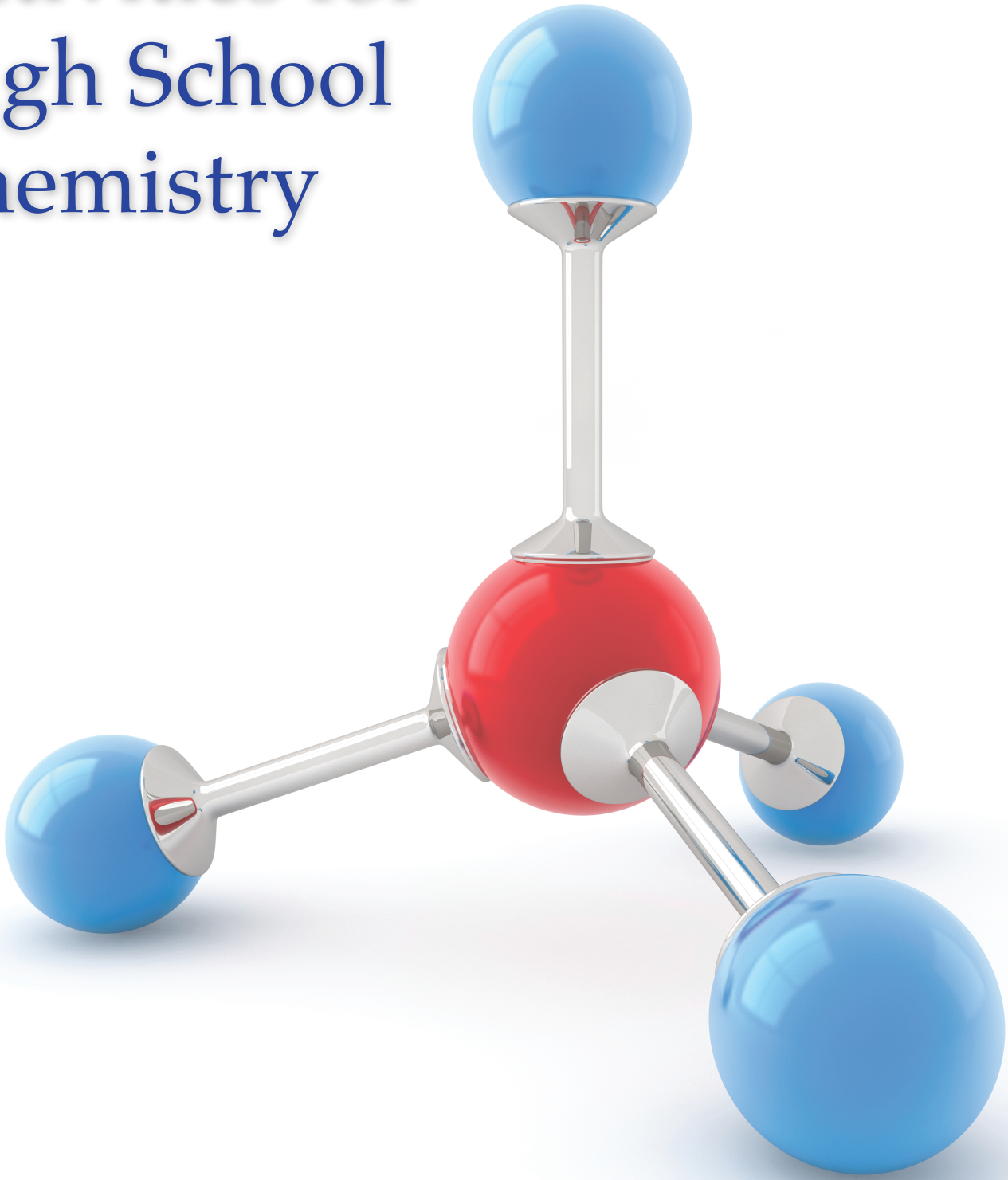
Formative Assessment Activities for High School Chemistry



a resource from

The Charles A. Dana Center at The University of Texas at Austin

Matter and the Periodic Table

Chemical Families and Periodic Trends

Purpose

The purpose of this station is to reinforce students' understanding of the organization and predictive power of the Periodic Table of the Elements and students' ability to use it to explain the chemical properties of families of elements and periodic trends in element families and periods.

Matter and the Periodic Table
Chemical Families and Periodic Trends

Teacher Pages

Essential Understandings

- Alkali metals are the most reactive metal family, with one valence electron that is easily lost, forming ions with a +1 charge.
- Alkaline earth metals are reactive and form ions with a +2 charge.
- Transition metals are typical metals that can have multiple oxidation states.
- Halogens tend to gain electrons, forming –1 ions.
- Noble gases have extremely low reactivity because they have full outer energy levels.
- A greater effective nuclear charge increases the attraction of the nucleus and pulls the electron cloud closer to the nucleus, resulting in a smaller atomic radius.
- An increased number of energy levels increases the distance over which the nucleus must pull and reduces the attraction for electrons.
- Full energy levels provide shielding between the nucleus and valence electrons.

Materials

Metal baking sheet (1 per station)
Magnetic tape roll (1 half-inch wide roll per station)

The following materials are included in the blackline masters for this station.

Station Information Sheet (1 per station)
Periodic Table Cards (1 per station)
Periodic Trend Arrows (1 per station)
Periodic Table Labels (1 per station)
Student Pages (1 set per student)
Periodic Table of the Elements (1 per station)

Advance Preparation

1. Print one copy of all the blackline masters for this station using a color printer. Color is essential to the station activities. Make one copy of the Student Pages (including the glossary) for each student.

