



TRENDSETTER LAB

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**Prepared as part of Target Inquiry Program
at Grand Valley State University**

A ball-and-stick molecular model showing a complex organic structure. The atoms are represented by spheres of different colors: grey for carbon, white for hydrogen, and red for oxygen. The spheres are connected by grey rods representing chemical bonds. The model is positioned on the left side of the slide, partially overlapping the text area.

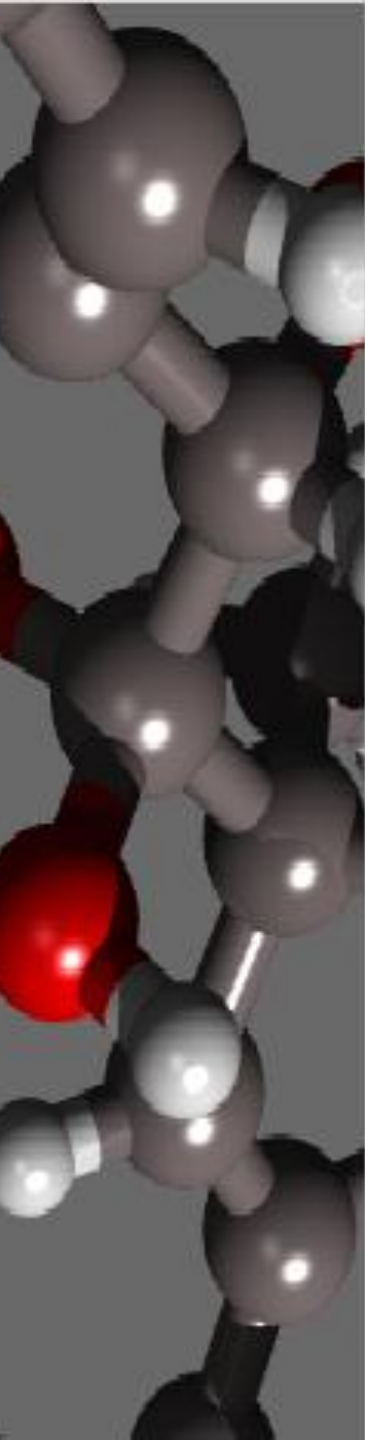
Chemistry Course

- All Michigan students are required to take chemistry OR physics (most take chemistry)
- 80% of our students take general chemistry
- 20% take Chem Essentials (Conceptual Chemistry)
- Students are in 10th or 11th grade.
- This lab is used in both courses.

A ball-and-stick molecular model showing a complex organic structure. The atoms are represented by spheres of different colors: grey for carbon, white for hydrogen, and red for oxygen. The spheres are connected by grey rods representing chemical bonds. The model is shown from a perspective that highlights its three-dimensional structure.

OBJECTIVES

- The student will be able to identify and explain trends of electronegativity, atomic radii and ionization energy on the periodic table.
- The student will recognize similarities of properties based upon location on the periodic table and be able to predict properties of an element based on the location of that element on the table.



PRIOR KNOWLEDGE

- Students should have a working knowledge of the parts of an atom.
- Students should be able to write the noble gas electron configurations of all the elements on the periodic table.
- Students should know the definition and have a basic understanding of ionization energy, electronegativity and atomic radii.



