A Lesson Plan to Accompany the 3D Alexander Arrangement of Elements Model

Randomized to Organized by Allison Despain and Roy Alexander

Lesson One

Overview

The periodic table is a marvelous tool created by and perfected by scientists across many generations spanning centuries. The sequential element line is identified while other property relationships are also evident.

The first true periodic table was made on a cylinder. Alexandre-Emile Beguyer de Chancourtois reasoned that this allowed him to group elements with similar chemical properties and simultaneously display the continuity of the elements in increasing weight (most likely), displaying periodicity for the first time.

Lothar Meyer and Dmitri Mendeleev also arranged the elements according to weights, but flat, by breaking the continuity between periods - a more convenient form for printing - and Mendeleev famously left chart spaces and property predictions for the elements to fill them.

Moseley used the new technology of X-Ray to order the elements by increasing atomic number of protons as we know it today. Application of technology advances continually permitted progress in improving the periodic table.

Producing numerous post-Uranium elements during WWII research, Seaborg moved these elements outside the main body of the table, but approved of the method of returning them in an update of the first periodic table into the three-dimensional tables of Roy Alexander and George Gamow.

Classroom introduction of the Seaborg approved Alexander Arrangement 3D model illustrates the Periodic Law, where the sequential element line of the periodic table is maintained in Moseley's order while other element property relationships are retained.

The unexcelled value of the standard flat table's full visibility and convenience as learning and working tools is identified in compare and contrast exercises, both in class and as research homework.

The purpose of this lab is to build a foundation for discovery of trends in reactivity of some elements in groups and across periods. The trends, introduced here and fully implemented in the following lesson, can be readily observed in 3D, and a learning aid is provided for this purpose.

Outline: **Randomized to Organized Lesson**

Engage

Randomized Card Sort. Following an introductory slide show of pre-periodic table history, students get first hand experience of how the periodic table was originally mapped. Students are given printed group 1a and 2A element property data boxes - jumbled and with no element name or symbol. Working in groups of 2 to 3, students will try to sort these mystery boxes into categories and position them based only on the data they bear. Students will use simple logic with numbers for the task.

Explore

Relationship Discovery. Students will discover property relationships, organize and attach the full set (17 or 20) according to one, then use another. Logic will lead them to the recognition that successful completion of both activities requires a three-dimensional solution.

Explain

Element Arrangers. At appropriate points in the lesson, students will view periodic table history PowerPoint slides and hold related discussions. The ground breaking of the early conceptualizers is noted, the establishment of the periodic table by the following visualizers will connect with some of the issues that students experienced in the previous activity, and technology that aided later manipulators in their the efforts toward improvements will be identified.

Elaborate

Periodic Table Modeling. Students having created a model for themselves will appreciate reinforcement by introduction to a professional version of their conclusion. They will develop a presentation that summarizes periodic table history, modeling according to an accepted scientific Law, identification of properties and trends, and comparing effectiveness and applications of informational model formats.

Evaluate

Compare and Contrast: The re-introduction of the familiar flat periodic chart contained within their classrooms, textbooks, and other learning aids, has gained added credibility by having had the logic clarified by 3D modeling. Classroom discussion and assigned research assures that removal of the 3D periodic table scaffold is satisfactorily carried out.

Randomized to Organized Lesson

Meets the following criteria of National Science Standards

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry
  - Structure and properties of matter
  - Science as a human endeavor

HS-PS1-1 Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

[Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.]

[Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3),(HS-PS2-6)

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)

Next Generation Science Common Core

1. **Practices:**

"The practices describe behaviors that scientists engage in as they investigate and build models and theories about the natural world and the key set of engineering practices that engineers use as they design and build models and systems."

2. **Crosscutting Concepts:**

Crosscutting concepts have application across all domains of science. As such, they are a way of linking the different domains of science. They include: Patterns, similarity, and diversity; Cause and effect; Scale, proportion and quantity; Systems and system models; Energy and matter; Structure and function; Stability and change.

- Practice 1: Asking questions and defining models
- Practice 2: Developing and using models for understanding
- Practice 3: Planning and carrying out investigations
- Practice 4: Analyzing and interpreting Data
- Practice 7: Engaging in argument from Evidence
- Practice 8: Obtaining Evaluating and communicating information
- PS 1A: Structure of matter (includes PS1.C Nuclear processes)

The sub-atomic structural model and interactions between electric charges at the atomic scale can be used to explain the structure and interactions of matter, including chemical reactions and nuclear processes. Repeating patterns of the periodic table reflect patterns of outer electrons.

Randomized to Organized Lesson

Possible Prior Knowledge:

General idea of the physical and chemical properties matter, elements, and compounds

General idea of the common two-dimensional periodic table

Understanding of the arrangement of electrons in the Bohr model of atoms

Some historical knowledge of the atom from Democritus to Rutherford

Prior to Day 1

Teacher will have retained the teaching aids within the package of the Alexander Arrangement 3D Forever Periodic Table: de Chancourtois Biography/Photo and sketches of 3D periodic tables on the other side.

