Bonding Chemistry and Argument: Teaching and Learning Argumentation through Chemistry Stories

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Introduction

In this booklet we present some example activities aimed for teachers and students in secondary chemistry education. Our approach in the design of the activities was informed by the need to motivate students by linking chemistry knowledge to everyday contexts through the use of imaginative and creative stories. The story contexts immerse students in purposeful pursuits in wanting to investigate and understand the chemistry knowledge in question. An important feature that has helped the framing of the activities is argumentation, the coordination of theory and evidence through justifications and reasons*.

A key goal in contemporary science education is the ability to engage in evidence-based reasoning in relation to both scientific and socio-scientific issues. Often such issues emerge in complex situations that demand the skills to articulate the difference between, for example, evidence and claim, as well as the ability to evaluate the credibility of evidence using a set of criteria such as accuracy and plausibility of the evidence. The activities integrate the promotion of such skills and provides teachers some example guidelines for structuring the lessons in ways that would support evidence-based reasoning to take place.

We are grateful to our respective universities, University of Bristol and Abant Izzet Baysal University for their support of our work as well as the Training and Development Agency for Schools and Bristol's Institute for Advanced Studies, and TC Yuksek Ogretim Kurulu, for financial support that made the production of these resources possible.

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* Erduran, S., & Jimenez-Aleixandre, M. P. (Eds.) (2008). *Argumentation in science education: perspectives from classroom-based research.* Dordrecht: Springer.

Contents

Activity 1: Halloween Crush! Teacher outline

This activity presents a set of alternative explanations about strange incidents that occurred when a group of students were having a party during Halloween in a chalet set in the mountains. Students are asked to evaluate through discussions in small groups the plausibility of the different explanations for why the lid of oilcan to shoot off when heated and why an oilcan collapses on itself when it's subsequently left to cool off. Furthermore, the activity immerses students to generate their own explanations to account for the observed phenomenon.

The aims
The aim of this exercise is to evaluate different theories for what causes the can to collapse and the lid to shoot off. Students will be required to justify with reasons their choice of claims and also justify with reasons why they do not agree with other claims.

Learning goals
The learning goals of this activity are for students:

- to learn to evaluate arguments and provide justifications for what they believe in;
- to provide justifications for why they think alternative arguments are not plausible;
- to evaluate alternative explanations and reasons.
- to think about the language they use, whether their reasoning is clear, and whether it justifies their conclusion.

Teaching points
For this activity students will need to know about the air pressure and the behaviour of gases. Also they need to know how to express their ideas in words.

Teaching sequence

- Distribute the activity sheet and explain the task.
- Probe the students' understandings of air pressure and the behaviour of gases through a brain storming session. This should take about 10 minutes.
- Now explain that the students will need to assess the explanations for the strange incidents that occurred in the chalet from the table on the sheet and give reasons why they think the observations took place. They will also need to create their own explanations about the situation. Ask the students to get into groups of 4 or 5 and discuss each explanation together before putting their responses in the boxes on the sheet. Allow about 20 minutes for the group task.
- Finally conduct a plenary of the results from the groups. Conduct a class discussion at the end and ask who would like to argue against other people's explanations.

Activity 1: Halloween Crush! Student exercise

Scenario

It was an unusually cold Halloween day. It was freezing and snow covered the mountains. A few teenagers had rented a chalet in the mountains to have a Halloween party. Because of the heavy snowstorm, they were stuck in the chalet. The teenagers did not care much about this unusual snowstorm because they had brought a lot of food and drinks with them. They started to prepare a big Halloween supper for themselves but after a while they realized that they had not brought any oil or butter with them. Because the chalet had not been used for a long time, there was little in the kitchen. After searching the chalet for a long time, they found one empty olive oilcan in the kitchen. They were upset and stopped preparing supper, eating just cold snacks and sandwiches in front of the fireplace. While they were telling each other horror stories, there was only Jane in the kitchen. Suddenly they heard Jane scream in the kitchen. The teenagers ran to the kitchen where they found Jane to be really scared. But a few seconds later when she saw her friends' fright, she burst into laughter and she cheerfully started to explain what happened. She said she realized there was some frozen olive oil at the bottom of the can, and in order to get rid of this frozen oil, she started to heat the can on the stove. However a few minutes later, because the lid of the can abruptly burst with a loud noise she got frightened and screamed. Another teenager, Eddie, held the oilcan with a piece of cloth and removed it from the stove. He attentively put the lid on the can and left it in the kitchen. After five minutes, while all the teenagers were in front of the fireplace continuing to tell horror stories, they heard some weird noises from the kitchen. But now, there was nobody in the kitchen. They got scared! At last when they plucked up the courage to go to the kitchen, they saw that there was nobody there, but the oilcan had crushed noisily by itself. Now they were really frightened and hugged each other in desperation. Sebastian tried to call them by saying that he knew what had happened! He remembered his chemistry lessons and he explained what had happened in the kitchen by using his chemistry knowledge.

Activity 1: Halloween Crush!
Student exercise

In the table that follows, some explanations are given. Decide which of the explanations Sebastian could have used to explain the lid was thrown off, and rank each explanation with points: 0 for not relevant; 1 slightly relevant; 2 definitely related to the explanation. If you are not sure or do not have an idea, please put down NI for “no idea”.

The reason of bursting of the lid was…	Points	Our explanation
increasing inside pressure of the can		
increasing volume of the gas molecules in the can		
Increasing speed of gas molecules in the can		
increasing impact of gas molecules on the can		
hot air rises		
the inequality of the pressure inside the can and the air pressure		
the expansion of the can by heating		

Our explanation about the reason for why the lid burst

Below are some explanations about why the oil can crushes by itself. Decide which of the explanations Sebastian could use and rank your choice from 1 (most relevant) to 6 (least relevant).

Oilcan crushed because of…	Rank	Our explanation
the power of air pressure		
no gas molecules inside		
the number of gas molecules inside decreases		
the volume of gas molecules inside decreases		
the speed of gas molecules inside decreases		
the volume of the can decreases		

Activity 1: Halloween Crush!
Student exercise

Our explanation about the reason for why the oil can crushes by itself

What would happen if Eddie had not closed the lid of the olive oilcan after he had removed it from the oven?