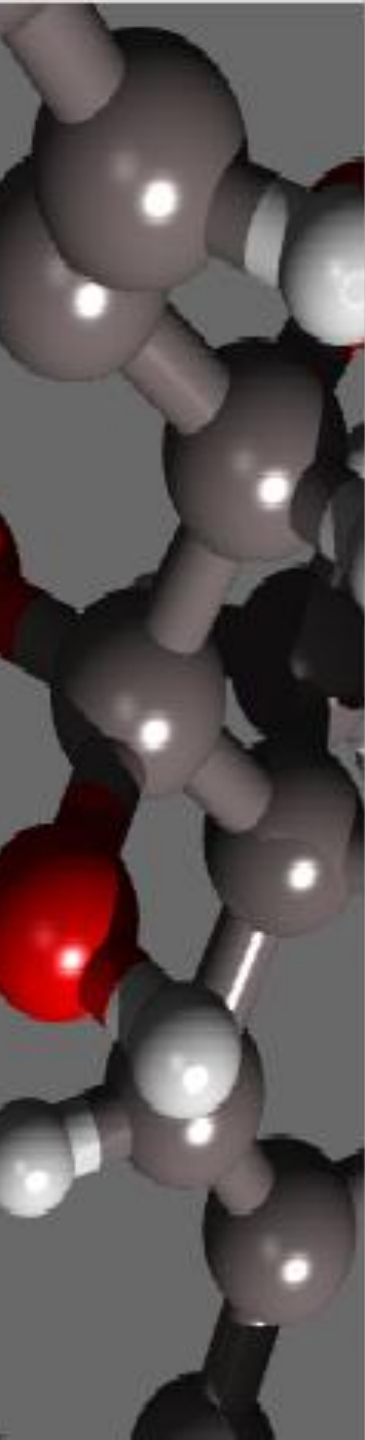
HISTORY OF PERIODIC TABLE

- In 1865, the English chemist, John Newlands arranged the first 16 elements known at that time in order of increasing atomic mass. He placed these elements into two rows and he observed that the elements in each column had similar chemical and physical properties.



MENDELEEV'S TABLE

- In 1870, Dmitri Mendeleev used this and other information to arrange the 63 elements known at that time. He wrote the element symbol, properties and atomic mass of each element onto individual cards. He noticed that if he put the elements in order of atomic mass, he saw a repeating pattern of properties. By making each successive series of properties into a new row, Mendeleev found a workable table for the elements. Mendeleev recognized a pattern of combining ratios or “valency”.



PRE-LAB

Define

- GROUP
- PERIOD
- ATOMIC MASS
- IONIZATION ENERGY
- ELECTRONEGATIVITY
- ATOMIC RADII

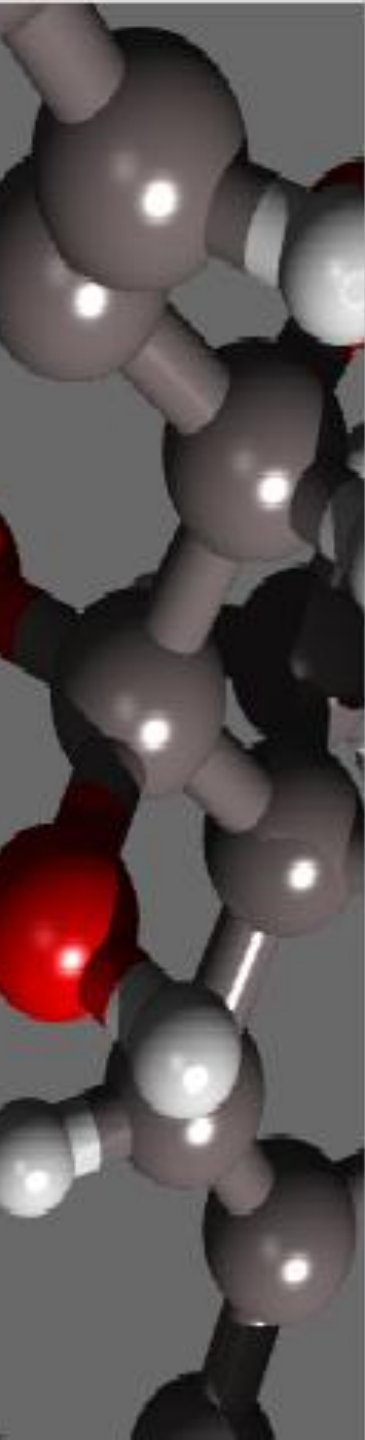
List the properties of

METALS....NONMETALS....& METALLOIDS

PREDICTIONS

Choose two or three of the listed elements that you feel confident may be grouped together. Explain your answer.

