Hydrocarbons

Introduction

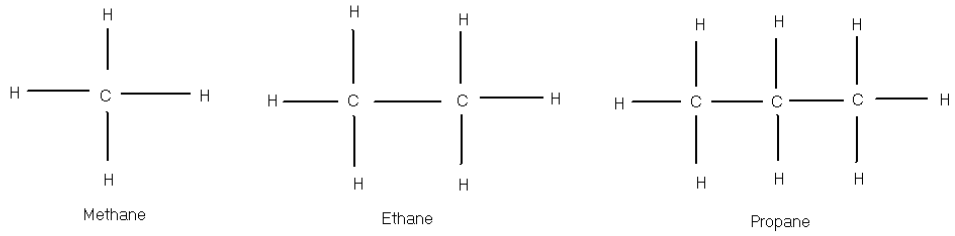
Mathematically this activity is similar to many others that involve spotting patterns, finding term-to-term and nth-term formulas. The main difference in the activity is that the problem itself comes from Chemistry and the formulas are actual Chemical formulas, so that a genuine connection can be made between subjects and it gives a real world reason for looking for general formulas. The availability of information on the internet also means that students can make predictions using mathematics and then find out more about hydrocarbons and see whether their predictions are correct using internet research. Some students will inevitably find the general chemical formulas from internet research, so the challenge then is to use the patterns in the chemical structure diagrams to explain why these general rules work.

This activity can make use of a number of features of Ti-Nspire without much prior experience so not only does Ti-Nspire give the user the facility to link together different aspects of the activity, but the activity itself could also provide an introduction to some of the features of the handheld or software.

Hydrocarbons activity Alkanes

Atoms of carbon combine with atoms of hydrogen to form hydrocarbons.
Carbon atoms have valency 4. This means that each carbon atom has 4 bonds that can link to other atoms.
Hydrogen atoms only have a single bond.

Saturated hydrocarbons or alkanes are the simplest type of hydrocarbon. The atoms are linked in a straight chain. They are composed entirely of single bonds and are saturated with hydrogen i.e. every bond is used.
The first 3 alkanes are shown. They are methane CH_4 ; ethane C_2H_6 ; propane C_3H_8 .



- Can you predict what alkanes with more carbon atoms will look like? You could use pencil and paper to do this or you could use a Geometry page to draw these.

- Can you suggest any connections between the number of carbon atoms and
  - **the number of hydrogen atoms,**
  - **the number of bonds**
  - **the chemical formulas**

- Can you complete more rows and columns of the table below? You could use a 'Lists & Spreadsheet' page to help you do this.

Name	Carbon atoms	Hydrogen atoms	Number of bonds	Chemical formula	
Methane	1	4	4	CH_4	
Ethane	2	6	7	C_2H_6	
Propane	3				
Butane	4				
Pentane	5				
Hexane					

- Could you predict what happens for other saturated hydrocarbons such as Decane which has 10 carbon atoms?
- **Could you suggest any general formulas and predict other hydrocarbons and their formulas?**
- Can you explain the methods that you used to find patterns and formulas? You could use a 'Notes' page for your explanation, but you might also have used formulas in a spreadsheet page or fitted functions to a graph. (There is a helpsheet for students with more information about doing this.)
- Can you explain why your rules work? How do the patterns in the diagrams of the chemicals help to explain this?
- What else can you find out about hydrocarbons? (Possible internet research)

Extension activity Alkenes and alkynes

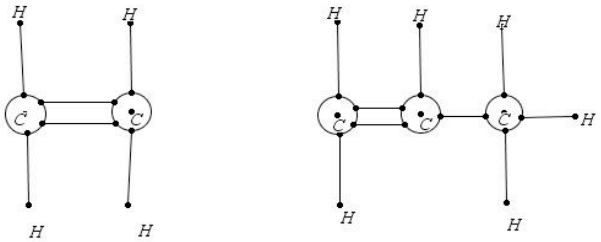
Unsaturated hydrocarbons have one or more double or triple bonds between carbon atoms.

Those with one double bond are called **alkenes.**

Those with a triple bond are called **alkynes**

Alkenes

The first two alkenes are **Ethene C_2H_4** and **Propene C_3H_6**



- Can you sketch some more alkenes and predict possible connections between the number of carbon atoms and the number of hydrogen atoms, bonds and the chemical formula? You might find a table useful like the one used for alkanes.

The first two alkenes (2 and 3 carbon atoms) are shown above and have a unique structure. The diagram for Propene has been drawn with the double bond on the left, but the structure would be the same if the mirror image was drawn i.e. the double bond on the right.
The structure for Propene could be broken down as **CH_2= CH-CH_3**

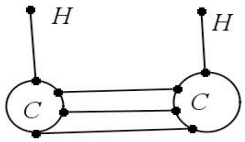
Alkenes with 4 or more carbon atoms can have more than one structure. Butene (4 carbon atoms) for example can have the double bond either in the centre or at one side of the chain of carbon atoms.

- Does the drawing and structure make any difference to the number of hydrogen atoms, bonds or the chemical formula?
- Can you predict the number of different structures for alkenes depending on the number of carbon atoms and use the diagrams to explain how your rules work?

Alkynes

What rules and formulas can you predict for alkynes, which have one triple bond between carbon atoms?

The first alkyne is **Ethyne C_2H_2**.