If the lid of the can was not closed…	Our explanation
the shape of the can would not be changed	
the shape of the can would increase because more molecules would enter the can	
the can would crush by itself again	

Our explanation for what would happen if Eddie had not closed the lid of the olive oilcan

Below is a figure that shows the condition of the can when teenagers first found it in the kitchen.

Consider Figure 1 and draw the final crushed oilcan.

Now, take a look at Figure 1 again. Draw what would have happened if Eddie had not closed the lid of the oilcan after he removed it from the stove.

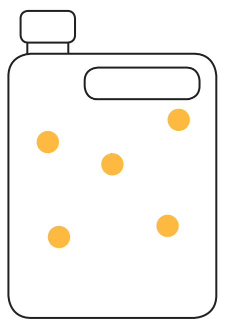


Figure 1: Olive oilcan with lid

Activity 2: Holiday in Dubai
Teacher outline

This activity requires students to use and evaluate evidence presented on cards to (a) construct an argument about the reason why a balloon exploded when it was taken outdoors and (b) to evaluate critically the arguments of other students. The students are asked to work in groups.

The Aims
The purpose of this exercise is to:
- provide a context for students to generate arguments about behaviour of gases using evidence
- to consider the evidence for the scientific conception of gas laws.

Learning goals
The learning goals of this activity are to:
- provide an opportunity to consider and evaluate evidence
- generate an explanation for what happens when the balloon was taken outdoors
- consider and evaluate the arguments of other students
- to work in small groups to develop the ability to construct an argument
- to have an opportunity to evaluate claims presented in the evidence cards

Teaching points
Students will need to have some understanding of gas laws and air pressure. The alternative explanations produced by the students will provide a context for argumentation. For example, one explanation could be that the balloon exploded when it was taken outdoors because when the temperature increases, gas molecules expand. Another could be that the balloon exploded because air pressure increase with temperature. The scientific explanation is that the kinetic energies of gas molecules are directly proportional with their temperature in Kelvin. In this case, we would expect the pressure of the balloon rise with increasing temperature. To decrease the pressure, the balloon increases in volume but if it is not possible to expand, it will explore because of the inequality between the pressure in the balloon and the air.

Teaching sequence
- Distribute the activity sheet, which explains the nature of the tasks.
- Now explain that the students will need to construct the best explanation for the questions. They will also need to support their explanations with evidence cards, which will need to be cut out.
- Explain they not need to use all evidence cards and also they can use one evidence card more than one questions. Warn students about the evidence cards because some evidence cards contain irrelevant or wrong information.
- Ask the students to get into groups of 4 or 5 and discuss each explanation together before putting their responses in the boxes on the sheet in an order where the most relevant card at the top and the least relevant at the bottom. Allow about 30 minutes for the group task.
- Finally conduct a plenary of the results from all the groups. Go through each card and ask who would like to argue for this explanation. Then ask who would like to argue against it.

Activity 2: Holiday in Dubai
Student exercise

Scenario

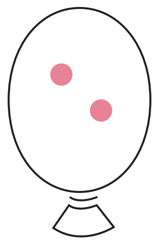
Jon and Frances, who went to Dubai for a holiday, got exhausted from heat since the outside air temperature was 50ºC. They went into the shopping centre, where air temperature was maintained at 25ºC. After they spent some time at the mall, Jon found two similar balloons left after a store opening. He gave the more bloated balloon (containing 1 mole of air) to Frances and kept the other (containing 0.5 mole of air) himself. Even though Frances was glad about this gesture, when they went out Frances' balloon exploded. Jon's balloon expanded and looked really beautiful. Hence, she was angry with him but in this situation there was something about chemistry that she forgot to take into account. Jon realized this fact and offered her to return to the mall and explain what happens.

You can use the evidence cards to explain the questions below. Write down the number of each used card according to the order of importance.

Why did France's balloon explode but Jon's balloon did not when they went outdoors?

Evidence Cards	

Below, Jon's balloon in the mall is represented. First draw the balloon outdoors and then draw the balloon indoors but consisting of 1.0 mole air. Take into account the possible changes in volume (V) and pressure (P) that occur in the balloon.



n_{air}= 0.5 mole, T= 25ºC	n_{air}= 0.5 mole, T= 50ºC	n_{air}= 1.0 mole, T= 25ºC
Volume V	Volume ……	Volume ……
Pressure P	Pressure ……	Pressure ……

Activity 2: Holiday in Dubai Student exercise

If they bought a crystal ball, which consisted of 1.0 mole air, what would happen to the crystal ball when they took out it outside? (i.e., pressure, volume)

Evidence Cards

Evidence cards:

1. Gases fill any container that they occupy

2. Gases have very weak intermolecular forces

3. Gas molecules expand when heated

4. The pressure of container having a piston is always equal to the air pressure

5. Air pressure changes with temperature

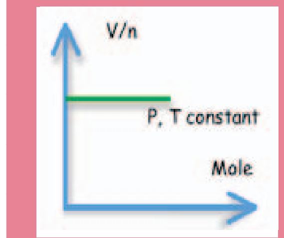
6. The kinetic energy of gas molecules is directly proportional to temperature

7. If the gas filled container having a piston is heated, it's volume will expand

8. At constant temperature, the volume of a container having piston increase with the number of molecules in it.

9. In a fixed volume container, increasing the number of gas molecules increase the total pressure

10.