2. Laminate the Station Information Sheet and the Periodic Table of the Elements.

3. Laminate and cut apart the Periodic Table Cards, Periodic Trend Arrows, and Periodic Table Labels. Attach a short piece of magnetic tape to the back of the Periodic Table Cards and Periodic Trend Arrows.

Place the Periodic Table Cards, Periodic Trend Arrows, and Periodic Table Labels in separate labeled envelopes.

Station Setup

1. Tape the Station Information Sheet to the station table. Students will use this to confirm the station is set up correctly.

2. Place Periodic Table of the Elements, metal sheet, Periodic Table Cards, Periodic Trend Arrows, and Periodic Labels at the table.

Procedures

1. Tell students to check the station setup against the Station Information Sheet when they arrive at the table. If anything is missing or out of place, they should notify you.

2. Pass out a copy of the Student Pages to each student. Instruct students to work through the procedures and answer the questions with their teammate(s).

3. As students work through the station activity, circulate around the room, checking their work and responding to questions.

Guide to Student Responses

Note—The suggested student responses presented below in italics represent the best possible answers to the student questions; actual student responses may vary.

Essential Question

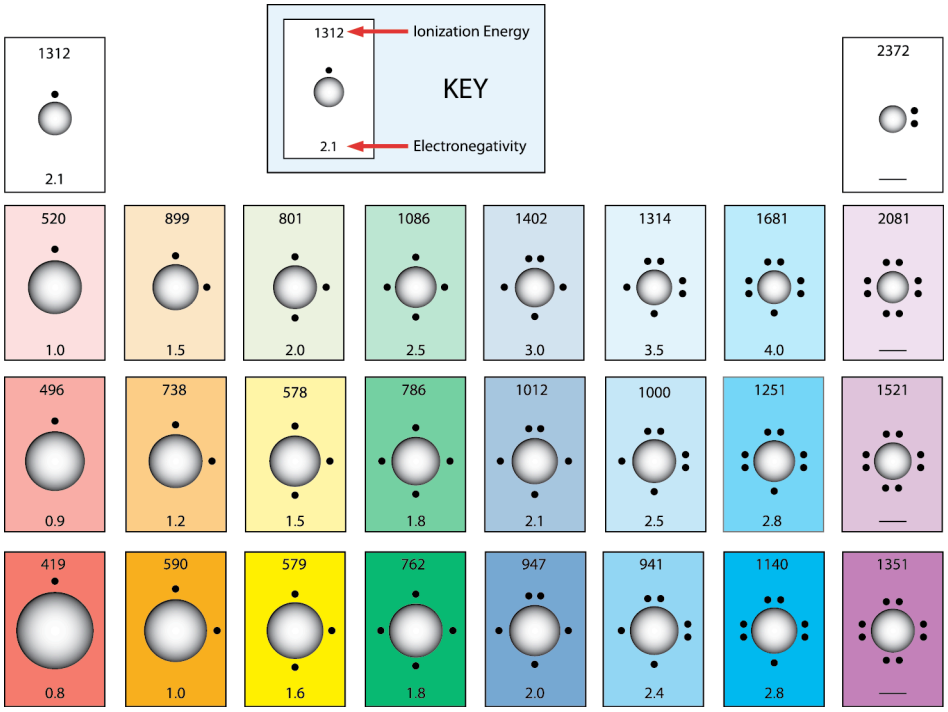
How can the Periodic Table of the Elements be used to predict periodic trends in chemical families and periods?

Elements in the same group on the table have similar chemical properties. Elements in the same period on the table show trends in atomic and ionic radius, ionization energy, and electronegativity.

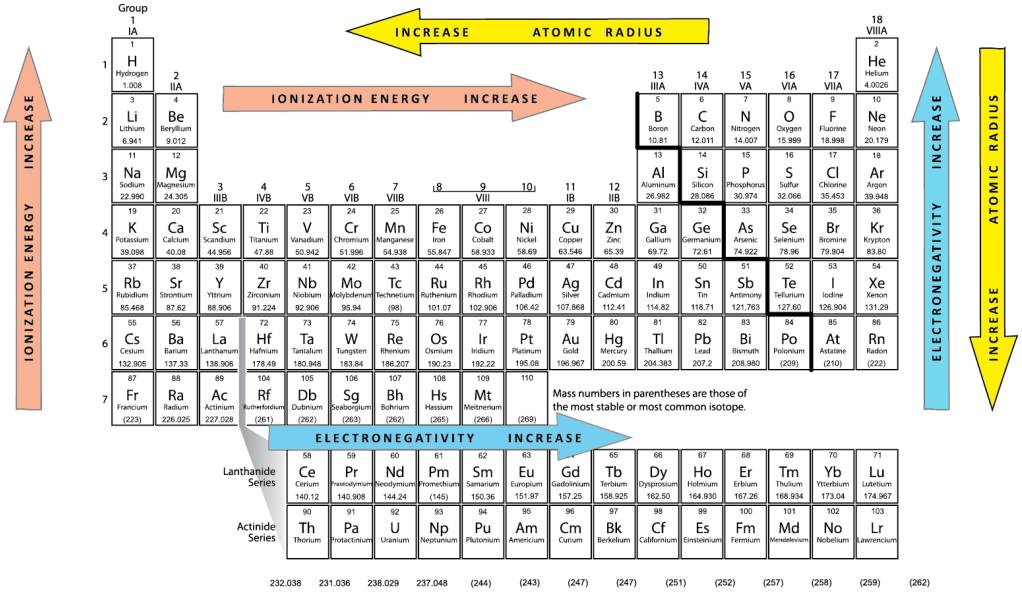
Part I: Periodic Table Trends

1. Arrange the Periodic Table Cards in a logical order on the metal sheet, creating a Periodic Table of the Elements.

Answers:



2. Using the information on the cards, place the Periodic Trend Arrows around the periodic table, showing the direction of increase in each trend.



