

Unit 1 – Investigation 1

Hydrocarbons

Introduction

This interdisciplinary lesson explores the mathematical pattern that emerges when atoms are joined together to form molecules. No special knowledge of chemistry is required to present this lesson. In fact, the lesson can be presented without any mention of chemistry simply by using building materials and specifying how they can be linked. The pattern emerges naturally as students build their models following the linking rules. The connection with chemistry can be developed later. In what follows, the chemistry connection is introduced once the students have had a chance to work with the models. This accentuates the mathematics of the pattern before exploring the interdisciplinary connections.



Titan

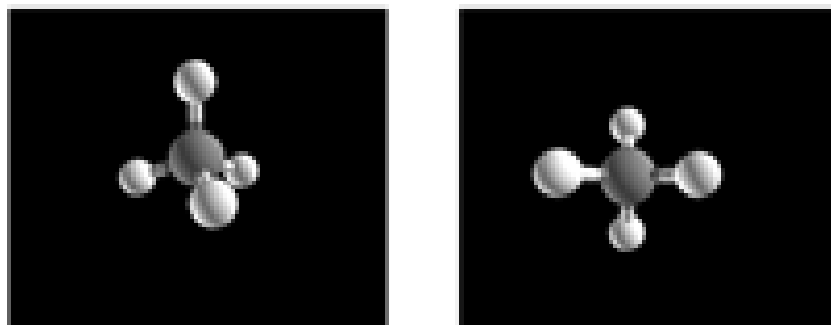
Closer view of Titan
taken by Cassini Spacecraft

Hydrocarbons are chemicals that contain carbon and hydrogen. Hydrocarbons have many uses including fuel for energy. The Earth's supply of hydrocarbons is becoming depleted, but there is a seemingly endless supply in liquid lakes on the surface of Saturn's moon Titan. Titan's lakes are a mixture of different hydrocarbons. Hydrocarbons that are normally a gas here on Earth are liquid or frozen on Titan due to the frigid temperatures. You are planning a space mission to Titan for the year 2022. The mission will harvest hydrocarbons from Titan's surface lakes and use the Sun's gravity return them to back to Earth.

Simple hydrocarbons called alkanes have a specific pattern to their structure and each one has its own specific name. You will build models of simple hydrocarbon molecules and find the mathematical pattern in their structures. The following instruction explains how to build models of these simple hydrocarbon molecules:

Grey balls represent carbon atoms and white balls represent hydrogen atoms. A Simple hydrocarbon has one or more carbon atoms and a number of hydrogen atoms. The following instructions tell how you may build models of hydrocarbon molecules: Grey balls must have exactly four links and may be connected to white balls or other grey ones. White ball must have exactly one link. Every different hydrocarbon has its own name. We can use the internet to find the name if we wish.

First build a model of hydrocarbon molecule having just one carbon atom. Check to see that it looks something like the images below. (Its name is methane – you may have heard that name before.) Notice that the hydrogen atoms are arranged in a special three dimensional pattern around the carbon atom. Try to make your model shape look similar.



Two views of a methane molecule

- The first way we will study the pattern is by analyzing information in a data table. Complete the following table by showing how many carbon atoms and how many hydrogen atoms are in the molecules you built with your models. Don't worry about their names for now.

Hydrocarbon name(s)	Hydrocarbon Molecules	
	Carbon Atoms	Hydrogen Atoms
Methane	1	4
Ethane	2	6
Propane	3	8
Butane	4	10
Pentane	5	12

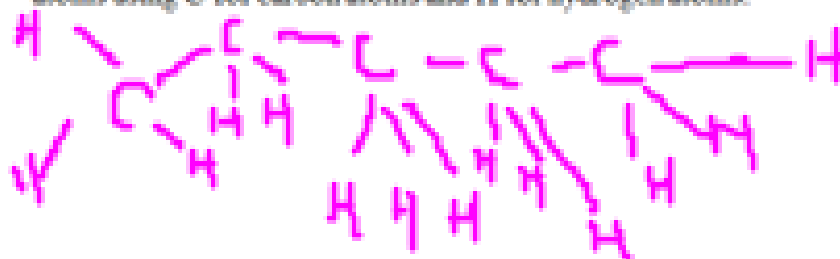
- Describe what happens to the number of hydrogen atoms when the number of carbon atoms is increased by one. The number of hydrogen atoms increases by 2.