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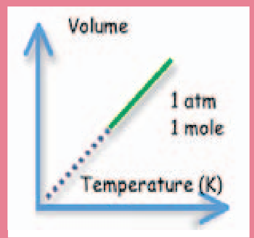

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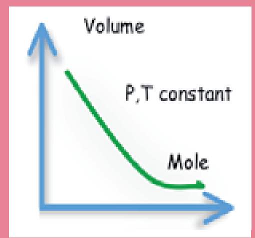

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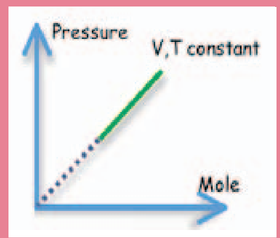


Activity 3: Mysterious Diaries Teacher outline

This activity presents two imaginary diaries about the ideal gas behaviours. One diary was written by the water molecule Weeny and it is mainly about Neverland which is a place the gases became ideal. The second diary was written by Amy who carried out an experiment to prove the ideal gases do not exist. First students are asked to discover hidden codes about the properties of the ideal gases in the diaries. Then the activity immerses students to think of and discuss about the conditions when the real gases show ideal gas behaviour. Students are also asked to evaluate plausibility of the experiments to investigate the inexistence of ideas gases.

The aims

The purpose of this exercise is to:

- to visualize, model and understand the properties of ideal gases.
- to evaluate the behaviour of real gases at different conditions

Learning goals

The learning goals of this activity are for students:

- to consider the concept of the ideal gas
- to predict how the behaviour of gases changes when the temperature and pressure change
- to evaluate the plausibility of the experiment done to explore the inexsitence of ideas gases

Teaching points

For this activity students will need to know about the chemical bonds and ideal gas laws. Also they need to know how to express their ideas in a written format.

Teaching sequence

- Probe the students' understandings of ideal gases by asking questions. For instance, why do we use the ideal gas equation? What is absolute zero? Why do we use kelvin as a measure of temperature rather than degree Celsius in the ideal gas equation? These questions could be answered at the end of the lesson and here the brain storming session should take about 5-10 minutes.
- Distribute the activity sheet and explain students that they have to investigate the properties of ideal gases by assessing the information in the diaries. Ask the students to (a) get into groups of 4 or 5 and discuss the diary information, and (b) write their explanation together in the boxes on the sheet. Allow about 10 minutes for the group task.
- Then write the properties of ideal gases on the board and discuss them as a whole class.
- Now explain that the students will need to consider the conditions affect the behaviour of real gases and they also need to assess Amy's experiment in terms of its plausibility.
- Finally conduct a class discussion in a plenary. You can ask additional questions. For example, what would happen if at the end of her experiment Amy pulled the piston suddenly and increased the volume of the container to twice as much?

Activity 3: Mysterious Diaries Student exercise

Weeny's Diary

May 23
Well, it is another freezing cold day. I am shivering like my friends are! We have to snuggle up to each other to keep warm. I hate this crowd. I have just fun listening to Neverland stories. Old lady at the corner always tells stories about Neverland. I would go there if I had enough energy left.

14.00 p.m.
My friends make fun of me again; they do not believe Neverland but one day I will go to Neverland. I will be size zero there. Can you imagine? I'll get around randomly all day without seeing anybody! It will be all peaceful and quiet, I will be free of others bumping into me. I won't be crushed and I will recover all my energy. I will be ideal there!

May 24
At last, I feel some energy in my body. It is a very hot day!!! I want to celebrate this heat with a dance!

I can hardly contain myself to jot down my feelings. I want to leave the others behind and fly away. Do you believe this? Superb!!! For the first time in my life, I feel that I can overcome the pressure that always I feel on me. I can fly away to Neverland.

May 25
I hate what happened yesterday. You won't believe what had happened. When I was flying to Neverland a wall suddenly appeared in front of me. I could not escape from it. Then, the crowd gradually increased and I started to feel weak again.

My friends and I are getting close again although are not as close as we were two days ago. I think I will never see Neverland. May be they are right. May be there is no Neverland.

Amy's Diary

May 23
I have to get up early tomorrow.

I will do the experiment I invented. It is about existence of ideal gases. Do you think I am weird because I care about such things? Well, I want to know how the universe works! Tomorrow, I will prove that the ideal gases do not exist.

P.S. To Do:
Do not forget!!!
- take out some ice from the freezer
- put into the container with a piston
- bring it to school !!!

May 24
Today is a big day.
I didn't forget anything. I prepared my materials and now I am waiting for my friends to come. Lesson starts at 8.05a.m.

P.S. The ice is melting slowly
I should heat it on the heater.
I can't wait!!

May 25
Yesterday was very cool.

I melted the ice in the heater. After all ice disappeared, I took the container from the heater and I showed it to my friends. Then I started to push the piston of the container slowly. After a while, we observed some water drops in the container.

Activity 3: Mysterious Diaries Student exercise

Some examples for the codes in Weeny's diary are given in the table.

Sentence containing hidden code	Our explanations about the codes
Along with all the other friends, I have been shivering as usual.	Weeny in ice form. Because the atoms of a solid vibrate.
Nearly we have to snuggle up to each other… I hate this crowd.	Weeny in ice form. Because the atoms of a solid are strongly attracted to each other
We are not close as far as when we were two days ago.	It is in liquid form. Because, the distance between the atoms of liquids is more than that in the solid form.

Find the hidden codes in Weeny's diary about properties of ideal gas.

Codes about properties of ideal gases	Our explanations

Now ask your teacher about the properties of ideal gases and discuss it in the class. Write your notes after your discussion in the box below.

Activity 3: Mysterious Diaries Student exercise

Think about the effects of the conditions in the table that follows. Guess the effects of the conditions on water molecules in Amy's container. Put down "I" for "increasing", D for "decreasing" and N for "not changed".

Conditions	Volume of Weeny	Distance btw molecules	Intermolecular forces of molecules	Speed of Weeny
Increasing Temperature				
Increasing Pressure				

Can you turn any real gas molecule to ideal gas by changing the conditions? Think about water vapour and Helium gas as examples.

At the end of the experiment Amy said that "Here we prove ideal gases do not exist. Because if there did, they could not be to changed into liquid" Do you in agreement with her? Why?