3. Electronegativity is the ability of an atom to attract electrons. Based on the information on the Periodic Table Cards, which element has the greatest electronegativity?

   Fluorine

4. Explain the trend in electronegativity as elements go . . .

   Down in a group:

   As the elements go down in a group, electronegativity decreases because the distance between the nucleus and valence electrons in the elements' atoms increases. More energy levels filled with electrons shield the nucleus.

   Across in a period:

   As elements move across a period, electronegativity increases as the nuclear charge increases.

5. Ionization energy is the energy required to remove an electron from an atom. Based on the Periodic Table of the Elements, how do the ionization energies of Group 1 compare to the ionization energies of Group 17?

   Ionization energy of Group 1 is low compared to that of Group 17.

   What causes the differences in ionization energies for these two groups?

   The elements in Group 17 have larger effective nuclear charges than those in Group 1.

6. Positive ions (cations) tend to be smaller than their corresponding neutral atoms. What is a possible explanation for this?

   Cations have fewer electrons than their corresponding neutral atoms, which increases the effective nuclear charge that draws the remaining electrons closer to the nucleus.

7. Negative ions (anions) tend to be larger than their corresponding neutral atoms. What could be an explanation for this?

   Anions have more electrons, and repulsion forces between electrons push them further apart. When electrons outnumber protons, the nucleus cannot pull the electron cloud as tightly around itself.

8. The following table shows the ionic radius for elements in Periods 2 and 3:

Period	Li^+	Be^{2+}	B^{3+}	C^{4+}	N^{3-}	O^{2-}	F^-
2	60	31	20	15	171	140	136
	Na^+	Mg^{2+}	Al^{3+}	Si^{4+}	P^{3-}	S^{2-}	Cl^-
3	95	65	50	41	212	184	181

   What is the general trend that occurs across each period?

   Ionic radius decreases for positive and negative ions, although negative ions are larger than positive ions.

9. What do you predict the trend will be for ionic radius down a group?

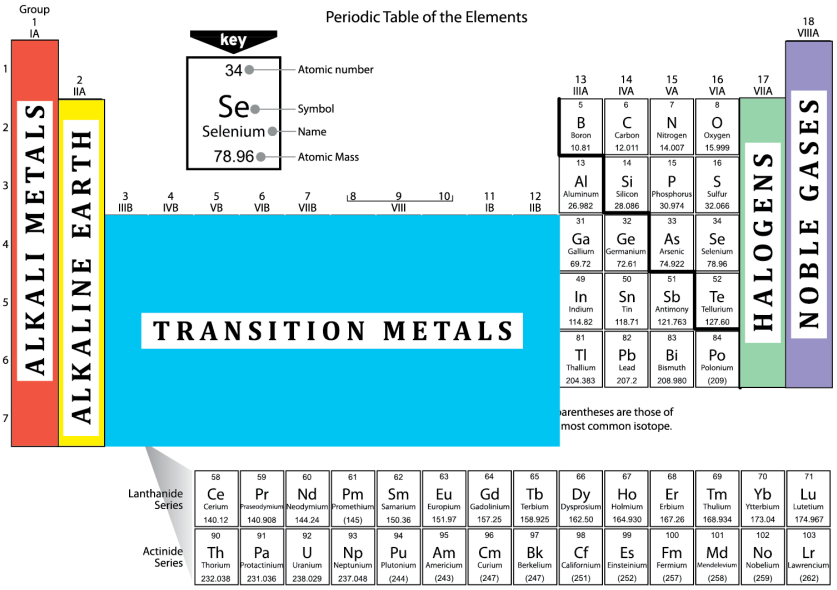
   Ionic radius increases as energy levels are added.

Part II: Chemical Families

Locate the Periodic Table Labels. Use the information in the Glossary to answer the following questions.

10. Place the Periodic Table Labels for alkali metals, alkaline earth metals, transition metals, halogens, and noble gases on the large Periodic Table of the Elements.

    (Answers shown below.)



11. Why is it important to know the properties of different groups of elements in the Periodic Table of the Elements?

    Classifying elements into groups with similar properties gives us information about their chemical reactivity.

12. Compare the reactivity of alkali metals and noble gases. What property of these groups of elements accounts for the differences in their reactivity?

    The alkali metals are very reactive, losing their single valence electron and forming compounds easily. Noble gases are very stable as they have a complete outer energy level.

13. Compare the reactivity of alkali metals and halogens. What accounts for their differences?

    The alkali metals tend to lose their single valence electron, forming positive ions. Losing one electron allows the alkali metals to achieve a stable noble gas configuration. Gaining one electron allows the halogens to achieve a stable noble gas configuration.

    The halogens tend to gain one electron, forming negative ions. The reactivity of the alkali metals increases as you move down the group because the outermost electron is more easily lost as it gets further away from the nucleus. The reactivity of the halogens decreases as you move down the group because electrons are less easily attracted by the nucleus due to increased shielding.

