Name: Maloney 2010-2011

A Matter of Laws & Theory

Review:
List 3 beliefs that philosophers and alchemists held regarding matter:
Accept any reasonable answers: philosopher's stone could be created and it provided a physical connection to the spiritual, elixir of life, transmutation of metals, the elements were accepted as being Earth, Fire, Air, and Water – they made up all of Earth (Aether made up the heavenly bodies) all matter was moving towards its natural place…

Then in….

1661	Robert Boyle Known elements: Sb, As, Bi, C, Cu, Au, Fe, Pb, Hg, Ag, S, Sn, Zn	Defined an element as… A substance that cannot be decomposed into a simpler substance by a chemical reaction
1789	Antoine Lavoisier By end of 18th century adds on Cl, Co, H, Mn, Mo, Ni, N, O, P, Pt, W	Observed … the total mass of the products of a chemical reaction is always the same as the total mass of the starting material ...and called it the "Law of Conservation of Matter"
1798	Joseph Proust	Observed… that different sources of the same compound always contained the same ratio by weight of their elements (H_2O has 8 times as much O as H; cinnabar has 6.25 as much Hg as sulfur) ... and called it the "Law of Constant Composition"
1803	John Dalton	Observed… when 2 elements combine they do so in a ratio of small whole numbers and if the 2 elements form more than one compound, when one element's mass is kept constant, there will be a constant ratio of small whole numbers among the mass of the second element ….and called it the "Law of Multiple Proportions"

The following activity is designed to help you understand these laws.

Two new elements have been discovered in the chemistry department of Hollis-Brookline High School. One has been named Rotellium and the other Saarium. Experiments with these two new elements show that they are very reactive and can form more than one compound with each other. This is very similar to carbon {C} and oxygen {O} which can form carbon monoxide {CO} and carbon dioxide {CO_2}. Samples of the newly discovered elements and their resulting compounds have been collected for you to study.
Duplicate chart on the board. Use balances that reflect student skill level. I find the best results come from giving lab partners one bottle to weigh and then record their measurement on white board. This also provides a formative assessment of weighing technique if pan balances

are used as "wrong"answers are easily spotted. I use this as a review of precision if same type of balance is used but differing numbers of sig figs are recorded.

Procedure:

1. Do not open the bottles. Carefully observe the labels on each bottle.
2. Using the balance at your station, record the mass of each substance in Table 1.
   - For this activity consider the mass of the container as part of the substance.
   - Be sure to record the mass of the bottle in the column and row that matches the label.
   - Remember that your measurement must reflect the precision of the instrument used.

Table 1. Raw Data (Data is purposely not "perfect" to allow for discussion; these values have been rounded; student measurements should be close to these)

	Reactants		Product
Reaction #	Rotellium (g)	Saarium (g)	Compound (g)
1	40	25	65
2	40	50	90
3	40	100	140
4	60	75	135

Analysis:

1. Explain how the data in Table 1. supports the Law of Conservation of Matter.

In each reaction the mass of the reactants is equal to the mass of the product

2. Do you think reactions 1, 2, 3 and 4 created the same compound? Explain.

Accept any reasonable response; typically students think the two elements will always form the same compound or that they are all different because the masses are different.

3.Often data needs to be "manipulated" (graphed, calculated, etc.) before patterns can be detected. Determine the percent composition by mass for each element using the following formula. Enter the data into Table 2.

$$\text{Element \%} = \frac{\text{Element (g)}}{\text{Compound (g)}} \times 100$$

Table 2. Manipulated Data

Reaction #	Rotellium (%)	Saarium (%)
1	62	38
2	44	56
3	29	71
4	44	56

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4. Which two reactions probably produced the same compound? Support how you know this using the data in Table 2. Which law does this exemplify? Reaction numbers 2 and 4, because the percent composition is the same. This is the law of constant composition.

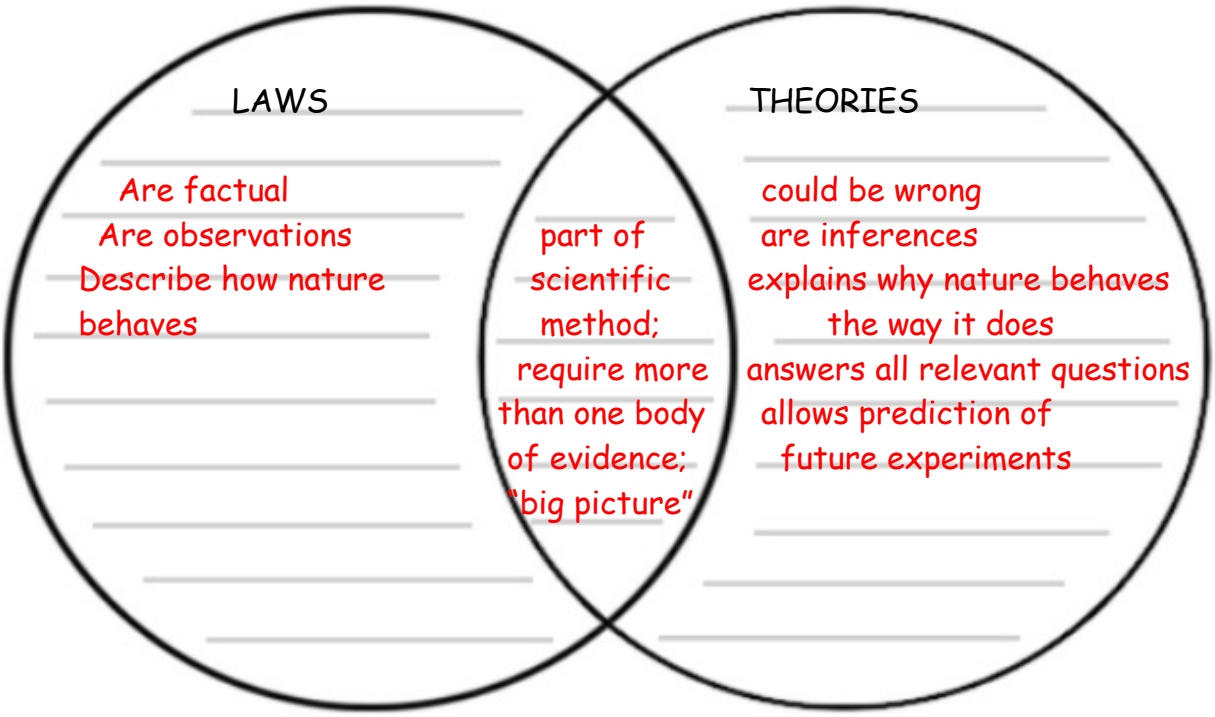
5. In order to understand the Law of Multiple Proportions we need to actually compare more than one ratio (thus we get "multiple proportions"). Round the masses recorded in Table 1 to whole numbers and fill in the boxes below.

