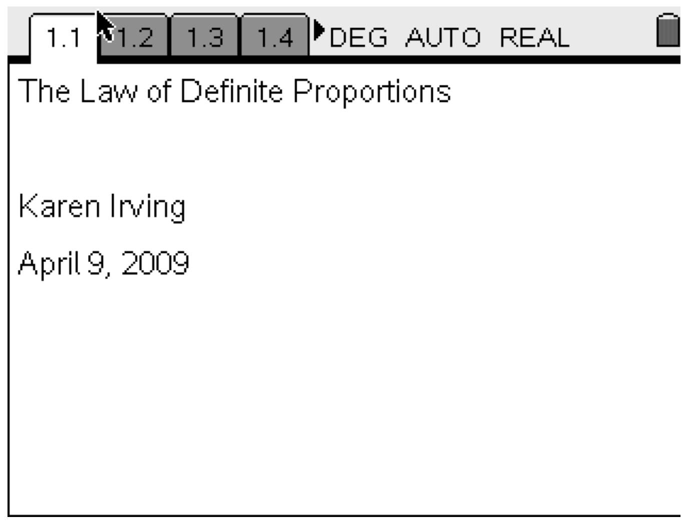
Law of Definite Proportions (LDP)

The law of definite proportions states that a chemical compound always contains exactly the same proportion of elements by mass. The French chemist Joseph Proust conducted several experiments between 1798 and 1804 to make this discovery. At the time (before Dalton had proposed his atomic theory), the law was controversial.

This activity is designed for the Nspire handheld and intends to help students increase their understanding of this law through application of the information to a set of unknown samples. Students will make claims and provide evidence for those claims.

Introduction

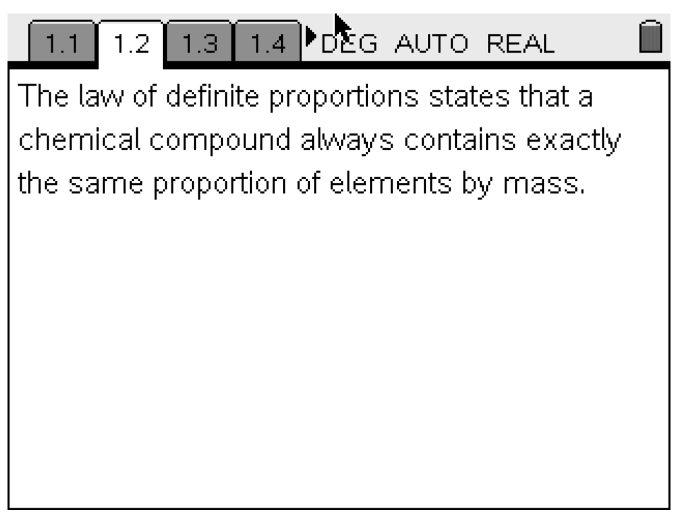
1. Open the LDPT.tns file.



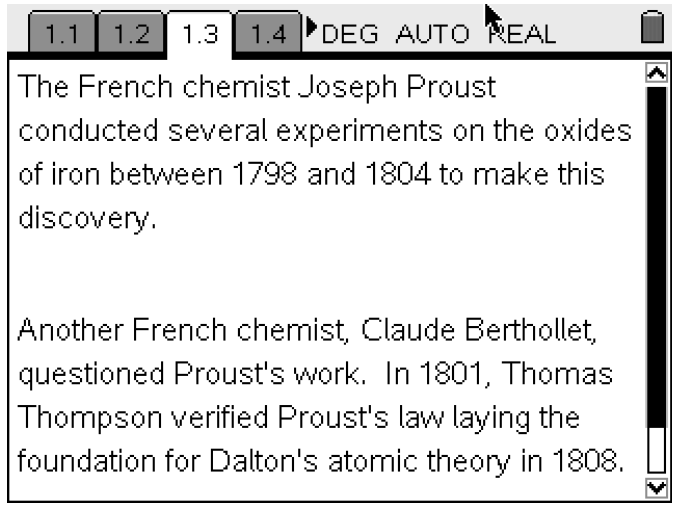
2. Ask students to read and think about the LDP.