14. Now that you have completed these exercises, return to the Essential Question. Would you like to modify or change your answer? Write any modifications to your answer below.

    Answers will vary.

Blackline Masters

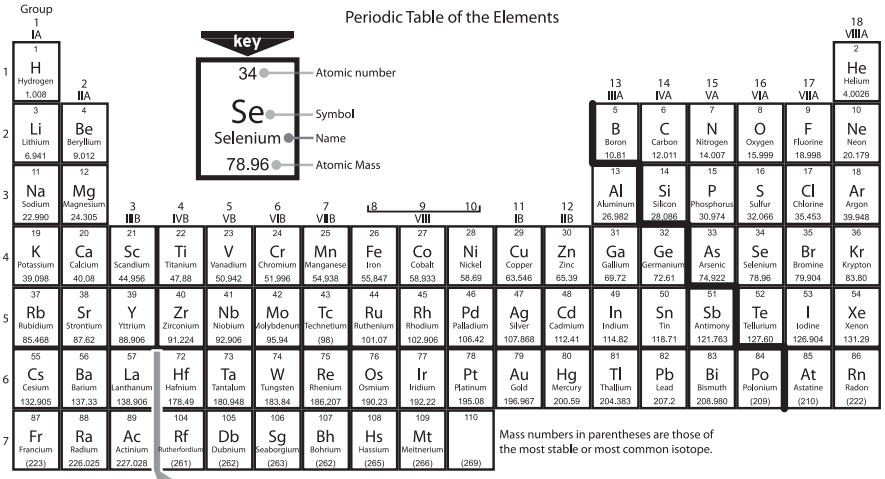
for

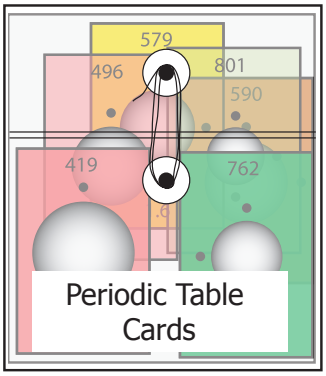
Matter and the Periodic Table

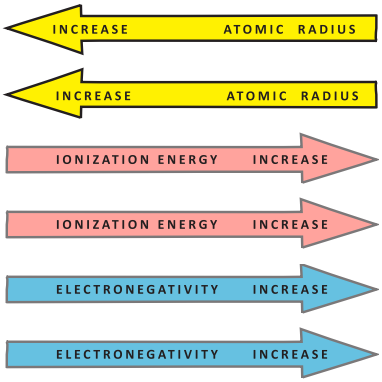
Chemical Families and Periodic Trends

Contents

Station Information Sheet
Chemical Families and Periodic Trends

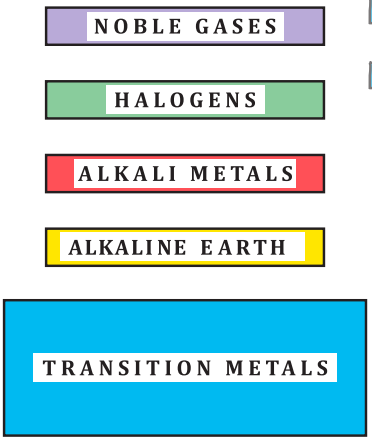






Periodic Trend Arrows

Metal Baking Sheet



Periodic Table Labels

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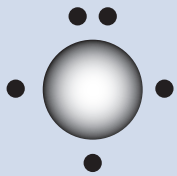

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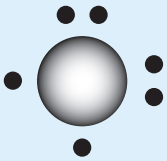

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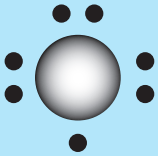

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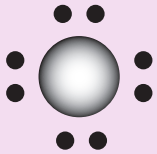

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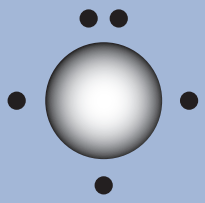

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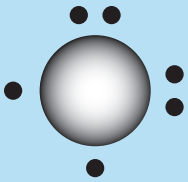

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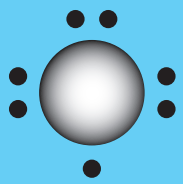

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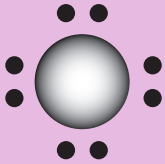

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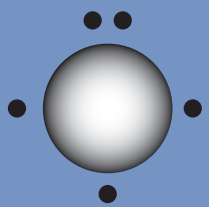

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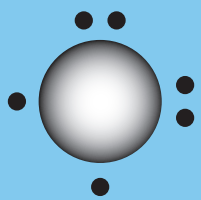

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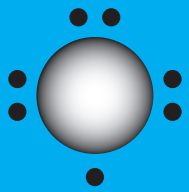

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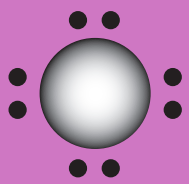