Activity 4: Alkanes in Stress Teacher outline

This activity requires students to use and evaluate evidence presented on graphs and evidence cards. In the graph, six different conformations of butane and their potential energies are shown. However, only two of the conformations, Newman projection formulas are given in the graph, and students are asked to predict the other four missing Newman projection formulas. Students discuss their observations and try to make prediction based on their observations. Then they compare their observations with their predictions. If they think their prediction is valid, they then need to support their predictions with evidence and they need to create explanations for their predictions.

The Aims

The purposes of this activity are to:

- provide a context for students to generate arguments about conformations of butane using evidence that they extracted from the graph;
- to consider the evidence for the scientific conception of conformations

Learning goals

- provide an opportunity to consider and evaluate evidence;
- generate an explanation for how the energy of the conformation of butane changes for different Newman projection formulas
- consider and evaluate the arguments of others.

Teaching points

Students will need to have some understanding of concepts such as of conformations, Newman projection formula, types of strain, VSEPR theory, hybridization, structural isomer and stereoisomers. The alternative predictions and explanations produced by the students will provide a context for argumentation. For example, one explanation could be that the stability of a molecule is not changed with the type or amount of the strain that the molecule has. The scientific explanation is that molecules have conformations with high strain as well as conformations with low strain. High strain conformations are when certain parts of the molecule that repel are forced to be close to one another. Molecules, therefore, are more stable at a low strain structure.

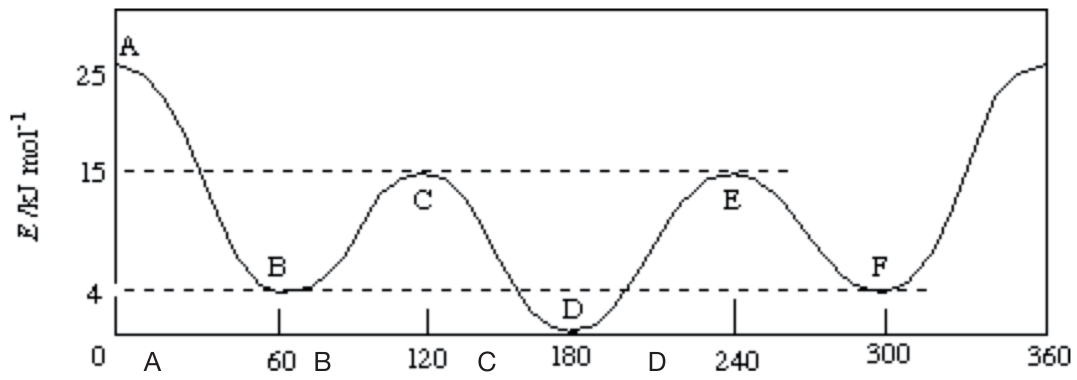
Teaching sequence

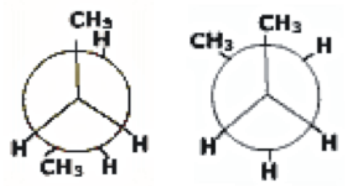
- Distribute the activity sheet and explain that students will need to observe how the potential energy changes with two different Newman projection formulas of butane at the graph.
- Then ask the students to work in pairs to complete the part of a sheet requiring a prediction. They should spend up to 25 minutes to complete the prediction section of the sheet. Emphasise that they should write an argument to justify their prediction.
- Tell the students that each group will need to select a member to present their results to the whole class.
- Conduct a plenary discussion with each group presenting their results. When there are differences between groups, encourage the students to provide justifications for how the other group's point of view is not valid. For instance, ask "does anyone want to suggest why they think that might be wrong?"In other words, encourage the hem to provide rebuttals to others' arguments.

Activity 4: Alkanes in Stress
Student exercise

Question 1

The graph below shows the changes that arise from rotation about the C_2-C_3 bond of butane. Here are the two Newman projection formulas for the conformations of butane. The other four Newman projection formulas for the conformations of butane in the graph were erased and they replaced with the letters A, B, C and D respectively.





Graph-1 The tortion angle-potential energy curve of butane

Below are the five different Newman projection formulas. Look at them and try to estimate the erased Newman projection formulas in the graph. Complete the below table and use the evidence from the evidence cards to substantiate your claims.

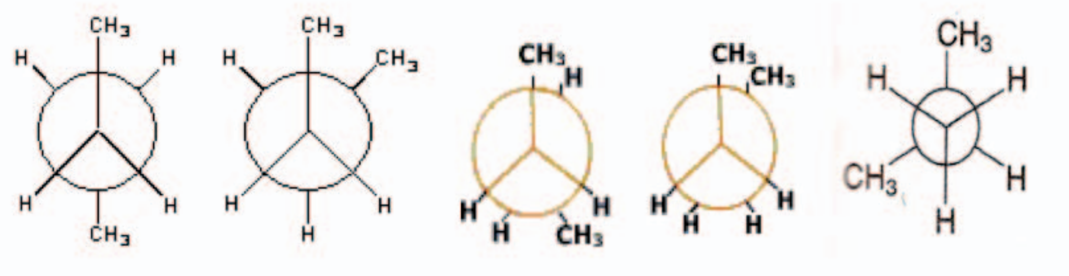


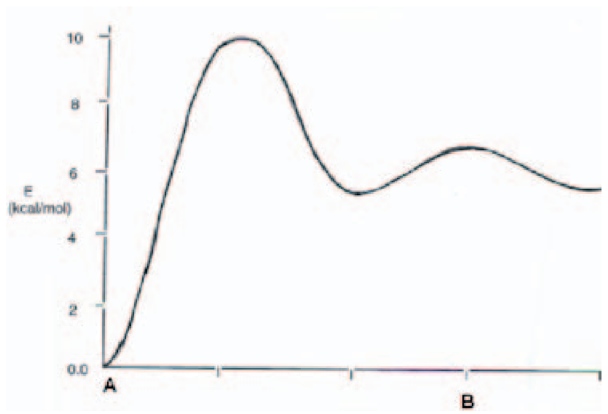
Figure-I *Figure-II* *Figure-III* *Figure-IV* *Figure-V*

Activity 4: Alkanes in Stress
Student exercise

Figure	A/B/C/D/none	Types of Strain (i.e.,Van der Waals, Torsional, Angle, None)	Evidence for your prediction
I			
II			
III			
IV			
V			

Activity 4: Alkanes in Stress Student exercise

Question 2
The graph to the right illustrates the relative energies of the various conformations of cyclohexane. Two conformations (chair and boat) of cyclohexane are represented as A and B. Look at them and try to estimate which conformations of cyclohexane represented by which letters. Complete the table and use the evidence from the evidence cards to substantiate your claims.