   Q1: How is a chemical compound different from an element?

   Chemical compounds contain atoms of more than one element. H_2O *is a compound.*
   Elements contain only atoms with the same atomic number (atoms of the same element). H_2 *and* O_2 *are elements.*



3. The development of the LDP represents an interesting demonstration of the nature of science.



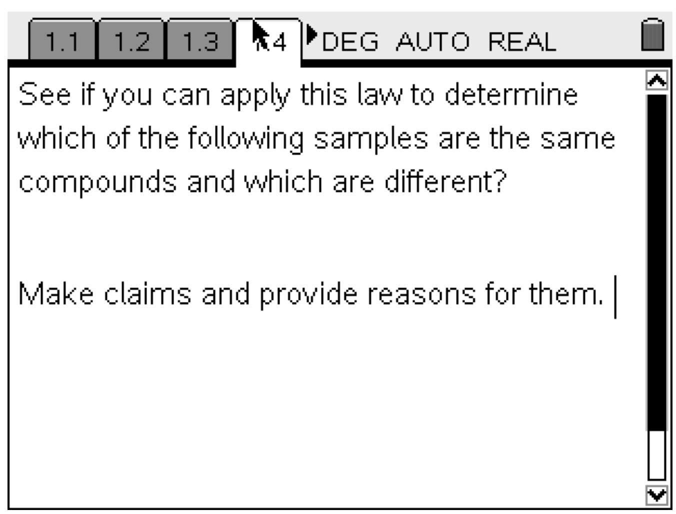
Q2: Was the LDP discovered before or after Dalton's atomic theory?
The LDP was discovered before Dalton's atomic theory.

Q3: Did all other scientists accept the LDP when it was first proposed?
No, the LDP was very controversial. Others believed that compounds could combine in any ratio of elements.

Q4: Why did Thompson need to verify Proust's work?
Additional work was needed to verify Proust's finding. This is part of how science is done. Verification by other scientists lends credibility to findings.

Q5: How did Dalton build on Proust's work?
Dalton's atomic theory provided an explanation for Proust's LDP.

4. Students will be asked to apply this law to a set of samples. They will make claims regarding the samples and will provide reasons for their claims.



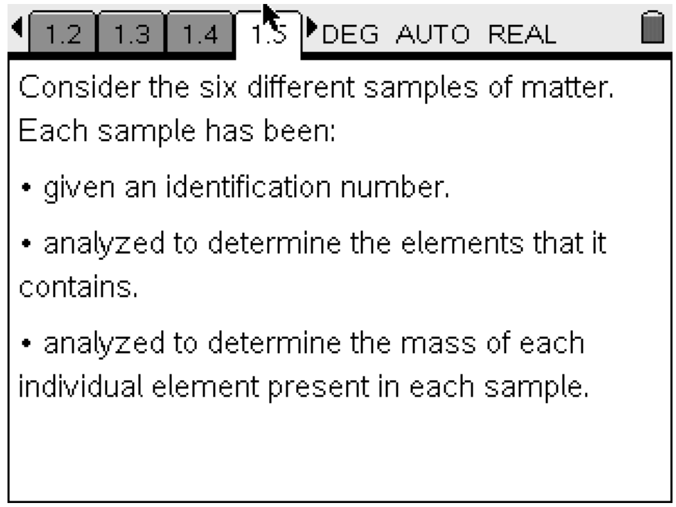
A claim is a statement or assertion that students believe to be true based on the information given.

Evidence is presented in statements from the information.

Reasons tie the evidence to the claim in a logical way.