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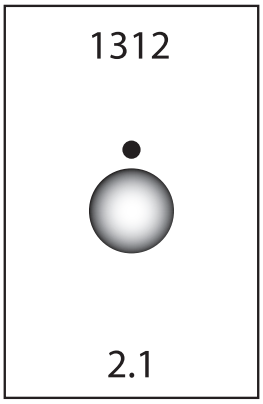
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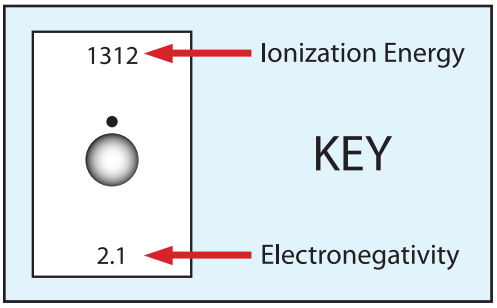
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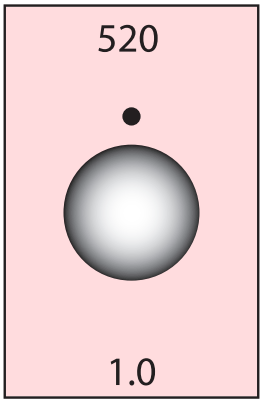
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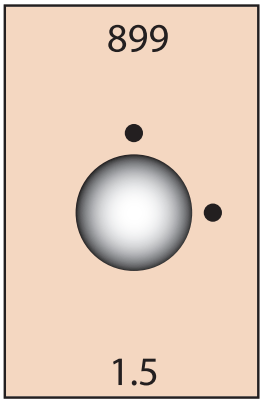
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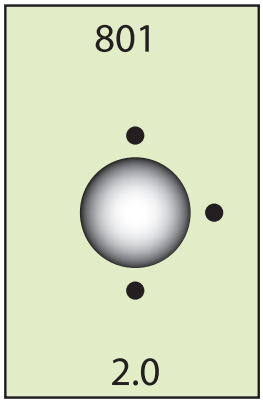
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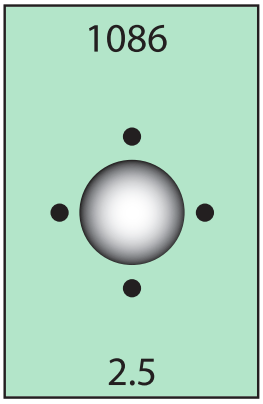
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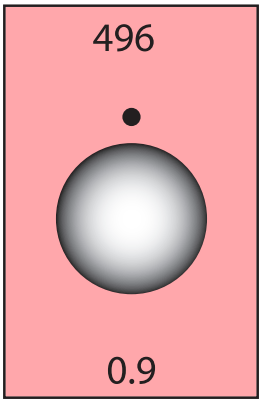
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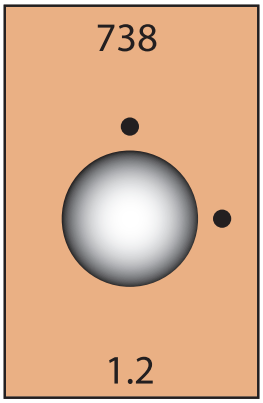
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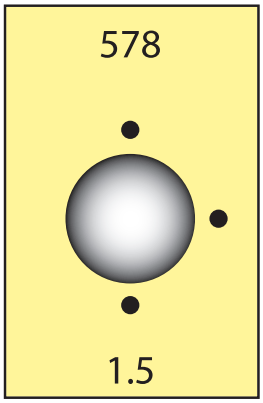