Element A	Silver colored liquid metal	Does not react with water	Reacts with Cl to form XCl_2
Element B	Somewhat hard silvery solid metal	Reacts very slowly with water	Reacts with Cl to form XCl_2
Element C	Purple solid nonmetal	Reacts slowly with metals	Reacts with Cl to form XCl
Element D	Soft silvery solid metal	Reacts very slowly with water	Reacts with Cl to form XCl_2



Card Information

Code	Physical Description
Atomic mass	1 st ionization energy
Ratio w/ oxygen	Electronegativity
Ratio w/ fluorine	Atomic radii
Reactivity	Phase @ room

Uu	Brittle, yellow nonmetal	
<input type="checkbox"/>	1.0	
XO	2.6	
XF ₂	.104	
Reacts slowly with metals	SOLID	

li	Soft, silvery metal	
26.98	.6	
X ₂ O ₃	1.5	
XF ₃	.125	
Does not react in presence of oxygen	SOLID	

GAS

XF
Reacts with water

Reacts slowly with metals

low
tely hard, metal

Vv
Red nonmetal
Hard
Reacts violently with water

Qq

Periods 1 & 2

Ww
16.00
XO
XF₂
1.0
1.0
1.3
3.5
.066

Lz
1.0
1.0
XF

Reacts slowly with water
Pale yellow
1.7
4.0
.064

Gg
Silver Metal
6.9
X₂O
XF
.5
1.0
.123

Reacts with water
GAS

26.98
X₂O₃
XF₃
.6
1.5
.125

Does not react in presence of oxygen

20.18
Colorless, Odorless
Rr
2.0
-.071

Unreactive
GAS

12.01
XO₂
XF₄
1.0
2.6
.077

Red
Oo
30.97
X₂O₃
XF₃
1.0
2.2
.110

Does not react with oxygen
SOLID

10.8
X₂O₃
XF₃
0.9
1.5
.089

Does not react with water
SOLID

2.4
-.03
GAS

Colorless, Odorless
2.4
-.03
GAS

Colorless, Odorless
1.4
3.1
.07

Does not react with oxygen

Silvery metal
Cc
69.72
X₂O₃
XF₃
Does not react with oxygen

Hard, clear, black
Vv
12.01
XO₂
XF₄
1.0
2.6
.077

Does not react with oxygen
SOLID

Periods 1 & 2

Zz	Colorless, Odorless
1.0	
K_2O	1.3
KF	2.2
	.03
Explodes in air when ignited	0.05

Gg	Silver-white
6.9	3
K_2O	1.0
KF	.123
Reacts with water	SOLID

Jj	Hard, lead-gray metal
9.0	0.9
KO	1.3
KF_2	.089
Does not react with water	SOLID

Pp	Hard, black metalloid
10.8	1.8
H_2O_2	2.0
KF_2	.088
Does not react with oxygen	SOLID

Rr	Colorless, Odorless
20.18	2.1
—	—
—	.071
Unreactive	GAS

Vv	Hard, silver-white metalloid (K, soft, black)
12.01	1.2
KO_2	2.6
KF_2	.077
Does not react with oxygen	SOLID

