UNIT 2 UNIT TASK

Altered Reality

In our universe the arrangement of the elements in the periodic table is a direct consequence of their four quantum numbers: n, l, m_l, and m_s. For example, all Group 1 elements have a similar electron configuration of one electron in the outermost *s* orbital. This configuration determines many of the group's chemical properties. The following is a description of each quantum number:

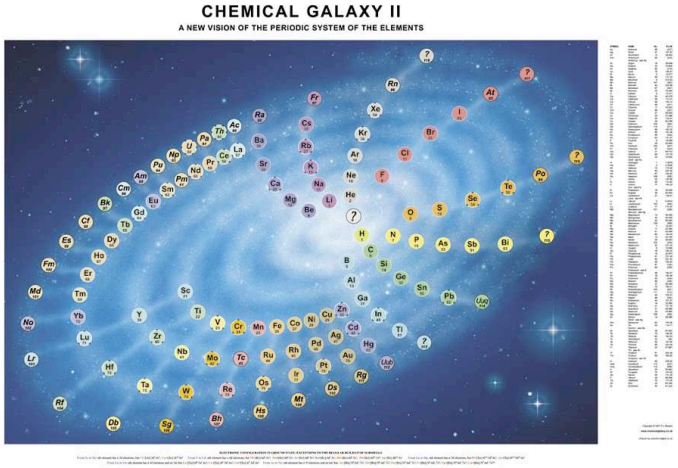
- n: main energy level, n = 1, 2, 3, 4,…
- l: shape of the orbitals (*s*, *p*, *d*, *f*, etc.), l = 0 to n–1
- m_l: magnetic quantum number for orbital orientation, where $m_l = -l$ *to* $+l$
- m_s: spin quantum number, $m_s = -½, +½$

Imagine that in your new universe this chemical reality has changed and that the universe now follows a different set of quantum number rules --- the old rules no longer apply. In the new universe, the following change occurred:

$m_l = -(n+1)$ to $(n+1)$

All of the other quantum numbers, n, l, and m_s, remain the same.

This change in one quantum number changes not only the laws of physics, but the periodic table as well --- the chemical properties of the elements changes. Your new universe is made of elements (**Figure 1**) that are arranged differently and follow a different set of fundamental standards from the elements in this universe.



CAPTION **Figure 1** The new universe with a different set of rules for the magnetic quantum number m_l.>

Task

In this Unit Task, you are a chemist who is responsible for developing a new periodic table of the first 40 elements. You will need to compile this new periodic table based on the new definition of the magnetic spin quantum number. This exercise will help you understand how chemists developed the original periodic table that we use today. In this activity, you will test your understanding of the use of quantum numbers to describe the organization of elements in the periodic table.

Purpose

To understand the relationship between quantum numbers and periodic trends among the elements by creating a new periodic table of the elements based on a hypothetical change to the magnetic quantum number.

Procedure

1. Using enough space for 40 elements, draw the outline of your new periodic table in which elements have a magnetic quantum number $m_l = -(n+1)$ to $(n+1)$.
2. Identify the groups and periods in your new periodic table.
3. Add the elements to your new table. You can use the names of the current first 40 elements, or you can create your own element names.

Analyze and Evaluate

(a) What variables did you use in this activity? What did you change? What was the result of each change? [T/I] <The four quantum numbers of each element are the independent variables in this experiment. The organization of the elements into a periodic table is the dependent variable. >

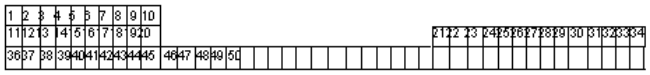
(b) Explain how the number of electrons allowed into the *s*, *p*, *d*, and *f* orbitals has changed from the real periodic table. [T/I]< The number of electrons for each period is different. For example, the current orbital shapes *s, p, d,* and *f* can hold up to 2, 6, 10, and 14 electrons respectively. In the new periodic table, 40 electrons can fit into only three orbital shapes that contain 10, 14, and 18 electrons each.>

(c) In your new periodic table, why is there a different number of groups compared to the real periodic table? [T/I] <Since there are more electrons in each orbital shape, there are more groups (columns).>

(d) In your new periodic table, why is there a different number of elements in a given period compared to the real periodic table? [T/I] <Since more electrons can fit into each orbital shape, more electrons fit in each shell and therefore there are fewer periods needed to accommodate 40 elements.>