Conformation	A or B	Types of Strain (i.e.,Van der Waals, Torsional, Angle, None)	Evidence that support your prediction
Chair			
Boat			

Activity 4: Alkanes in Stress Student exercise

Evidence cards:

Strain: Energy associated with a system due to its geometry.

Torsional strain: Destabilization due to the repulsion between pairs of bonds caused by the electrostatic repulsion of the electrons in the bonds.

Van der Waals strain: Destabilization due to the repulsion between the electron clouds of atoms or groups. This occurs when atoms or groups are too close to each other due to the electrostatic repulsion of the electrons.

Angle Strain: Destabilization due to distortion of a bond angle from its optimum value caused by the electrostatic repulsion of the electrons in the bonds.

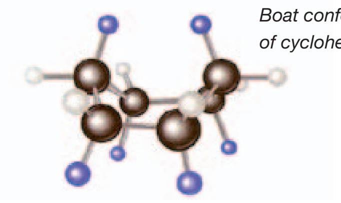
The different spatial arrangements that a molecule can adopt due to rotation about s bonds are called **conformations.**

In **structural isomers**, the atoms and functional groups are joined together in different ways.

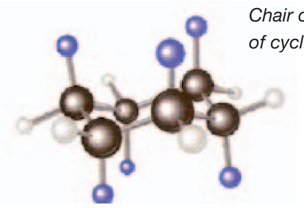
In **stereoisomers** the bond structure is the same, but the geometrical positioning of atoms and functional groups in space differs.

Isobutene is more energetically stable than n-butane.

VSEPR theory is useful to explain the stability of different conformations of molecules.



Boat conformation of cyclohexane



Chair conformation of cyclohexane

Activity 5: Organic Potions
Teacher outline

This activity requires students to design experiments to synthesize some compounds. The activity places some contraints in the synthesis strategies that can be offered by the students. For example, it requires students to use each reaction given in the evidence cards just once. Also, there is limited amount of material in the laboratory and students have to evaluate the materials presented in the list. These constraints are designed to be simulate realistic constraints that face chemists themselves in the laboratory, therefore creating an authentic context for the planning of experiments. Furthermore, they are given opportunities to generate arguments in writing and to revise their writing to take into account what they learn from class discussions.

The Aims

The purpose of this exercise is to provide an opportunity for students to consider how they plan an experiment to synthesize new compounds. It also presents a context for students to develop understanding of organic chemistry reactions and to construct a written argument.

Learning goals

The learning goals of this activity are:

- to construct an argument about how to synthesize some organic compounds;
- to use the materials in the laboratory in their synthesis reactions;
- to learn organic chemistry synthesis reactions;
- to use writing frames to construct their arguments and to revise their arguments based on discussions in class.

Teaching points

Students will have some understanding of concepts such as the name of the organic compounds and will be able to draw the structures of organic compounds. There is no simple one way to synthesize one compound. Sometimes they have to synthesize one organic compound from the other organic compound that they have already synthesized. Also, there is a time limit to synthesize the compounds. They should use their time effectively and try to synthesize as many compounds as they possibly can. You might need to encourage the students to use the evidence cards and think about the materials they have. Some students may be need some help with interpreting the use of the writing frames. Spend some time to explain what the students are supposed to write down in the boxes provided.

Teaching sequence

- Distribute the activity sheet and the evidence cards.
- Spend about 10 minutes introducing the task and explaining what the students will be expected to do. They will be designing experiments to synthesize new compounds. They can start any compounds they like. You should encourage students firstly to think about the properties of compounds that they want to synthesize and write the structural formula of them. Then they should look at the materials they have and the reactions given in the evidence cards. They should use each reaction given in the evidence cards just once and they should construct an argument about how they chose the compounds that they are synthesizing. They will need to write the chemical reactions that underpin the synthesis reactions.
- Ask the students to work in pairs.
- Explain the example of writing frame given in the activity and encourage the students to justify their synthesis methods. They should spend about 25 minutes on this task.
- Tell the students that each pair will need to present their results to the whole class.
- If you have a time after the activity, you can ask students to draw a concept map from their findings.

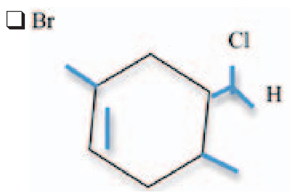
Activity 5: Organic Potions
Student exercise

Organic Potions

Rachel at last fulfils her ambition of being an assistant in an organic chemistry laboratory. On her first day in the lab, she has a list of some reactions and organic compounds that she will be responsible for. Her task is to synthesize each of the organic compounds in the list. First, she goes to the lab to check the materials. Then she synthesizes 4,4-Dimethyl-1-Pentyne and writes the way that she synthesized it. Unfortunately she then develops a flu and does not get a chance to complete the report. Give her a hand and help her to synthesize the rest of the organic compounds and write the rest of her laboratory report.

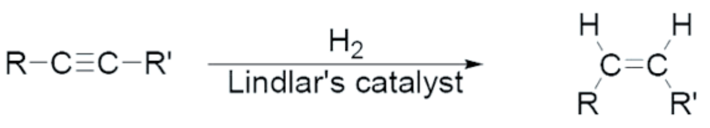
Chemistry material lists				
Plenty of these materials:				**Just for one time:**
$NaNH_{2(aq)}$	NH_3	H_2	H_2SO_4	$(H_3C)_3CCH_2Br$
H_2O_2	HC=CCH$_3$	NaOH	CH_3CH_2C=CCH$_3$	BH_3
HC=CH	H_2O_2	Na	Lindlar Pd	1,3-butadiene
H_8SO_2	CH_3CH_2OH	Pd/C	$KOCH_2CH_3$	2-bromo-1,3-butadiene
Cl_2	O_3	Pt	HCl	

The compounds are given in the following table. At the end of the lesson, tick the compound you synthesize, count the number of your ticks and compare it with the other pairs' scores. Each tick means 1 point.