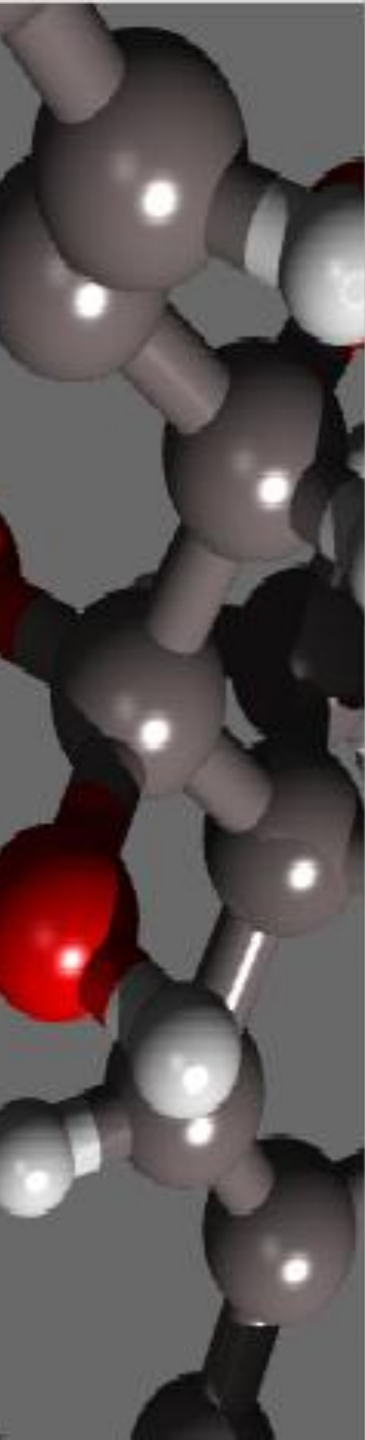
Tt	Colorless, Odorless
14.01	1.4
K_2O_2	3.1
KF_2	.07
Not very reactive	GAS

Ww	Colorless, odorless
16.00	1.3
KO	3.5
KF_2	.068
Reacts slowly with metals	GAS

Ss	Pale yellow
19.00	1.1
H_2O	4.3
KF	.08
Explodes upon contact with metals	GAS

Once the first 10 elements are arranged, the students are asked to complete the rest of the table (all 26 elements) based on similarities and trends that they see.

COMMON ERRORS



Reacts with water SOLID	Does not react with water SOLID	Does not react with oxygen SOLID	Unreactive GAS
Mm Soft, silvery metal <input type="checkbox"/> 0.5 X ₂ O 0.9 XF .157 Reacts vigorously with water SOLID	Hh Moderately hard, silvery metal <input type="checkbox"/> .7 XO 1.2 XF ₂ .136 Reacts only slightly with water SOLID	Cc Silvery metal 61.72 X ₂ O ₃ .58 XF ₃ 1.6 .125 Does not react with oxygen SOLID	Nn Moderately hard, silvery metalloid <input type="checkbox"/> 0.8 XO ₂ 1.9 XF ₄ .117 Reacts very slowly with oxygen SOLID
Bb Very soft, silvery metal <input type="checkbox"/> 0.4 X ₂ O 0.8 XF .203 Reacts violently with water SOLID	Kk Moderately hard silvery metal <input type="checkbox"/> 0.6 XO 1.0 XF ₂ .174 Reacts with water SOLID	Ll Soft, silvery metal 26.98 X ₂ O ₃ .6 XF ₃ 1.5 .125 Does not react in presence of oxygen SOLID	Xx UNKNOWN ELEMENT

COMPLETE TABLE

Zz Colorless, odorless

1.0	1.3
X ₂ O	2.2
XF	.03

Explodes in air when sparked GAS

Gg silver metal

6.9	5
X ₂ O	1.0
XF	.123

Reacts with water SOLID

Jj Hard, lead-gray metal

9.0	0.9
XO	1.5
XF ₂	.089

Does not react with water SOLID

Pp Hard, black metalloid

10.8	1.8
X ₂ O ₃	2.0
XF ₃	.088

Does not react with oxygen SOLID

Rr Colorless, odorless

20.10	2.1
—	—
—	.071

Unreactive GAS

Vv Hard, very soft metalloid (sl. sp. lity)