3. Can you discover a rule that predicts the number of hydrogen atoms in a hydrocarbon molecule if you know the number of carbon atoms? Write a verbal description of the rule.

Take the number of carbon atoms, multiply by 2, then add two.

4. The next larger simple hydrocarbon has five carbon atoms. From your answer in question 2, and using the table, how many hydrogen atoms would you predict that this hydrocarbon has? 12
Add this information to the blank row in the table.

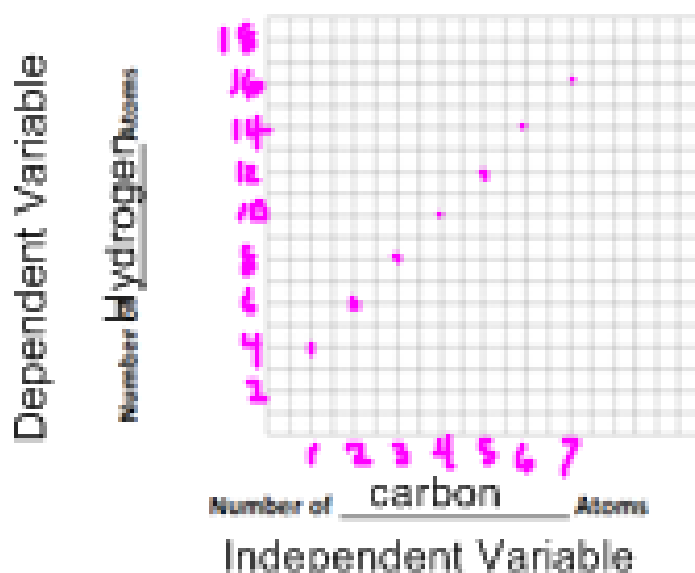
5. Based on your prediction in question 3, draw a rough stick model of a hydrocarbon with five carbon atoms using C for carbon atoms and H for hydrogen atoms.



Will everyone's stick model look the same? NO
Explain your answer:

6. Use the coordinate grid below to draw a graph that shows the relationship between the number of carbon atoms and the number of hydrogen atoms in the hydrocarbons that you listed in your table. Make sure to label the coordinate grid and use an appropriate scale.

Name of graph: Simple Hydrocarbons



7. In your own words, explain how you chose your labels for the horizontal and vertical axes?
8. Would you be able to extend the graph to see how many hydrogen atoms there would be in a hydrocarbon with six carbon atoms? _____ How can you be sure of this?
9. What would happen if you extended the graph to the left?
10. Using the table and the graph we see a pattern emerging. If we know the number of hydrogen atoms in a simple hydrocarbon with nine carbon atoms, how many will there be in a simple hydrocarbon with 10 carbon atoms?
11. Are we able to write a formula that will work for any hydrocarbon. Let c represent the number of carbon atoms. Going from a pattern to a formula is a guess and check process. Guessing takes practice. Look at the data in the table you created above.

If c represents the number of carbon atoms in a simple hydrocarbon molecule, and h represents the number of hydrogen atoms then the expression to find the number of hydrogen atoms would be $2c+2$, so we could say that $h=2c+2$

12. Use this to find the number of hydrogen atoms in a hydrocarbon with eight carbon atoms.

$$h = 2(8) + 2$$
$$h = 18$$

13. Suppose a simple hydrocarbon has 22 hydrogen atoms. Can you work backwards to determine how many carbon atoms it would have?

14. Can a simple hydrocarbon have 25 hydrogen atoms? _____ Explain your answer in the space below.