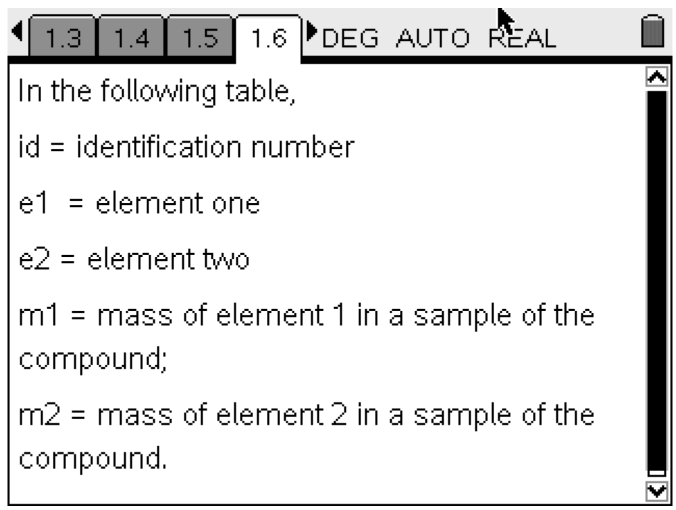
5. In this activity, you will be asked to consider six different samples of matter.

    - Each sample has been given an identification number.
    - Each sample has been analyzed to determine the elements that it contains.
    - An analysis has determined the mass of each individual element present in each sample.

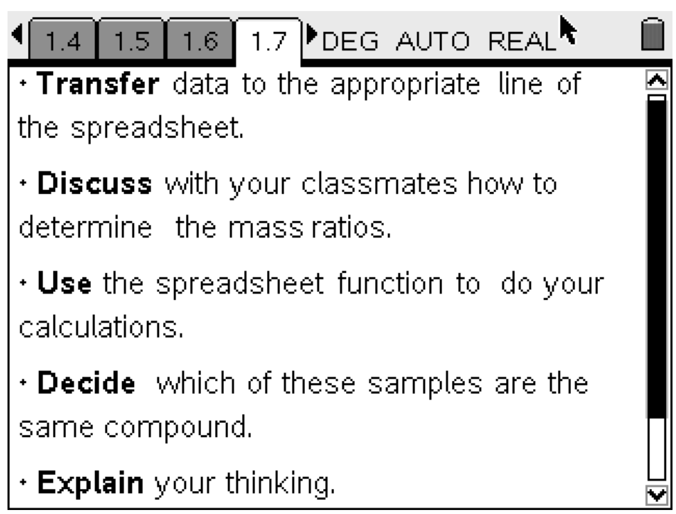


6. Use this information to make sense of the data presented in the following spreadsheet.

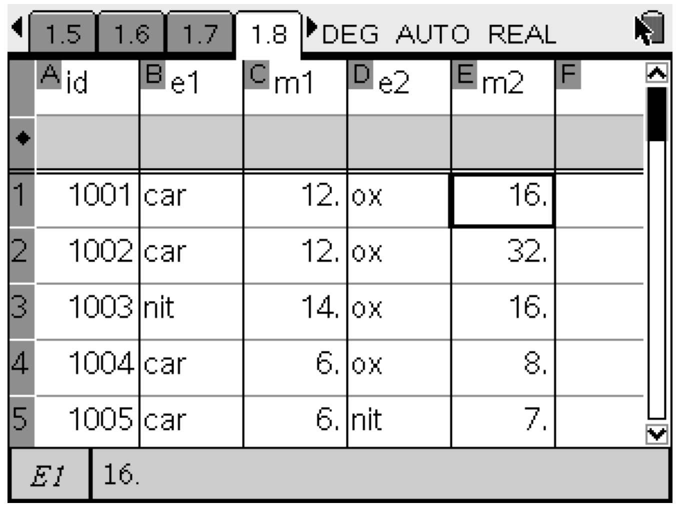
    In the following table,
    Id = identification number
    e1 = element one
    e2 = element two
    m1 = mass of element 1 in a sample of the compound;
    m2 = mass of element 2 in a sample of the compound.