12.01	1.1
XO ₂	2.6
XF ₃	.077

Does not react with oxygen SOLID

Tt Colorless, odorless

14.01	1.4
X ₂ O ₃	3.1
XF ₃	.07

Not very reactive GAS

Ww Colorless, odorless

16.00	1.3
XO	3.1
XF ₃	.066

Reacts slowly with metals GAS

Mm Soft, silvery metal

0.5	0.5
X ₂ O	0.9
XF	.157

Reacts vigorously with water SOLID

Hh Moderately hard, silvery metal

7	1.2
XO	1.2
XF ₃	.136

Reacts only slightly with water SOLID

Ii Soft, silvery metal

16.98	.6
X ₂ O ₃	1.5
XF ₃	.125

Does not react in presence of oxygen SOLID

Nn Moderately hard, silvery metalloid

0.8	1.9
XO ₂	1.9
XF ₃	.117

Reacts very slowly with oxygen SOLID

Oo Red

35.97	1.0
X ₂ O ₃	2.2
XF ₃	.110

Does not react with oxygen SOLID

Ju Brittle, yellow

1.0	2.6
XO	2.6
XF ₃	.104

Reacts slowly with metals SOLID

U Greenish yellow

1.3	1.2
X ₂ O	1.2
XF	.099

Reacts violently with metals GAS

Bb Very soft, silvery metal

0.4	0.8
X ₂ O	0.8
XF	.203

Reacts violently with water SOLID

Kk Moderately hard silvery metal

0.6	1.0
XO	1.0
XF ₃	.174

Reacts with metal SOLID

Cc Silvery metal

69.72	.58
X ₂ O ₃	1.6
XF ₃	.125

Does not react with oxygen SOLID

UNKNOWN ELEMENT

Qq Brittle, steel-gray metalloid

74.92	.95
X ₂ O ₃	2.0
XF ₃	.121

Reacts very slowly with oxygen SOLID

Ee Gray

.94	2.5
XO	2.5
XF ₃	.117

Reacts slowly with metals SOLID

Aa Reddish-brown

1.14	2.9
X ₂ O	2.9
XF	.114

Reacts vigorously with metals LIQUID

Ff Colorless

—	—
—	—
—	—

Unreactive

Vv Colorless, odorless

4.00	2.0
—	—
—	—

Unreactive

Ss Pale yellow

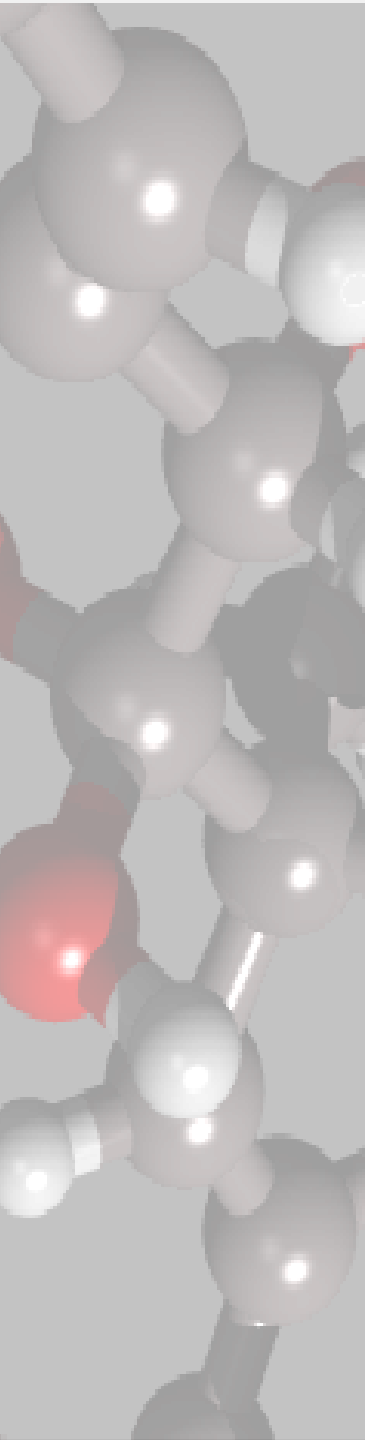
19.00	1.3
X ₂ O	3.1
XF	.066

Explodes upon contact with metals

Dd Colorless

—	—
—	—
—	—

Unreactive



I	II	III	IV	V	VI	VII	VIII
Zz							He
Gg	Jj	Pp	Vv	Tt	Ww	Ss	Rr
Mm	Hh	li	Nn	Oo	Uu	LI	Dd
Bb	Kk	Cc	Xx	Qq	Ee	Aa	Ff