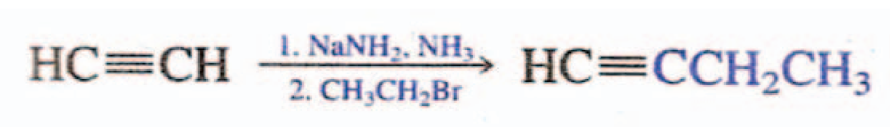
☑ / ☒ **Organic Compounds**	☑ / ☒ **Organic Compounds**
❑ 4,4-Dimethyl-1-Pentyne	❑ 4,4-Dimetil-2-Pentene
❑ Cis-2-Pentene	❑ Ethanal
❑ Trans-2-Pentene	❑ 2,2-Dichloro-4,4-Dimethylpentane
❑ 1,2-Dichloropropane	❑ 2-Propanol
❑ Pentane	❑ 1-Propanol
❑ 3-Chloro-1-Butene	❑ Acetone
❑ 	

Activity 5: Organic Potions Student exercise

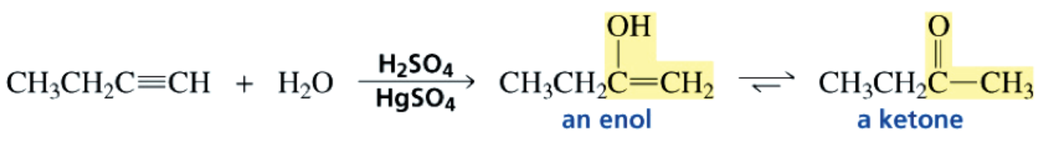
Example Cards | **Type of the reaction**



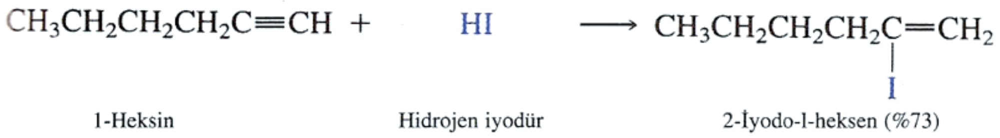
Hydrogenation of Alkynes with Lindlar catalyst



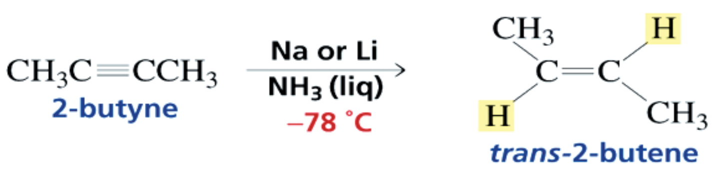
Synthesis of Alkynes from other alkynes



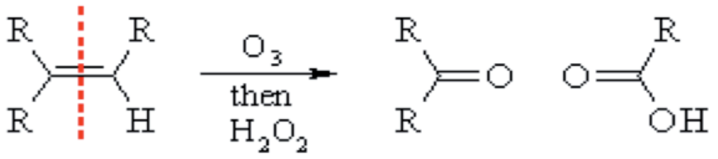
Addition of Water to Alkynes



Reaction of Alkynes with Hydrogen Halides

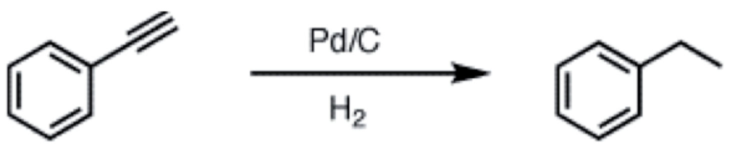


Dissolving Metal Reduction of Alkynes

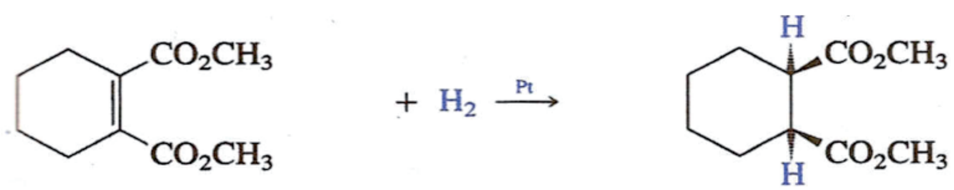


Ozonolysis of alkenes

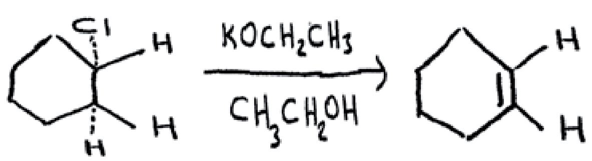
Halogenation of alkenes



Hydrogenation of Alkynes to alkanes using Pd/C catalyze



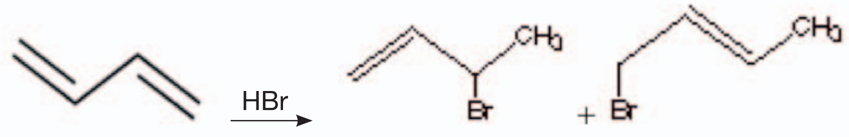
Hydrogenation of Alkenes



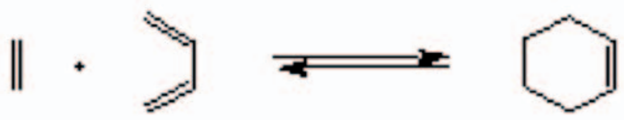
Dehydrohalogenation of alkyl halides

Activity 5: Organic Potions Student exercise

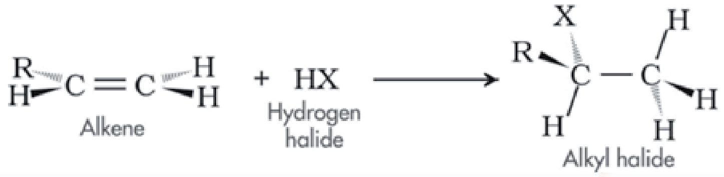
Example Cards | **Type of the reaction**



