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Chemistry of Uniqueness and Value: An Introductory First-Year Chemistry Investigation for High School Sophomores

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Chemistry of Uniqueness + Value: the intersection of economics with chemistry

<table>
<tr><th colspan="3">Stage 1 – Desired Results</th></tr>
<tr><td rowspan="4">Established Goals

Chemistry TEKS

2(F) collect data and make measurements with accuracy and precision
2(H) organize, analyze, evaluate, make inferences, and predict trends from data
2(G) express and manipulate chemical quantities using scientific conventions and mathematical procedures, including dimensional analysis, scientific notation, and significant figures;
6(A) understand the experimental design and conclusions used in the development of modern atomic theory, including Dalton's Postulates, Thomson's discovery of electron properties, Rutherford's nuclear atom, and Bohr's nuclear atom
6(D) use isotopic composition to calculate average atomic mass of an element
7(D) describe the nature of metallic</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will independently use their learning to...
● Chemistry is the study of turning stuff into other stuff and identifying the composition and components of that stuff. While we can do many amazing things with chemistry, there are limits on what we can do on earth and on what we can do as humans in our universe.
● Chemistry and other sciences can offer deeper, potentially clarifying whys to complex global and universal questions.</td></tr>
<tr><td colspan="2">Meaning</td></tr>
<tr><td>Understandings
Students will understand that….
● In science, nothing is ever completely, irrevocably known. Some ideas are considered facts after widespread experimental corroboration with many, many unsuccessful attempts at refutation, but every idea in science is subject to revision with future data.
● Identifying what you have requires experimental investigation and becomes increasingly more difficult with more complex molecules.
● Economic value (in a free market) is determined by supply and demand. Supply of a chemical species is influenced by stability, nuclear size, and scarcity on earth. Demand of a chemical species is influenced by usability or productivity.</td><td>Essential Questions
● How do you know the identity of something? How do we ever know what we have?
● What makes one metal or material different from another?
● What do macroscopic properties reveal about the sub-microscopic?
● What makes some metals or materials more or less valuable?
● Is it possible to turn something less valuable (maybe nickel, bismuth, or manganese) into something more valuable (maybe silver, gold, or platinum)?
● Is it wise to invest in silver, gold, or other precious metals?</td></tr>
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	Acquisition	
bonding and apply the theory to explain metallic properties such as thermal and electrical conductivity, malleability, and ductility Economics TEKS 1(A) explain why scarcity and choice are basic economic problems faced by every society 1(D) ...explain the concepts of opportunity costs and scarcity 2(A) understand the effect of changes in price on the quantity demanded and quantity supplied 2(B) identify the non-price determinants that create changes in supply and demand, which result in a new equilibrium price 2(C) interpret a supply-and-demand graph using supply-and-demand schedules	Knowledge *Students will know…* ● Chemistry is all about turning stuff into other stuff. Most chemical reactions involve rearranging atoms into different molecules. ● Significant figures standardize the way scientists report numeric values. Significant figures communicate the precision of a value. ● Matter is composed of submicroscopic particles: atoms (from Greek, *atomos*, meaning indivisible). ● The number of protons defines the atom. ● The mass of an atom is the sum of the protons and neutrons. ● Neutrons and protons are located in the nucleus of an atom. Neutrons stabilize the nucleus, buffering the repulsion of all the positively charged protons. ● Isotopes are atoms of the same type (same number of protons) but different masses (same number of neutrons) ● Electrons exist in an electron cloud outside and around the nucleus. ● Elemental metals are composed of 1 type of metal atom. The metal atoms ionize, creating a sea of electrons, bonding the metal. ● Matter is neither created nor destroyed.	Skills *Students will be able to…* ● Create and interpret a supply-and-demand graph ● Collect mass and volume data and determine the density of a sample ● Use density to identify a sample ● Describe the Thomson's cathode ray tube experiment and how it evidenced the presence of electrons ● Describe Rutherford's gold foil experiment and how it evidenced the presence of atomic nuclei ● Predict the stability of a nucleus based upon the ratio of protons to neutrons ● Apply chemical concepts of stability and usefulness to choice, scarcity, and opportunity cost in society ● Calculate the average atomic mass of an atom given mass spectrometry data (masses of each isotope and relative abundance values)

	● Opportunity costs are the potential losses from not selecting other options associated with making one particular choice.	