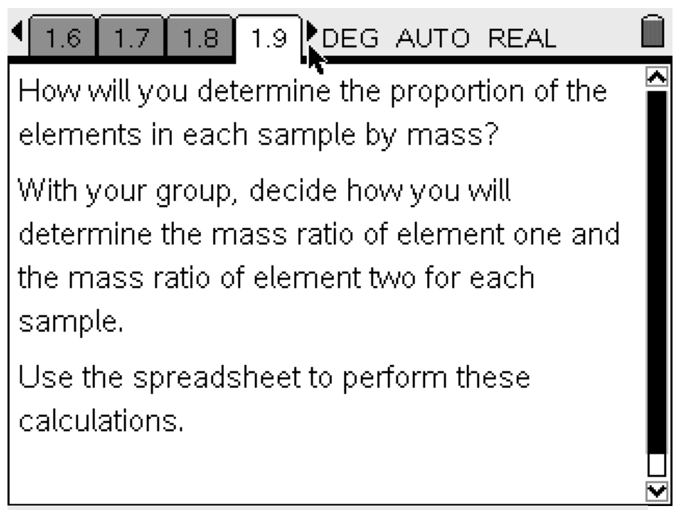
7. Follow these directions:
    - Transfer data to the appropriate line of the spreadsheet (next screen).
    - Discuss with your classmates how to determine the mass ratios for each sample.
    - Use the spreadsheet function to do your calculations.
    - Decide which samples are the same compounds.
    - Explain your thinking.



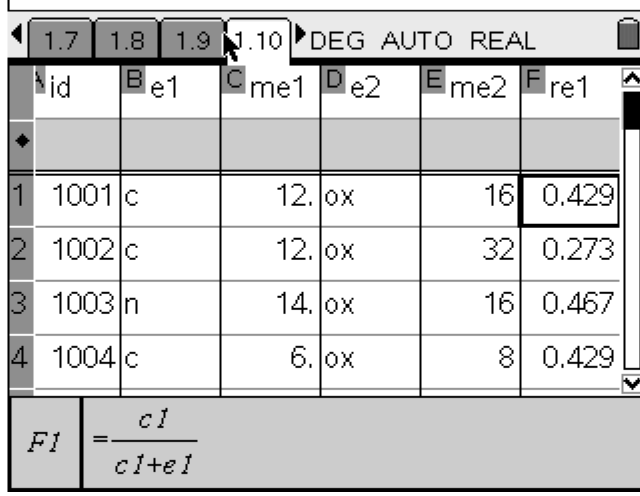
8. *Students will transfer data from their Sample ID sheets (see handout) to their table. Be sure to include decimal points after the mass values to show the decimal form of calculated values. If students enter whole numbers without decimal values, Nspire may produce fractions rather than decimal values in the ratio column of the spreadsheet. While the activity can be completed using these fractions, this will introduce an added layer of complexity to the discussion.*



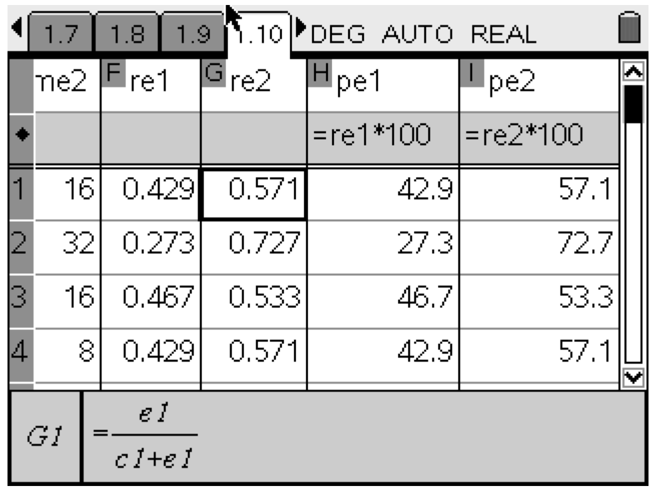
9. *A variety of methods may be used to calculate the mass ratios. Students might determine percent composition of individual elements, they might use fractional values, or they might calculate the ratio of one element and find the second by subtraction. This would be a good time to discuss the advantages or disadvantages of different calculation methods.*