IN THE LAB

- Place samples of **CALCIUM** and **MAGNESIUM** into separate beakers of water (with drop of phenolphthalein).
- Observe difference in reactivity.
- Assign Ca and Mg to the cards Hh & Kk.

PREDICTING PROPERTIES OF THE UNKNOWN ELEMENT

9.0 XO XF ₂ Does not react with water SOLID	0.9 1.5 .089	10.8 X ₂ O ₃ XF ₃ Does not react with oxygen SOLID	1.8 2.0 .088	20.18 — — Unreactive	Nonmetal 2.1 — .071 GAS	12.01 XO ₂ XF ₄ Does not react with oxygen SOLID	metalloid OR soft, black nonmetal 1.1 2.6 .077	14.01 X ₂ O ₃ XF ₃ Not very reactive GAS	1.4 3.1 .07
Hh Moderately hard, silvery metal [] XO XF ₂ Reacts only slightly with water SOLID	.7 1.2 .136	li Soft, silvery metal 26.98 X ₂ O ₃ XF ₃ Does not react in presence of oxygen SOLID	.6 1.5 .125	Nn Moderately hard, silvery metalloid [] XO ₂ XF ₄ Reacts very slowly with oxygen SOLID	0.8 1.9 .117	Oo Red nonmetal 30.97 X ₂ O ₃ XF ₃ Does not react with oxygen SOLID	1.0 2.2 .110	Ju Brittle, yellow nonmetal [] XO XF ₂ Reacts slowly with metals SOLID	1.0 2.6 .104
Kk Moderately hard silvery metal [] XO XF ₂ Reacts with water SOLID	0.6 1.0 .174	Cc Silvery metal 69.72 X ₂ O ₃ XF ₃ Does not react with oxygen SOLID	.58 1.6 .125	Xx UNKNOWN ELEMENT		Qq Brittle, steel-gray metalloid 74.92 X ₂ O ₃ XF ₃ Reacts very slowly with oxygen SOLID	.95 2.0 .121	Ee Gray nonmetal [] XO XF ₂ Reacts slowly with metals SOLID	.94 2.5 .117

A ball-and-stick molecular model of a polymer chain, showing a repeating unit of a carbon-based backbone with various side groups. The atoms are represented by spheres of different colors (grey, white, red, black) and are connected by sticks representing chemical bonds. The model is shown in a perspective view, extending from the foreground into the background.