Teacher will download and print; 1. the randomly ordered element data boxes, 2. the Mendeleev Periodic Law card, and 3. the de Chancourtois Vis Tellurique image (which they will mount wrapped around a paper towel tube).

Teacher will download and become familiar with the content and Notes of the *Past & Present Arrangers of the Elements* PowerPoints, and plan the selections for use according to her/his class makeup, prior lessons, and school/curriculum requirements.

Teacher will have the Alexander Arrangement of Elements Illustrated 3D periodic table assembled, using the latest assembly notes (or video) online at http://alexanderarrangementofelements.com/3D, and familiarize her/himself with the features of this model at http://www.3dperiodictable.com/.

Equipment needed for student organization of data box activity will be: scissors, clear adhesive tape, and (optimal) dark permanent marker.

Randomized to Organized Lesson

Engage:

Without prior knowledge, students get first hand experience of how the periodic table was originally mapped, discovering a new format.

The teacher will show part 1 of the slide show *PAST AND PRESENT ARRANGERS OF CHEMICAL ELEMENT SYSTEMS*, which illustrates different approaches to thinking about what matter is, how to represent observations, and attempts to 'get it right' by Democritus, Aristotle, Diderot, Lavoisier, Dalton, Avogadro, and Cannizzaro, whose goal was to help to position the elements in such a way as to have the arrangement help in teaching and performing chemistry.

Student activity is to use common sense, logic and the minimal properties arrangers had at that time to give order to data boxes bearing these properties of elements.

Ask: "*What were the two major element properties commonly known at the time of creation the first element chart showing periodicity?*"

Data boxes are to be cut from a downloaded data set representing 2 (or 3) properties of the first 17 (or 20) elements. (Property and element numbers to be selected by the teachers according to their class capabilities.)

Working in groups of 2 and no more than 3, students will try to emulate the early element arrangers using the logical arrangement of information on the data boxes, which is similarly limited to the information these men had a century and a half ago.

Instructed to put the boxes in sequence, most students will go straight to ordering them according to number value. Some will attempt to use the plus/minus (valence) numbers, but as there is no complete sequence without repetition, this will fail.

Ask: "*Tell us your reasons for arranging them the way you are doing.*"

Once students have organized them in a horizontal numeric sequence they will tape the boxes together in left to right order to create a long horizontal ribbon.

This may be a good time to show students the Periodic Law card, and discuss the logic of the application of numeracy to determining organizational arrangement, and the general definition of a Law in science, vs. Rule, Theory, etc.

Ask: "*How can you arrange it so that the remaining properties are correctly connected, but without changing the first?*"

If some - with the 20 set instead of 17 - use the Atomic Numbers and oxidation/mass numbers for both sets of properties, the explanation can be that they will learn who made the new numbers will be in the next PowerPoint, but these few elements were pretty much in the same order either way - except at one place they may discover soon.

While students continue arranging the element ribbon until a second property given on the cards are arranged in a way that they can also be taped directly together as the first were, explain that the plus and minus numbers are valences, and what that means.

Oxidation may be explained during this process, and valence. Students will manipulate the ribbon of data boxes by wrapping, so that valence numbers that are alike occur over and under each other.

Let the students know they are on the right track when seen forming a helical (spiraling) structure. If some - with the 20 set instead of 17 - discover a problem when connecting the last few data boxes the concept of pair reversals can be taught. Explanation can be that they will learn who fixed this reversal in the next PowerPoint, and to revise the sequence according to the valences for now.

Begin part 2 of the *ARRANGERS* slide show within thi period of student effort. Show *duh shank coor twah* (phonetic for de Chancourtois) screens and stop.

Introduce his reasoning for the period table: that he probably arranged the table according to the new weights provided just earlier by Cannizzaro. Show students the model of his *vee tell ooo reek* (Vis Tellurique) periodic table (that has been downloaded and mounted to a tube), plus the de Chancourtois biography and photo card from the original kit.

Ask: "*Why do you think you haven't seen the Vis Tellurique before, and only the flat periodic tables?*"

The vis can be passed among the students for closer examination and to elicit questions. Discuss why de Chancourtois' element arrangement was unnoticed.

As the helical forms are produced, students will have used the pattern repeat, which will be identified as periods, hence name 'Periodic' for the arrangement. The valence pattern itself can be identified as Group and Family – and these terms discussed.

Advance to Henry Moseley on the PowerPoint and explain how he finally perfected the periodic table according to atomic number, which is the number of protons in each, determined using wavelengths of X-Ray spectra.

Ask: "*What technology was responsible for other advances in periodic table development?*"

This would be a good place for technology crosscutting, to review the advances in technology over the course of the whole process of creating the periodic table that permitted new information to be developed for improved charts.

Start the third Arranger PowerPoint and discuss Glenn Seaborg; atom bomb development, addition of transuranium elements, re-arrangement of the PT (f-block shift), and his photo with and approval of the 3D table. Point out top 2 periods in the photo – like the student's!