10. In the table shown here, re1 refers to the ratio of element 1. Check out the *F1* line to see how the calculation was done. A similar calculation is done in column G (not shown in this screen shot) to find re2, ratio of element 2.



This screen shot shows one method to calculate the ratios as well as percent element 1 and percent element 2 calculations. Students may prefer to use percentage values rather than decimal values.

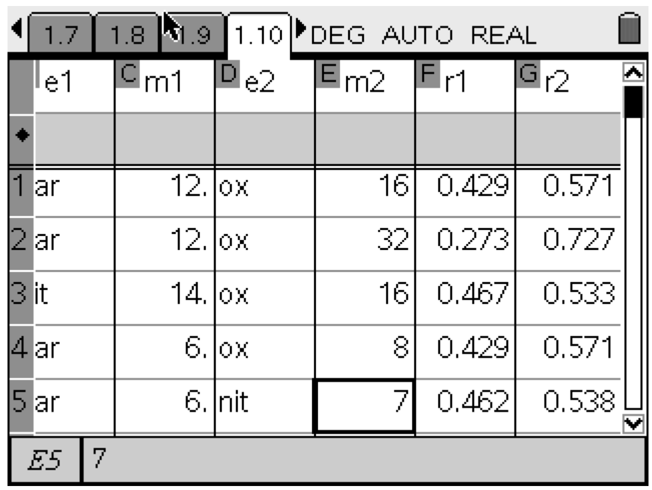


1.7 1.8 1.9 1.10 DEG AUTO REAL

	me2	F re1	G re2	H pe1	I pe2
◆				=re1*100	=re2*100
1	16	0.429	0.571	42.9	57.1
2	32	0.273	0.727	27.3	72.7
3	16	0.467	0.533	46.7	53.3
4	8	0.429	0.571	42.9	57.1

G1 $= \frac{e1}{c1+e1}$

11. Review Proust's Law of Definite Proportions. What claims can you make regarding these six samples? Be sure to provide an explanation for each claim.



1.7 1.8 1.9 1.10 DEG AUTO REAL

	e1	C m1	D e2	E m2	F r1	G r2
◆						
1	ar	12.	ox	16	0.429	0.571
2	ar	12.	ox	32	0.273	0.727
3	it	14.	ox	16	0.467	0.533
4	ar	6.	ox	8	0.429	0.571
5	ar	6.	nit	7	0.462	0.538

E5 7

Sample ID	Element 1	Element 2	Ratio Element 1	Ratio Element 2
#1001	CARBON	OXYGEN	.429	.571
#1002	**CARBON**	**OXYGEN**	**.273**	**.727**
#1003	NITROGEN	OXYGEN	.467	.533
#1004	CARBON	OXYGEN	.429	.571
#1005	CARBON	NITROGEN	.462	.538
#1006	**CARBON**	**OXYGEN**	**.273**	**.727**

12. Some example claims that students might make include the following:

Claim 1: *Sample 1003 is a different compound than any of the others.*

Evidence: *Sample 1003 has nitrogen and oxygen atoms. None of the other samples contain these two elements.*

Reasoning: *Since all samples of the same compound contain the same elements, none of the other samples can be the same substance as sample 1003.*

Claim 2: *Sample 1005 is a different compound than any of the others.*

Evidence: *Sample 1005 has carbon and nitrogen atoms. None of the other samples contain these two elements.*