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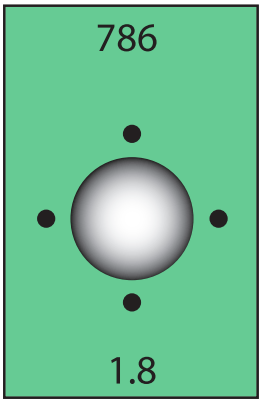
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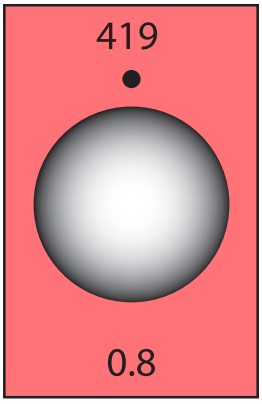
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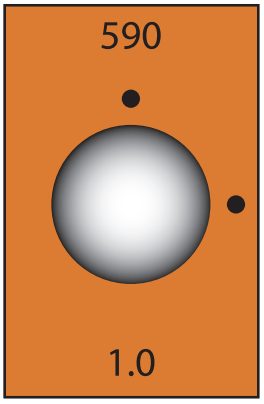
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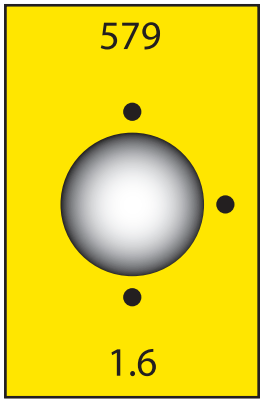
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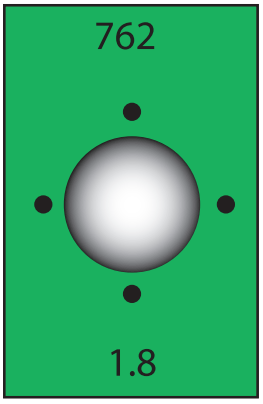
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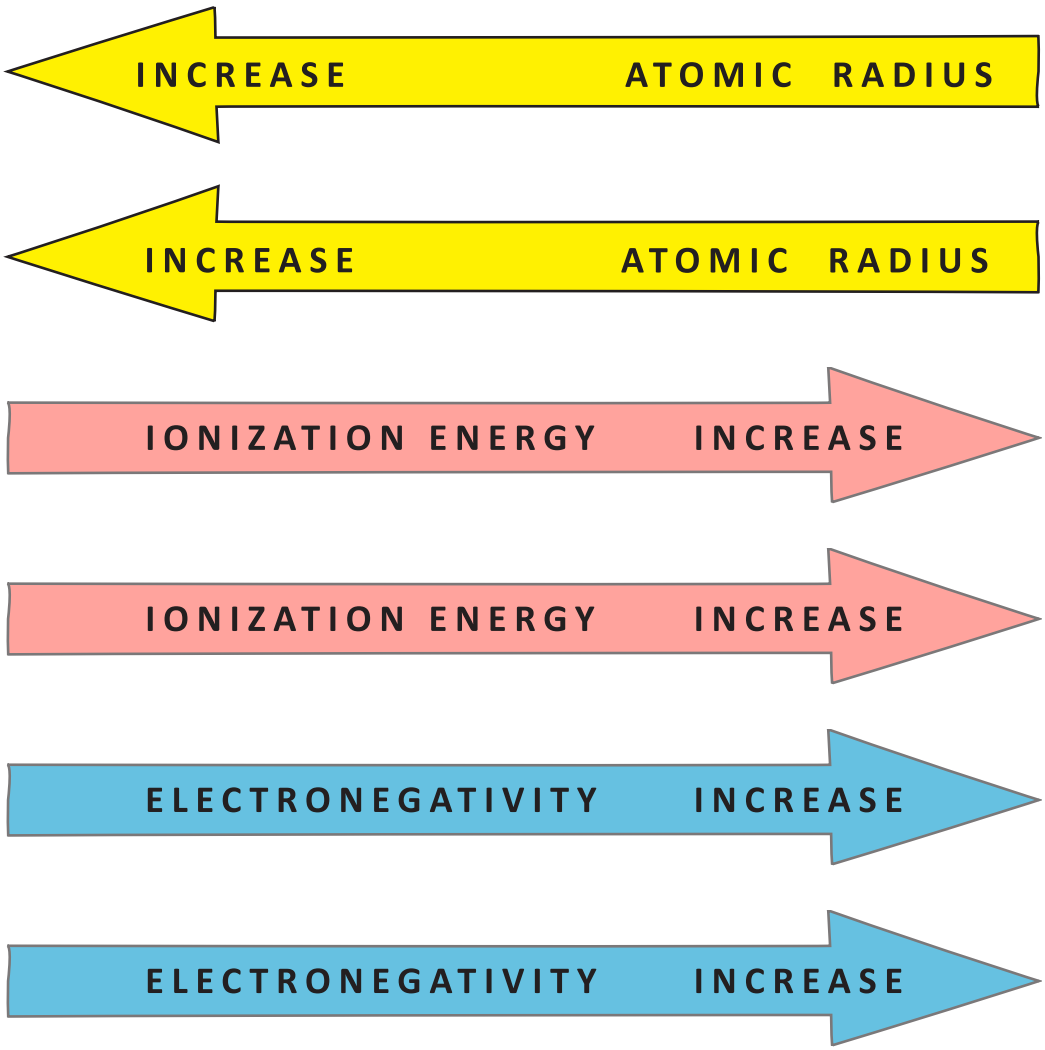
INCREASE ATOMIC RADIUS
INCREASE ATOMIC RADIUS
IONIZATION ENERGY INCREASE
IONIZATION ENERGY INCREASE
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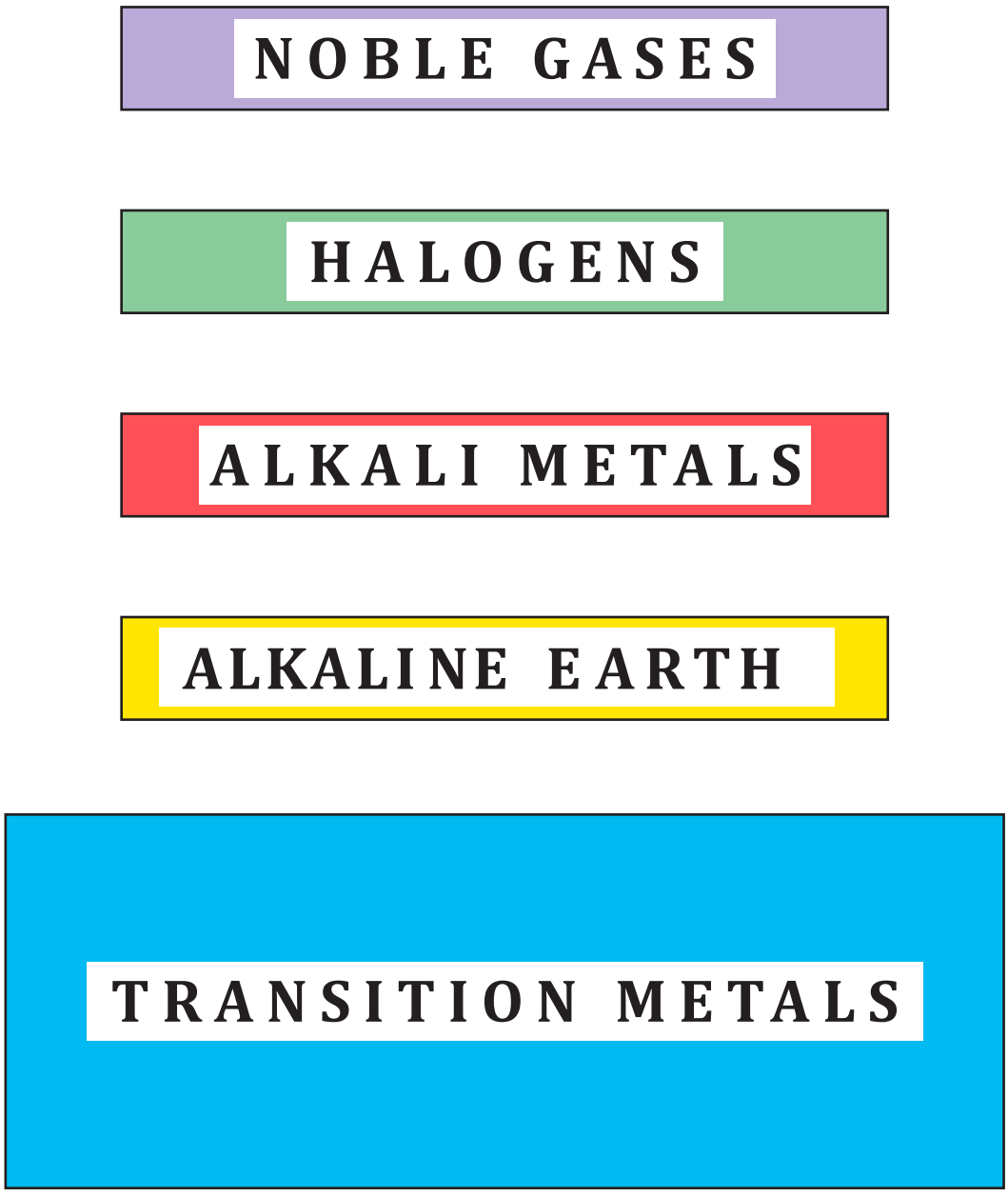
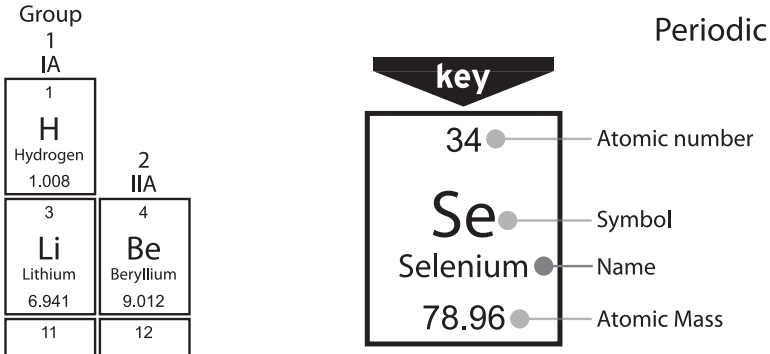