Continue to Alexander PowerPoint.

Reveal the illustrated 3D model of the Alexander Arrangement of Elements to students at this time. Pass it around the class and elicit comments. Call attention to the unity of the Main Group elements (Ia to VIIIa), the same source and return of both the d- and f-blocks, and the multiple connections of H in the Hydrogen Crown.

Continue with the PowerPoint screens about 3D periodic tables and George Gamow. Pass around the 3D sketch card (other side of de Chancourtois card), or project it on screen.

Ask: "*What other charts have two full sequences of identifiers split vertically and horizontally?*" (hint: week, day).

Call attention to the features of the wall or book familiar flat periodic charts, which may include full visibility of all elements, periods explicit, and groups and blocks obvious, plus the enormous benefit of this kind of this kind of arrangement being convenient for reproduction.

Ask: "*Why does the broken Mendeleev's line, displaced f-block, and separated Group A elements need to be overlooked in the high school education process?*"

Assign homework for the students to prepare a chart that compares the educational values of; 1. their classroom creations, 2. the classroom's wall hung or book standard flat periodic table, 3. the Vis Tellurique, and 4. the Alexander Arrangement, listing their online and/or book sources for each, plus write a 50 word (minimum) statement of their overall conclusions.

Analysis - Quiz:

Why did de Chancourtois make the first periodic table on a tube?

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Why did Glenn Seaborg separate out the transition metals?

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How does having the Lanthanide and Actinide metals below the main body of the flat periodic table lead to misunderstandings about the periodic table in general.

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Glenn Seaborg stated in 1997 that the Alexander Arrangement was a “correct” periodic table. What evidence do you see that it would be considered correct?

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Based on what you have observed in this lesson, why or why not do you think that group A elements should be placed together as they are in the Alexander Arrangement model?

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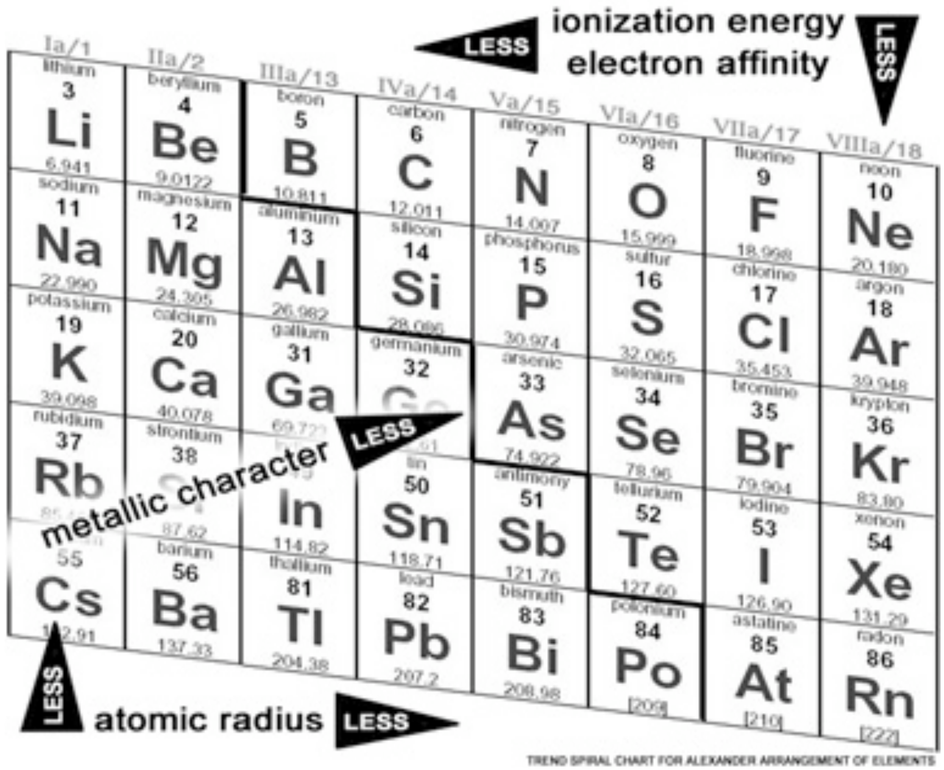
Following Lesson Content:

The lesson after *Randomized to Organized* will address property trends within the periodic table. These trends include atomic radius, ionization energy, electron affinity, and metallic character. Students will research, discuss, and then compare and contrast the various periodic tables, then submit a homework report on their research and conclusions.

During the process, students must be able to analyze trends in order to critique the existing periodic table trends teaching aids while building content knowledge.



This trends chart has been developed explicitly for use in the indication of element property trends for Alexander Arrangement of Elements 3D periodic tables, using the main group elements only, as the trends are more apparent among them, and more clearly observed than when the d-block is included.

The joining of the ends - making a tube - provides greater proximity between the elements of greater and lesser ionization energy for additional clarity.