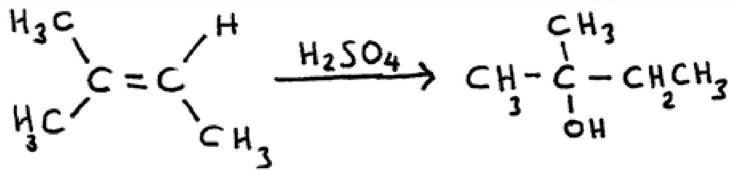
Electrophilic addition to Dienes



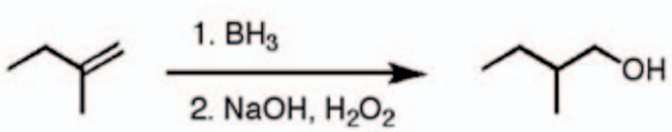
Diels–Alder reaction



Electrophilic addition of HX to alkenes



Hydration of alkenes



Hydroboration of Alkenes

Activity 5: Organic Potions
Student exercise

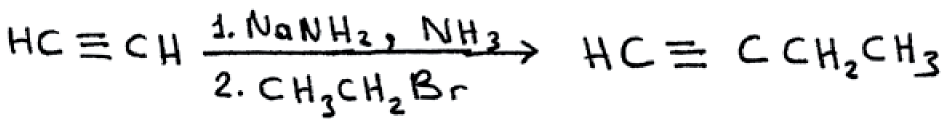
Rachel's Notes

4,4-Dimethyl-1-Pentyne

The structure formula of the compound is $(H_3C)_3CCH_2C{\equiv}CH$

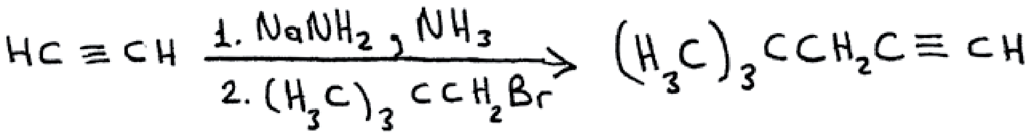
How can we obtain the compound with the materials in the lab?

I have ethyne ($HC{\equiv}CH$) in the lab and I know I can syntheses alkynes from other alkynes.
Also there is an example of "Synthesis of Alkynes from other alkynes'.
According to the example for the reaction,



I need $NaNH_2$ and NH_3 (I have got plenty of these). Also, I have to choose appropriate alkyl halides to obtain 4,4-Dimethyl-1-Pentyne. I have $(H_3C)_3CCH_2Br$ in the lab and it is perfectly fit here.

My reaction mechanism:



Our Notes

Activity 6: Cheating on the Exam
Teacher outline

This activity requires students to use and evaluate evidence presented on cards to argue whether the compounds provided regarding different reaction mechanisms are either (a) a nucleophile or an electrophile, both or neither (b) Bronsted acid or Lewis acid both or neither. The students are asked to work in groups and also to conduct presentations following group work.

Aims
The aim of this exercise is to consider the evidence about whether the compound is (a) a nucleophile or an electrophile, both or neither, and (b) Bronsted acid or Lewis acid both or neither. Students will use the evidence presented on cards to argue for the appropriate classification of the compound.

Learning goals
- Students will have the opportunity to construct arguments for the compound given in the reaction classifying either (a) a nucleophile or an electrophile (b) Bronsted acid or Lewis acid and use the evidence from the cards to justify their claims.
- Students will learn to evaluate the evidence presented on the cards and select them to support their points of view about the compounds' behaviour in the reactions. Since some of the evidence can be ambiguous and could indicate that the compound in the reaction is both an electrophile and a nucleophile, the activity provides an opportunity to generate cognitive conflict and argumentation for students.

Teaching points
For this activity students will need to know the concepts of proton, electron, covalent bond, electrophile, nucleophile and mechanism of organic reactions and the definitions of acids and bases.

Teaching sequence
- Distribute the activity sheet with columns and the evidence cards. Explain that the students will need to place each compound in the column where they think the statement goes. Arrange the students into groups of three or four.
- Now explain that the students will need to classify the compounds and they will need to support their classifications with evidence cards, which will need to be cut out.
- Explain that they not need to use all evidence cards. Warn students about the evidence cards because some evidence cards contain irrelevant or wrong information. The activity asks for the ability to distinguish between relevant information from irrelevant information, and to evaluate the accuracy.
- Allow about 10-15 minutes for students to work as a group to sort out the cards. While they are working in their groups, go around and probe their reasoning for selecting cards to put in one column over another column. Encourage students to use the textbook to look up any of the evidence that they may not be sure about.
- Hold a class plenary at the end. Ask each group's idea about each compound respectively. Ask the students to report on their discussions and indicate the outcome of the group's exploration. Then ask who would like to argue against the presented ideas. Encourage the groups to rebut each other's argument by providing evidence that would counter their position. Ask questions such as "what information would you use from the cards to prove that his argument is not true?"

Activity 6: Cheating on the Exam Student exercise

Scenario

In an organic chemistry exam, the teacher found some organic chemistry reactions written on Tom's desk. The teacher warned Tom that she would fail him. Tom objected because he believed that there were no questions in the exam about the reactions written in his desk. Having looked at the Tom's desk, April, another student in the class, was not in agreement in Tom and she said the first question of the exam could be answered with the help of the reaction mechanisms written on the desk. Who was right, Tom or April? Whom do you agree with and why? Try to justify your decision by looking at Tom's desk and the first question of the exam.

1st question of the exam

Decide whether each compound given below is (a) a nucleophile or an electrophile, both or neither (b) Brønsted Acid or Lewis acid, both or neither.