NOBLE GASES
HALOGENS
ALKALI METALS
ALKALINE EARTH
TRANSITION METALS

Periodic Table of the Elements



Group	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIII	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 H Hydrogen 1.008																	2 He Helium 4.0026
2	3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.179
3	11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948
4	19 K Potassium 39.098	20 Ca Calcium 40.08	21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.847	27 Co Cobalt 58.933	28 Ni Nickel 58.69	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.72	32 Ge Germanium 72.61	33 As Arsenic 74.922	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
5	37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.763	52 Te Tellurium 127.60	53 I Iodine 126.904	54 Xe Xenon 131.29
6	55 Cs Cesium 132.905	56 Ba Barium 137.33	57 La Lanthanum 138.906	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
7	87 Fr Francium (223)	88 Ra Radium 226.025	89 Ac Actinium 227.028	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (263)	107 Bh Bohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (266)	110 (269)								

Mass numbers in parentheses are those of the most stable or most common isotope.

Lanthanide Series	58 Ce Cerium 140.12	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.97	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.50	67 Ho Holmium 164.930	68 Er Erbium 167.26	69 Tm Thulium 168.934	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
Actinide Series	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

Matter and the Periodic Table
Chemical Families and Periodic Trends

Student Pages

Purpose

The purpose of this station is to understand the organization and predictive power of the Periodic Table of the Elements and to use it to explain the chemical properties of families of elements and periodic trends in families and periods.

Before You Begin...

Check to see that all the items are present and organized according to the Station Information Sheet. If you notice a problem, notify your teacher immediately.

Materials

Station Information Sheet
Periodic Table of the Elements
Metal baking sheet
Periodic Table Cards
Periodic Trend Arrows
Periodic Table Labels

Essential Question

How can the Periodic Table of the Elements be used to predict periodic trends in chemical families and periods?

Part I: Periodic Table Trends

Locate the Periodic Table Cards and the metal baking sheet.

1. Arrange the Periodic Table Cards in a logical order on the metal sheet, creating a Periodic Table of the Elements.

2. Using the information on the cards, place the Periodic Trend Arrows around the Periodic Table, showing the direction of increase in each trend.

3. Electronegativity is the ability of an atom to attract electrons. Based on the information on the Periodic Table Cards, which element has the greatest electronegativity?

4. Explain the trend in electronegativity as elements go . . .

   Down in a group:

   Across in a period:

5. Ionization energy is the energy required to remove an electron from an atom. Based on the Periodic Table of the Elements, how do the ionization energies of Group 1 compare to the ionization energies of Group 17?