Reaction 1		Reaction 2		Reaction 3
40 Rotellium (g) / 25 Saarium (g)	:	40 Rotellium (g) / 50 Saarium (g)	:	40 Rotellium (g) / 100 Saarium (g)

6. When the amount of one element is held constant (doesn't change) we should be able to see a ratio among the second element that can be reduced down to small whole numbers. The amount of Rotellium has been held constant in each reaction above. What is the ratio ***between the amounts of Saarium*** from each reaction. Be sure to reduce the numbers.

Reaction 1		Reaction 2		Reaction 3
1	:	2	:	4

7. The laws described in this activity were crucial in the development of atomic theory. Use the Venn diagram to explore the differences and similarities between natural laws and scientific theories.



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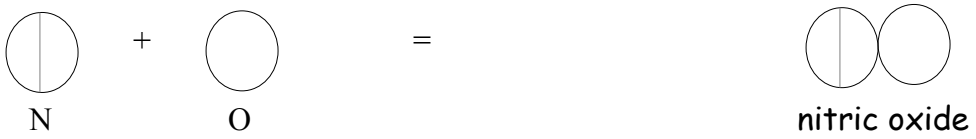
1808	John Dalton	Infers the existence of atoms and is credited with the first modern atomic theory.

8. Match the following postulates of Dalton's atomic theory :

1. Elements are considered pure because __C_____
2. Elements differ from each other because __E_____
3. Unlike mixtures, compounds are pure substances because __A____
4. Compounds have constant composition because __D___
5. Compounds and elements are the outcomes of chemical changes because __B___

A. atoms of different elements are "hooked" (bonded) and can only be chemically unhooked.
B. chemical reactions involve the rearrangement of combinations of atoms.
C. all atoms of an element are identical in mass and other chemical and physical properties.
D. they contain fixed ratios of atoms and each atom's mass is fixed so the compounds mass is fixed.
E. atoms of each element are different from each other.

9. In 1808 Dalton presented a model of his theory in the form of a chart of symbols and formulas for elements and several compounds. For example he symbolized the elements nitrogen, oxygen and two of their compounds as follows:



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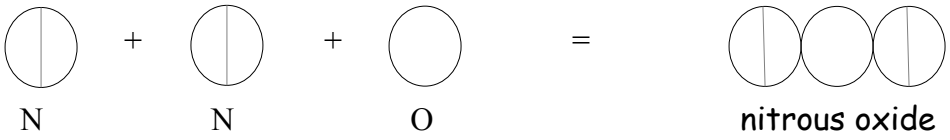
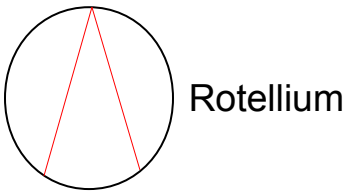
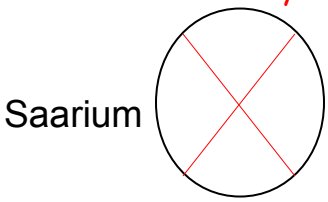
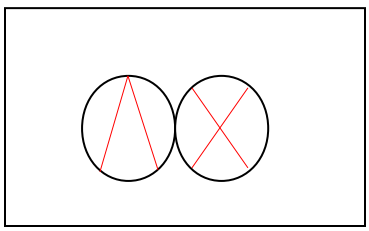
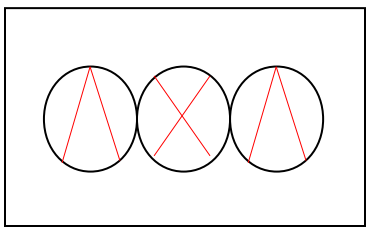


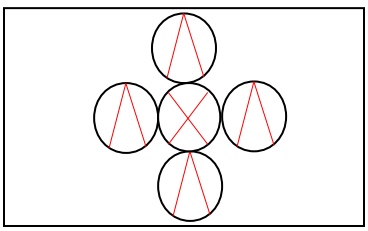
Infer as to the chemical formulas for the three compounds that form between Rotellium and Saarium. In the circles below create a symbol for Rotellium and Saarium. In the boxes use your symbols to depict the compounds that formed. Students should keep design simple so that it can easily be duplicated






Compound: Reaction 1


Compound: Reaction 2


Compound: Reaction 3

Homework: Assume the role of John Dalton and <u>using your own words</u> prepare a speech to present to the scientific community of 1808 that will convince them of the existence of atoms.

I John Dalton know that atoms exist because...