Stage 2 – Evidence		
CODE (M or T)	**Evaluative Criteria** (for rubric)	
M (T?)	Background, hypothesis, procedures, data, analysis	Performance Task(s) *Students will demonstrate meaning-making and transfer by…* Creating a series of 3 tests to determine the authenticity of metal currency *For teachers' reference:* ● Tests I anticipate students will likely select: ○ Density ○ Magnetism ● Tests students will likely need to further investigate and more deeply discover: ○ Specific heat / thermal conductivity ○ Electrical conductivity ○ Bleach + silver reaction ○ Nitric acid and muriatic acid + silver reaction ○ XRF instrument (try borrowing one from a local university's analytical chemistry department or an art museum's preservation team)
A, M M A, M M A, M A A, M A, M		--- Other Evidence (e.g., formative) ● Think-square-share: One question I now have is… ● Chalk talk around essential questions ● Exit ticket: Chemistry is… ● Think-square-share: Why would we want to turn stuff into other stuff? ● Inquiry lab: Learning about stuff (before we try to turn it into other stuff) ● History of atomic theory guiding worksheet ● "The Atom Throughout History" group performance

M (T?) A A, M A, M		● Quiz or entry ticket to assess students' individual understandings of atomic theory and history, including the question, "what makes one metal or material different from another?" ● Island of Stability application ● Intro to quantum and electron configuration, whiteboard practice and total response signals ● Coulomb's Law POGIL ● Metallic bonding and beginning periodic trends (ionization energy and electronegativity), whiteboard practice and total response signals

Stage 3 – Learning Plan

CODE (A, M, T)	Pre-Assessment *How will you check students' prior knowledge, skill levels, and potential misconceptions?*	
	Learning Activities *Day 1*	Progress Monitoring (e.g., formative data)
M	● What is this? Activity with silver, iron, zinc, platinum, tin, antimony, aluminum (and other metals that are visually different?) Begin questioning about what each metal is, how we know or think we know what we have, etc	Allowing student response to guide discussion and further questioning
A, M	● What is this? Activity with pile of nails and a small piece of silver ○ Why was I easily able to gather a pile of nails but wasn't able to obtain a pile of silver pieces? ○ How do you know this is silver? ○ What are these nails made of? How do you know? ○ Why is this small piece of silver more valuable than all these nails?	
A	● Plating a coin with 'silver' (actually zinc) and heating it to turn it into 'gold' (actually a zinc-copper alloy) ○ http://www.rsc.org/learn-chemistry/resource/res00000839/turning-copper-coins-into-silver-and-gold?cmpid=CMP00005974 ○ Did the coin turn silver? Where did what was on the penny before go? If so, where did the silver come from? Is it silver throughout now? How would you find out? ○ Did the coin turn gold? If so, where did the gold come from? Where did the silver go? Is	

A, M	it gold throughout now? How would you find	Think-square-share
A, M	out?	Chalk talk
	● Think-square-share: One question I now have is...	
	● Chalk talk around silver-specific versions of the essential questions:	
	○ How do you know something is silver? How do we ever know what we have?	
	○ What makes silver different from something else?	
	○ What makes silver valuable? What makes other things more or less valuable than silver?	
	○ Is it possible to turn something less valuable (maybe nickel, bismuth, or manganese) into something more valuable (maybe silver, gold, or platinum)?	
A, M	○ Is it wise to invest in silver, gold, or other precious metals?	Exit ticket
	● Exit ticket: Chemistry is...	
A		Think-square-share
	Day 2 + 3	
A, M, T	● Think-square-share: Why would we want to turn stuff into other stuff?	Inquiry lab guiding worksheet
	● Inquiry lab: Learning about stuff (before we try to turn it into other stuff)	
	1. What do these pieces of equipment do? Exploration	
	2. Using these pieces of equipment, measure stuff for silver, iron, zinc, platinum, tin, antimony, and/or aluminum	
	3. Generate information charts about these metals	
	a. Which pieces of data will be true for all samples of each metal (i.e., intrinsic properties)?	
	b. Which pieces of data will only hold true for your specific sample of metal (i.e., extrinsic properties)?	Total response signals during discussion
	4. Regroup as class	
	a. Discussion of intrinsic vs. extrinsic properties	
	b. Discussion of density	
	c. Discussion of sig figs	
	d. Discussion of measured vs. calculated data	
	e. Add calculated data to information chart	