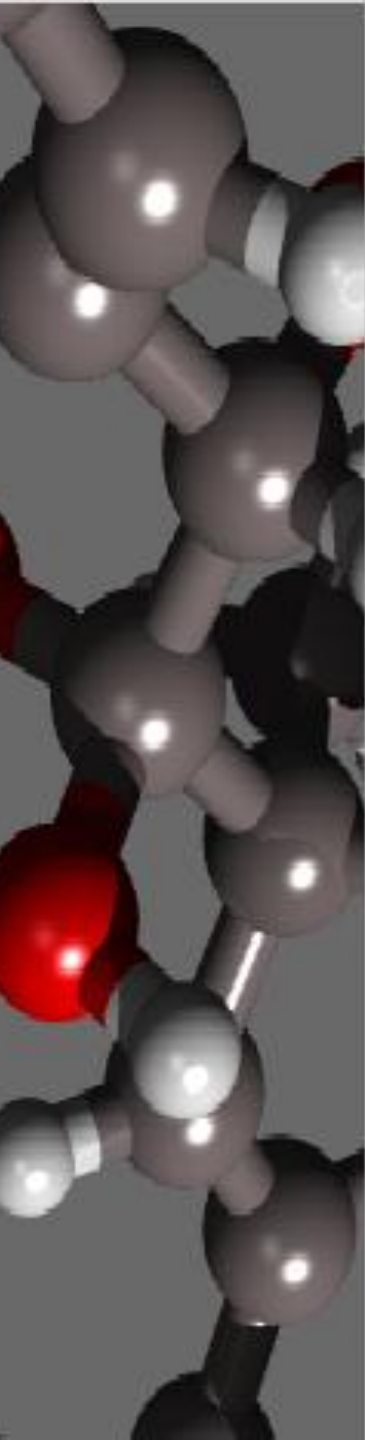
Consider the Trends

- Explore trends of atomic radii, ionization energy, electronegativity, etc.
- Teacher explanations may extend to WHY at this point OR that explanation may be saved for later.



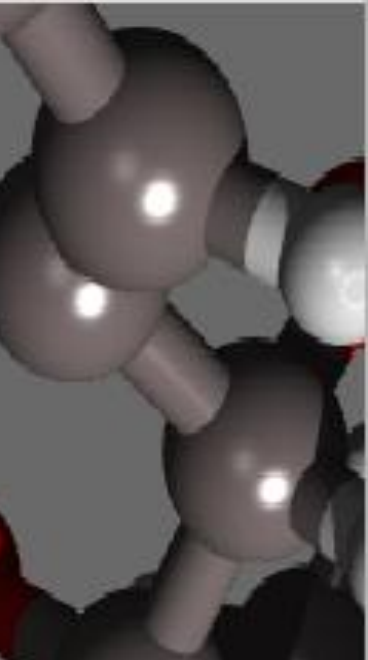
Scaffolding of Questions

- Look at the table you created. List patterns and/or trends you used while arranging the element cards.
- Identify where the metals, metalloids and nonmetals are found on the table.
- Identify where most of the gases are found on the table.



The next level of questions:

- In which two areas of the table do you find the most reactive elements? What property trends are related to reactivity? Predict an explanation for this.**
- Find strontium on the periodic table. Considering Part B of the procedure, predict the reactivity of strontium with water.**



ASSESSMENT

Students create a table of their own design to highlight trends and properties of elements.

I	II											III	IV	V	VI	VII	VIII



GOING FURTHER – more scaffolding of questions

1. a) What do you think happens to the size of an atom as the number of electrons increase?

b) Does your explanation correspond to the trend seen for atomic radii? Explain.

2. The 10 groups added between the main group elements are called Transition Elements.

(a) Predict what phase they will be in at room temperature. Explain.

(b) What do the electron configurations of these elements have in common?

A ball-and-stick molecular model showing a complex organic structure. The atoms are represented by spheres of different colors: grey for carbon, white for hydrogen, red for oxygen, and black for sulfur. The spheres are connected by grey rods representing chemical bonds. The model is shown from a perspective that highlights its three-dimensional structure.

REFERENCES

- Stacy, Angelica M., Coonrod, Jan, and Claesgens, Jennifer, Living by Chemistry General Chemistry, Alchemy, Key Curriculum Press, 2003.
- Winter, Mark, WebElements: The Periodic Table on the WWW (<http://webelements.com/>), University of Sheffield and WebElements Ltd, UK, 2003-2009.

A ball-and-stick molecular model of a polymer chain, showing a repeating unit of a carbon-carbon backbone with various substituents. The atoms are represented by spheres of different colors: grey for carbon, white for hydrogen, and red for oxygen. The model is shown in a perspective view, with the chain extending from the top left towards the bottom right.

QUESTIONS?

- Check out the materials at the **Target Inquiry** Web site.
- Contact me directly for more information and/or comments.

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Special thanks to Ellen Yeziarski of Miami University in Ohio and Debbie Herrington of Grand Valley State University in Michigan for their continued mentorship.