Can you find any other types of hydrocarbons?

Possible further extension activity

Alkanes may be gases, liquids or solids at room temperature. Their boiling points and solidification points vary. The more carbon atoms there are the lower the boiling point so a further more advanced extension activity could be to search for a connection between the boiling point or solidification point and the number of carbon atoms. This has important practical considerations which might be relevant to students, for example which to use as fuel for camping stoves in different climatic conditions. http://library.thinkquest.org/3659/orgchem/alkanes.html

Sources of further information

An internet search will give a lot more information about alkanes, alkenes and alkynes. Some sites such as Wikipedia give rather too much information, which can be very daunting and complex. Some sites go straight to the chemical formula. Searches under the three individual headings can prove more useful than a general search for 'hydrocarbons'. These are some examples:

http://www.chemguide.co.uk/organicprops/alkanes/background.html#top
http://www.chemguide.co.uk/organicprops/alkenes/background.html#top
http://hyperphysics.phy-astr.gsu.edu/HBASE/Organic/alkane.html
http://hyperphysics.phy-astr.gsu.edu/hbase/Organic/alkene.html
http://library.thinkquest.org/3659/orgchem/alkanes.html
http://www.gcsescience.com/ihydrocarbons.htm
http://library.thinkquest.org/3659/orgchem/alkenes-alkynes.html

Further help for students

1. Using formulas in a spreadsheet

One way to test out formulas is to open a 'Lists & Spreadsheet' page and enter the information in the table. You could then test out your formulas by entering them into the spreadsheet.

To enter a formula for a particular cell type "=" followed by the cell label e.g. "B5" and the operation e.g. "+1". Such formulas can be copied and pasted down a row. Press enter to see if you get the value you want.

	A	B carbon	C hydrogen	D bonds	E
1	Methane	1	4	4	
2	Ethane	2	6	7	
3	Propane	3	_		
4	Butane	4	_		
5	Pentane	5			
6	Hexane	=B5+1			
7					

	A	B carbon	C hydrogen	D bonds	E
1	Methane	1	4	4	
2	Ethane	2	6	7	
3	Propane	3	_		
4	Butane	4	_		
5	Pentane	5			
6	Hexane	6			
7					
8					

If you have a general formula you can enter this in the cell at the top of a column.
For example if you thought that the number of hydrogen atoms is equal to one more than three times the number of carbon atoms you could type in

- "= 3*carbon + 1"in the shaded cell at the top of a new column or
- "=3*b[] + 1" since column B has the carbon figures in. Square brackets [] indicate a column.
- Press enter and see if the values in the new column agree with those in the hydrogen column.

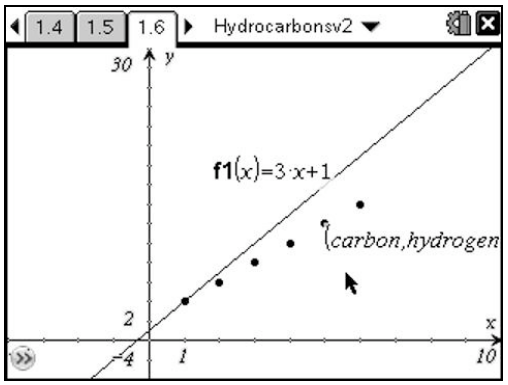
- If they don't match why do you think this is?
- Can you find a rule that does work?
- What about formulas for the number of bonds or for the general chemical formula?

	A	B carbon	C hydrogen	D bonds	E	F	G
					=3*carbon+1	=3*b[]+1	
1	Methane	1	4	4	4	4	
2	Ethane	2	6	7	7	7	
3	Propane	3	8		10	10	
4	Butane	4	_		13	13	
5	Pentane	5			16	16	
6	Hexane	6			19	19	
7							
8							
9							
10							
	A1	"Methane"					

2. Fitting a formula to a Scatter Plot

Another way to look for patterns and rules is to open a Graphs page and plot points where the x-coordinate is one of the values (say the number of carbon atoms) and the y coordinate is the value that goes with it from another column (say the number of hydrogen atoms).

1. Open a Graphs page.
2. From menu 4 select 'zoom quadrant 1' then from menu 3 select 'Scatter Plot'
3. Use the arrow keys in the boxes to set x and y to the columns that you want -in this case 'carbon' for x and 'hydrogen' for y. This will give you a scatterplot for all the values you have entered in these columns.
4. The next step is to try to fit the graph of a function, so from menu 3 select 'function' and type in your rule after '**f1(x) =**'in the entry line at the foot of the screen.
   For example if you think that
   hydrogen atoms = 3* carbon atoms + 1,
   type in
   f1(x) =**3*x+1**



Some questions to think about

- Does the graph fit the points on the scatterplot?
- Can you find a rule that does fit?
- What are the connections between the points in your table, the function for the graph and your rule?
- What other rules can you find connecting the number of carbon atoms to other features of hydrocarbons such as the number of bonds or the chemical formula?
- Can you explain how the rules you have found can be obtained by looking at the diagrams for the chemical structure?

Extension suggestions

Try to set up a new document with a 'Lists & Spreadsheet' page so that you can investigate 'Alkenes' or 'Alkynes' Find out more about alkanes, alkenes and alkynes by doing some internet research. How well do your formulas match? What else could you investigate?