Reasoning: *Since all samples of the same compound contain the same elements, none of the other samples can be the same substance as sample 1005.*

Claim 3: *Samples 1001 and 1004 are samples of the same compound.*

Evidence: *Samples 1001 and 1004 both contain carbon and oxygen. They have the same proportion of each element by weight.*

Reasoning: *Samples 1001 and 1004 are the same compound because they contain the same two elements in the same mass ratio.*

Claim 4: *Samples 1002 and 1006 are samples of the same compound.*

Evidence: *Samples 1002 and 1006 both contain carbon and oxygen. The ratio of elements is the same for each sample.*

Reasoning: *Samples 1002 and 1006 are the same compound because they contain the same two elements in the same mass ratio.*

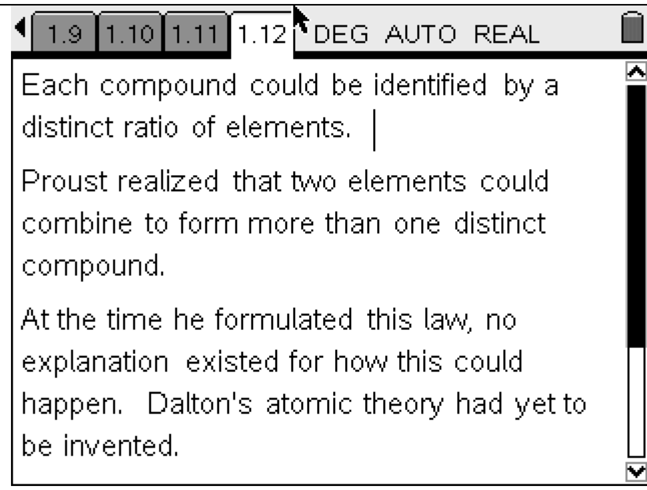
Claim 5: *Samples 1001 and 1004 are not the same compound as samples 1002 and 1006.*

Evidence: *All four samples contain two elements, carbon and oxygen. But, samples 1001 and 1004 have a different ratio of elements from samples 1002 and 1006.*

Reasoning: *Samples 1001 and 1004 are the same compound as each other, but are a different compound from Samples 1002 and 1006. At least two different compounds of carbon and oxygen exist. One compound has 42.9% carbon and 57.14% oxygen. The other compound has 27.3% carbon and 72.73% oxygen.*

12. Proust's Law of Definite Proportions meant that each compound could be identified by a distinct ratio of elements. In addition, two elements could combine to form more than one distinct compound.

At the time he formulated this law, no explanation existed for how this could happen. Dalton's atomic theory had yet to be invented.



Assessment of student learning

Checking up:

Which of the following samples are the same compounds? Explain why?

Sample	Element 1	Element 2	Ratio element 1	Ratio element 2
A	N	O	.226	.774
B	N	H	..226	.774
C	N	O	.304	.696
D	N	O	.226	.774
E	H	O	.111	.889

Sample response:

Claim: Samples A and D are the same compound.
Evidence: They both contain nitrogen and oxygen. The ratio of elements is the same.
Reasoning: Samples of the same compound will have the same elements with the same ratio.

Follow up questions:

Why are samples A and B not the same compound? (Different elements)
Why are samples A and C not the same compound? (Same elements, different ratio)

SAMPLE ID 1001 Elements: Carbon: 12.0 g Oxygen: 16.0 g	SAMPLE ID 1002 Elements: Carbon: 12.0 g Oxygen: 32.0 g
SAMPLE ID 1003 Elements: Nitrogen: 14.0 g Oxygen: 16.0 g	SAMPLE ID 1004 Elements: Carbon: 6.00 g Oxygen: 8.00 g
SAMPLE ID 1005 Elements: Carbon: 6.00 g Nitrogen: 7.00 g	SAMPLE ID 1006 Elements: Carbon: 3.00 g Oxygen: 8.00 g