in a water bath with 60 degree Celsius can happen in a moment. So the chemical reactions can happen more slowly in a cool environment. It causes that we can preserve the foods longer in a fridge.

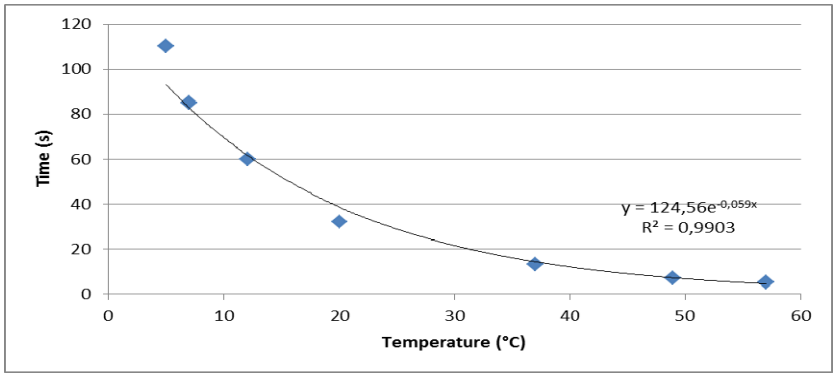
This table below is given away only in that case if they are not able to create an appropriate one.

The results of a possible measuring series:

Temperature of the water bath (°C)	Time needed for precipitation of sulfur (s)
5	110
7	85
12	60
20	32
37	13
49	7
57	5

The graph can be made:

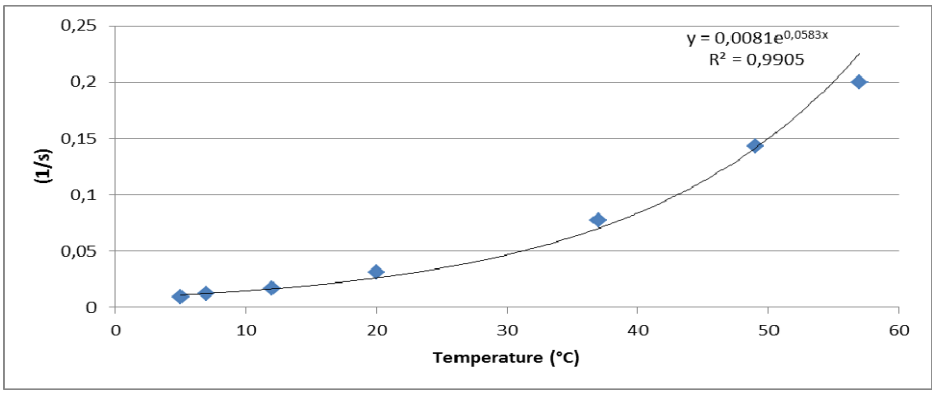
The students may illustrate the data as a change in reaction time in respect to temperature. It is clearly apparent from the chart that the change cannot be considered linear. The measurement marks cannot be joined by a straight line, only a curve.
If there is the possibility of using graph software, than the curve should be constructed. It would also be important to look up a function that describes the curve constructed from the data.



The reaction time in connection with temperature

The concentration change is the same if we pour same volume, so the reaction speed will be proportional with the reciprocal reaction time.

Temperature of the water bath (°C)	Reciprocal time needed for precipitation of sulfur (1/s)
5	0,0091
7	0,012
12	0,017
20	0,031
37	0,077
49	0,143
57	0,2



The change of the reaction speed in connection with temperature

It is apparent from this graph that the change is not linear, but exponential.