In the reaction of Alcohols with Hydrogen Halides,
- o tert-Butyl alcohol, Hydrogen chloride, tert-Butyloxonium ion; tert-Butyl cation and H_2O

In the reactions of Electrophilic addition of HX to alkenes
- o Alkene and HX

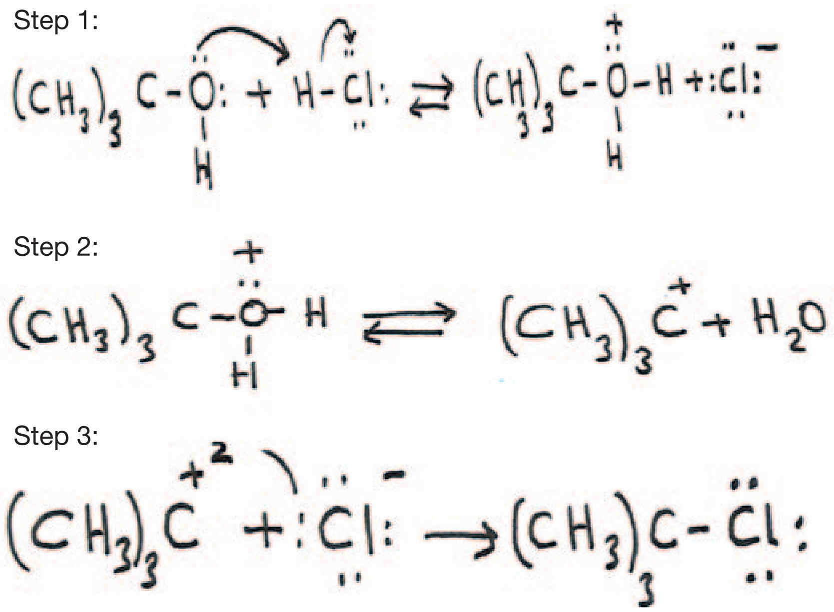
In the Nucleophilic substitution reactions,
- o Methyl bromide and Hydroxide ion

In the reactions between carbocation and Halogen anion
- o Carbocation and Halogen anion

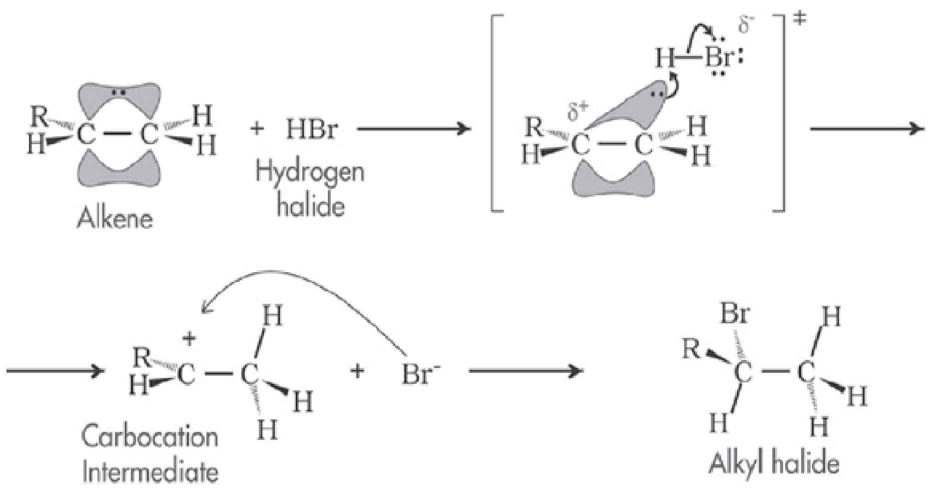
Activity 6: Cheating on the Exam Student exercise

Tom's Desk

Mechanism of the Reaction of Alcohols with Hydrogen Halides



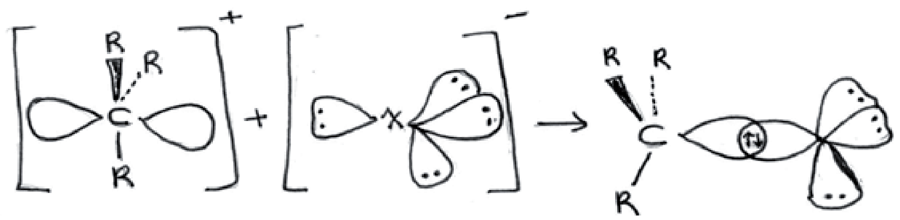
Electrophilic addition of HBr to alkenes



Nucleophilic substitution reactions

$$R\text{-}Br + OH^- \longrightarrow R\text{-}OH + Br^-$$

Reaction between carbocation and halogen anion



Activity 6: Cheating on the Exam Student exercise

Nucleophile or Electrophile?
Decide whether each compound given in the first question of the exam whether it is a nucleophile or an electrophile, both or neither. Then write down your evidence to justify your decisions in the table that follows.

Nucleophile	My Evidence	Electrophile	My Evidence
Either electrophile or nucleophile	My evidence	Neither electrophile nor nucleophile	My evidence

Activity 6: Cheating on the Exam Student exercise

Bronsted Acid or Lewis acid?
Decide each compound given in the first question of the exam whether is Bronsted acid or Lewis acid, both or neither. Then write down your evidence to justify your decisions in the table that follows.

Bronsted Acid	My Evidence	Electrophile	My Evidence
Either Bronsted or Lewis acid	My evidence	Neither Bronsted or Lewis acid	My evidence

Activity 6: Cheating on the Exam
Student exercise

Evidence cards:

It gives proton
It takes proton
It gives H^+ into the solution
It gives OH^- into the solution
It is looking for electrons
It is looking for nucleolus
It has non-bonding electron pair
It is positively charged
It is negatively charged
It is neutral
It has Carbon with sp^2 hybrid (orbital)
Carbon has empty orbitals
It is tertiary carbocation
It is an acid-base reaction

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T.C. YÜKSEKÖĞRETİM KURULU

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