	5. Identify an unknown metal using information charts generated from known metals	
	Day 4 - 6	
A	● Guiding question: *What do macroscopic measurements and calculated values reveal about the structures within?*	History of atomic theory guiding worksheet
A, M	● History of atomic theory inductive activity (materials attached)	
	● "The Atom Throughout History" group performance: each inductive activity group is assigned or selects an atomic model to create a scene illustrating. Each group performs for the rest of the class in sequence, creating the timeline of atomic experiments, ideas, and theories up to and including the modern quantum + quark theory perhaps.	Group performance
M		Quiz/entry ticket
	Day 7	
A	● Quiz/entry ticket to assess students' individual understandings of the atom, including the question, "*what makes one metal or material different from another?"*	
A	● Isotopes ○ Average atomic mass	
M, T	○ Mass spec	Island of stability application
	● Proton vs. neutron stability curve	
	● Island of stability + application ○ All the super heavy elements synthesized in labs thus far are incredibly unstable, decaying into smaller elements within nano or milliseconds after formation. Some scientists hypothesize that there exists within the super heavy elements not yet synthesized an *island of stability*, a stable group of super heavy elements. Using your understanding of the atom, the nucleus, and stability, would you support this hypothesis? Justify your response. Responses may take the form of a written piece, cartoon or comic strip, performance, video, song, or another expressive medium (pending approval). ■ https://www.youtube.com/watch?v=c1rYuslEQLs concerning element 120 and the hypothesized island of stability ■ https://www.youtube.com/watch?v=z3oY-XHwss8 particle accelerator in	

	which 6 superheavy elements have been synthesized ■ https://www.youtube.com/watch?v=wswa0NuBbMw new elements named	
	Day 8 - 10 ● Guiding question: *What makes some metals or materials more or less valuable?* Turning stuff into other stuff: let's start with the easy changes first, ***the electrons and their movements*** ● Intro to quantum chem ● Electron configuration + magnetism and conductivity ● Noble metals + noble gases	Whiteboard practice and total response signals Coulomb's Law POGIL
	Day 11 ● Coulomb's law ● Metallic bonding ○ Electronegativity ○ Ionization energy	Whiteboard practice and total response signals
	Day 12 ● How do stability and usefulness of a metal influence its supply (or scarcity) and demand? How do the stability and usefulness of a metal influence the economic choices and opportunity costs individuals are willing to make and relinquish? ● Why is it important at all to distinguish one metal from another?	
	Transition question into nuclear chemistry: *Is it possible to turn something less valuable (maybe nickel, bismuth, or manganese) into something more valuable (maybe silver, gold, or platinum)?*	

A
A
M

M
A

M, T

M, T

Super expensive metals: https://www.youtube.com/watch?v=Fg2WzCzKpYU

Most interesting metal for a ring: https://www.youtube.com/watch?v=sANZdO4d01k

Metal activity series:
http://www.compoundchem.com/wp-content/uploads/2015/03/The-Reactivity-Series-of-Metals.png

Nickel allergy linked to single receptor in immune pathway:
http://www.nature.com/news/2010/100815/full/news.2010.407.html

Super cheap XRF:
http://www.ebay.com/itm/XRF-METAL-ANALYSIS-TESTING-THERMO-NITON-XL3-XRF-ANALYZER-/291690734421