(e) What are the atomic numbers of the elements in the new universe that are likely to have properties similar to the alkali metals

in our universe? Why? [C] <1, 11, and 35. They all have one electron in their highest principal quantum number shell (the valence shell).>
(f) How many of the first 40 elements are probably nonmetals? Why? [C] <Answers will vary as many hypothetical explanations are possible. As one example, in the original periodic table, all of the first row elements plus all the second row elements with *p* valence electrons are non-metals. In the new periodic table, there are 10 first row elements and 14 second row elements with *p* valence electrons for a total of 24. Assuming this trend holds in the new periodic table, 24 of the first 50 elements should be nonmetals. You could also argue that it is rare in the real periodic table for atoms with more than 18 electrons to be nonmetals and so fewer than 24 of the first 50 atoms would be nonmetals.>
(g) What is the electron configuration of element number 20 in the new periodic table? [C]<$1s^{10}2s^{10}$>
(h) How do you think chemical bonding would be different in this new universe? [A] <Different three dimensional structures would form and different hybrid orbitals would form. Also, there may be molecules that would have more than 3 bonds between atoms and the octet rule would likely not exist. You may have a "dec-tet" rule instead. <CATCH: table example:



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(i) Complete the following table with the allowed values for all four quantum numbers for the elements in your new periodic table:

Principal Quantum Number (n)	Secondary Quantum Number (l)	Magnetic Quantum Number (m_l)	Spin Quantum Number (m_s)
1	0 *(s)*		
2	0 *(s)*		
	1 *(p)*		
3	0 *(s)*		
	1 *(p)*		
	2 *(d)*		

[A]<

Principal Quantum Number (n)	Secondary Quantum Number (l)	Magnetic Quantum Number (m_l)	Spin Quantum Number (m_s)
1	0 *(s)*	<-2,-1,0,1,2>	<+1/2,-1/2 >
2	0 *(s)*	<-2,-1,0,1,2>	<+1/2,-1/2 >
	1 *(p)*	<-3,-2,-1,0,1,2,3>	<+1/2,-1/2 >
3	0 *(s)*	<-2,-1,0,1,2>	<+1/2,-1/2 >
	1 *(p)*	<-3,-2,-1,0,1,2,3>	<+1/2,-1/2 >
	2 *(d)*	<-4,-3,-2,-1,0,1,2,3,4>	<+1/2,-1/2 >

>
(j) What type of bonding would you expect from an element in the first group of the new periodic table that bonds to an element in group 41, the second-last element in the *p* orbital? [A] <It would likely be an ionic bond, with the transfer of one electron from group 1 to group 41, since group 41 would be very electronegative compared to group 1.>

Apply and Extend

(k) Imagine that you have just made a purchase and the company from which you have bought your item needs to send it to you. Explain how quantum numbers are similar to your address. [A] <Quantum numbers describe a single electron's location. Therefore, you need all four quantum numbers to identify a particular electron. Just like a package couldn't be delivered if the address has a missing house number or street name, an electron can't be located on an atom unless all 4 quantum numbers are specified.>
(l) What would happen if you only gave the store your street address? Compare this situation to knowing only one quantum number. [A] <Similarly, when you provide your address, you need more than just the street address. The state, city, or zip code, and even your name are necessary to get the package to you personally. One item alone will not completely describe your location, and one quantum number does not completely describe an electron's location.>

Your completed Unit Task will be assessed according to these criteria:

Knowledge/Understanding
☑ Identify the manipulated and controlled variables

Thinking/Investigation
☑ Develop a plan to determine the arrangement of elements in your new periodic table.
☑ Correctly use the variables in the activity.
☑ Fill out the new periodic table correctly.
☑ Analyze the results.
☑ Evaluate the new periodic table.

Communication
☑ Effectively illustrate the new periodic table.
☑ Prepare a suitable lab report that includes the complete procedure for creating the new periodic table, the new completed periodic table, a summary of the new periodic table, and your analysis and evaluation of the new periodic table.

Application
☑ Analyze the results of the new table as compared to the current periodic table.

Altered Reality Assignment Marking Scheme Name:_____

Application mark Final Mark /26

Section	Criteria	Mark	Comments (if any)
PERIODIC TABLE	➢ 40+ elements are shown ➢ each period has the correct number of elements ➢ the groups are properly organized ➢ division between metals and non-metals is shown ➢ orbital blocks are identified ➢ the noble gases are identified	/6	
ANALYSIS	➢ explanation for the difference between the altered reality table and the actual table (3) ➢ explanation of atomic number that would be alkali metals (2) ➢ explanation of number of elements that would be non-metals (2) ➢ electron configuration with explanation (2) ➢ bonding questions with explanation (2) ➢ apply and extend questions (2)	/12	

Communication Mark

Mark	1 or 2	3 or 4	5 or 6	7 or 8
	There is little explanation or reasoning. Answers to the analysis questions are rambling or off topic. There is poor use of terminology with several grammar/spelling mistakes.	Explanation or reasoning is incomplete. Answers to the analysis questions are poorly focused. Scientific terms are used but there are some spelling/grammar mistakes.	Explanations and reasoning demonstrate a good understanding of the material. Answers to the analysis are clear and there proper use of scientific terms with few spelling/grammar mistakes.	Explanations and reasoning demonstrate complete understanding. Answers are clear, concise, use proper scientific terms and there are no spelling/grammar mistakes.

Comments -