   What causes the differences in ionization energies for these two groups?

6. Positive ions (cations) tend to be smaller than their corresponding neutral atoms. What is a possible explanation for this?

7. Negative ions (anions) tend to be larger than their corresponding neutral atoms. What could be an explanation for this?

8. The following table shows the ionic radius for elements in periods 2 and 3:

Period	**Li^+**	**Be^{2+}**	**B^{3+}**	**C^{4+}**	**N^{3-}**	**O^{2-}**	**F^-**
2	60	31	20	15	171	140	136
	Na^+	**Mg^{2+}**	**Al^{3+}**	**Si^{4+}**	**P^{3-}**	**S^{2-}**	**Cl^-**
3	95	65	50	41	212	184	181

What is the general trend that occurs across each period?

9. What do you predict the trend will be for ionic radius down a group?

Part II: Chemical Families

Locate the Periodic Table Labels. Use the information in the Glossary to answer the following questions.

10. Place the Periodic Table Labels for alkali metals, alkaline earth metals, transition metals, halogens, and noble gases on the large Periodic Table.

11. Why is it important to know the properties of different groups of elements in the Periodic Table?

12. Compare the reactivity of alkali metals and noble gases. What property of these groups of elements accounts for the differences in their reactivity?

13. Compare the reactivity of alkali metals and halogens. What accounts for their differences?

14. Now that you have completed these exercises, return to the Essential Question. Would you like to modify or change your answer? Write any modifications to your answer below.

NOTE: Because other students are going to do the activity after you, be sure to put all the materials at the station back as you found them. Sometimes there will be materials that need to be renewed or replaced. If you need assistance or have any questions, ask your teacher.

I Need to Remember . . .

Complete this part **after** class discussion of this station.

I need to remember . . .

Glossary for *Chemical Families and Periodic Trends*

Alkali Metals

Alkali metals have one valence electron, which is easily lost, causing ions that carry a *+1* charge to form. As metals get larger, the outer electrons are more easily lost because they are shielded from the positive nucleus by electrons in lower energy levels.

Alkaline Earth Metals

Alkali metals have two valence electrons and form ions carrying a *+2* charge.

Atomic Radius

The atomic radius is equal to one half the distance between the two nuclei in a molecule made up of two identical atoms.

Electronegativity

Electronegativity is the tendency of an atom in a molecule to attract electrons to it.

Halogens

Halogens are nonmetals that tend to gain an electron and form ions carrying a *–1* charge. As you move down the group on the Periodic Table and more energy levels filled with electrons shield the positive charge of the nucleus, halogens have more difficulty gaining electrons.

Ionic Crystal

An ionic crystal is a compound held together by ionic bonding and formed from the attraction between oppositely charged ions, such as NaCl.

Ionic Radius

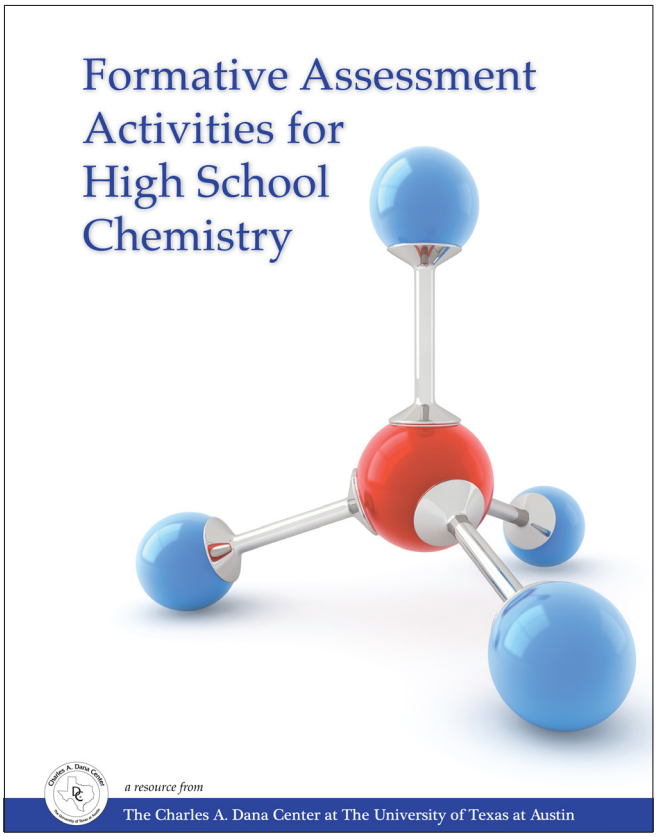
The ionic radius is the radius of an ion in an ionic crystal.

Ionization Energy

Ionization energy is the energy needed to remove the most loosely held electron from an atom in the gaseous state.

Noble Gases

Noble gases are also called inert gases because they generally do not react with any other elements.



Formative Assessment Activities for High School Chemistry

This full-color book provides 14 hands-on, interactive activities designed to assess and reinforce students' knowledge of chemistry content and scientific practice skills in five categories: matter and the periodic table, atomic structure and nuclear chemistry, bonding and chemical reactions, gases and thermochemistry, and solutions and chemical reactions.

These activities address key chemistry standards from the Next Generation Science Standards and the Texas Essential Knowledge and Skills. A table in the introduction lists the specific standards addressed by each activity.

The book comes with a full-color DVD so you can print blackline masters. The DVD provides a complete electronic copy of the book and may be purchased separately.

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