Azer's Interactive Periodic Table Study Set

NEMETH Version
Kit Catalog Number: 1-08856-01

AMERICAN PRINTING HOUSE

Azer's Interactive Periodic Table Study Set

(NEMETH Version)

Teacher's Guidebook

AMERICAN PRINTING HOUSE

1839 Frankfort Avenue
Louisville, Kentucky 40206
502-895-2405 • 800-223-1839
www.aph.org • info@aph.org

Azer's Interactive Periodic Table Study Set

Azer's Interactive Periodic Table Study Set
[Complete Kit, NEMETH version,
Catalog #: 1-08856-01]

Note: Accessible versions of the Teacher's Guidebook are available for free download at www.aph.org.

PROJECT STAFF

Tactile and Visual Designer/Author
Karen J. Poppe

Product Consultant/Originator
Samir Azer, Teacher of the Visually Impaired

Project Assistant/Science Consultant
Rosanne Hoffmann

Research Assistant
Rachel White

Model/Pattern Makers
Patrick White
Tom Poppe

Manufacturing Specialists
Rod Dixon
Andrew Moulton
David McGee

ACKNOWLEDGEMENTS

Special thanks to the following professionals who contributed their time and expertise to the field evaluation of *Azer's Interactive Periodic Table Study Set:*

Paul Baldwin, Science Instructor, Washington State School for the Blind, Vancouver, Washington

Peggy Bergman, Teacher of the Visually Impaired, Gwinnett County Schools, Parkview High School, Lilburn, Georgia

John Davis, Science Teacher, Minnesota State Academy for the Blind, Faribault, Minnesota

Joanne Devine, Vision Support Teacher, Pittsburgh Public Schools, Pittsburgh, Pennsylvania

Carol Hoover, Teacher of the Visually Impaired, Round Rock ISD, Round Rock, Texas

Jeff Killebrew, Science Teacher, New Mexico School for the Blind and Visually Impaired, Alamogordo, New Mexico

Rebecca Kuhn, Teacher of the Visually Impaired, Tennessee School for the Blind, Nashville, Tennessee

Jonathan McCoy, Chemistry Teacher, Gwinnett County Schools, Parkview High School, Lilburn, Georgia

Jan Megarry, Teacher of the Visually Impaired, Colorado School for the Deaf and the Blind, Colorado Springs, Colorado

Production of *Azer's Interactive Periodic Table Study Set* would not be possible without the special talents of many individuals. Thanks to those who helped with thermoforming, die-cutting, collating, braille translation, purchasing, and support services.

Table of Contents

Introduction

Azer's Interactive Periodic Table Study Set is designed to make learning about the periodic table of the elements accessible to students with visual impairments and blindness. The tangible materials included with this study set complement APH's *Periodic Table of the Elements Reference Chart* and allow students to enhance their understanding of the following concepts:

- Structure of atoms
- Transfer of energy
- Structure and properties of matter
- Chemical reactions
- Interactions of energy and matter

This study set is intended to complement, not replace, the student's current science curriculum. Teachers can use the tangible materials included in this study set to assist in the instruction and demonstration of concepts related to the overall arrangement of the periodic table, atomic structure, ionic and covalent bonding, and balancing of chemical equations to students who would benefit from a hands-on, interactive model.

Overview of Study Set Materials

Azer's Interactive Periodic Table Study Set is intended to be used in conjunction with the student's current chemistry curriculum. The study set's primary purpose is to provide the student with visual impairments and blindness with a tangible means of understanding chemistry-related concepts typically presented in an abstract, visual fashion. Special attention was given to make the materials tactually discriminable and visually appealing for the target population, yet appropriate for all students regardless of visual acuity.

Included in the study set are the following items:

(1) Tri-fold Board

(1) Housing binder to store the hexagonal elements

Storage Tip: Store the pieces in the binder in a way that is meaningful (e.g., alphabetically by element name, by atomic number, etc.). Refer to ***Appendix C: Binder Storage of Elements and Accessories*** for an example.

(8) Binder storage panels, including:

- (7) 3-hole punched black panels
- (1) 3-hole punched, double-sided black felt panel

Note: The loop-covered inside-back cover of the binder provides extra storage space.

(1) Template for loop-backed circle placement

Assembly Instructions: Use the open-circle template to position the loop [soft] circles on the front and back of each of the black panels. Place the template on top of a black panel and place a white, adhesive-backed loop circle in each opening to create the proper spacing to accommodate 20 hexagonal shapes (5 rows x 4 columns).

Storage Tip: Use the double-sided felt panel and the binder's inside-back cover to store the smaller interactive pieces (i.e., oxidation numbers, arrows, plus signs, etc.) as shown in ***Appendix C***.

(294) hexagonal elements [a minimum of one per element] and polyatomic ions in the following quantities:

H-12	**Na**-6	**Sc**-1	**Ga**-2
He-1	**Mg**-4	**Ti**-1	**Ge**-2
Li-6	**Al**-5	**V**-1	**As**-3
Be-4	**Si**-3	**Cr**-4	**Se**-3
B-3	**P**-3	**Mn**-4	**Br**-7
C-8	**S**-7	**Fe**-4	**Kr**-1
N-5	**Cl**-9	**Co**-4	**Rb**-3
O-12	**Ar**-1	**Ni**-4	**Sr**-4
F-9	**K**-6	**Cu**-6	**Y**-1
Ne-1	**Ca**-4	**Zn**-2	**Zr**-1

Nb-1	Eu-1	At-1	Bh-1
Mo-1	Gd-1	Rn-1	Hs-1
Tc-1	Tb-1	Fr-1	Mt-1
Ru-1	Dy-1	Ra-1	Ds-1
Rh-1	Ho-1	Ac-1	Rg-1
Pd-1	Er-1	Th-1	Cn-1
Ag-3	Tm-1	Pa-1	Nh-1
Cd-1	Yb-1	U-1	Fl-1
In-1	Lu-1	Np-1	Mc-1
Sn-3	Hf-1	Pu-1	Lv-1
Sb-1	Ta-1	Am-1	Ts-1
Te-1	W-1	Cm-1	Og-1
I-7	Re-1	Bk-1	ClO_3-4
Xe-1	Os-1	Cf-1	CO_3-4
Cs-3	Ir-1	Es-1	NH_4-4
Ba-4	Pt-1	Fm-1	NO_3-4
La-1	Au-1	Md-1	OH-4
Ce-1	Hg-3	No-1	PO_4-4
Pr-1	Tl-1	Lr-1	SO_4-4
Nd-1	Pb-5	Rf-1	
Pm-1	Bi-1	Db-1	
Sm-1	Po-1	Sg-1	

(1) X hexagonal assessment piece

(1) Y hexagonal assessment piece

(17) coefficient numbers

(30) oxidation numbers and/or ionic charges

(27) subscript numbers

(6) arrows

(10) plus signs

(6) pairs of parentheses

(2) Atomic Models

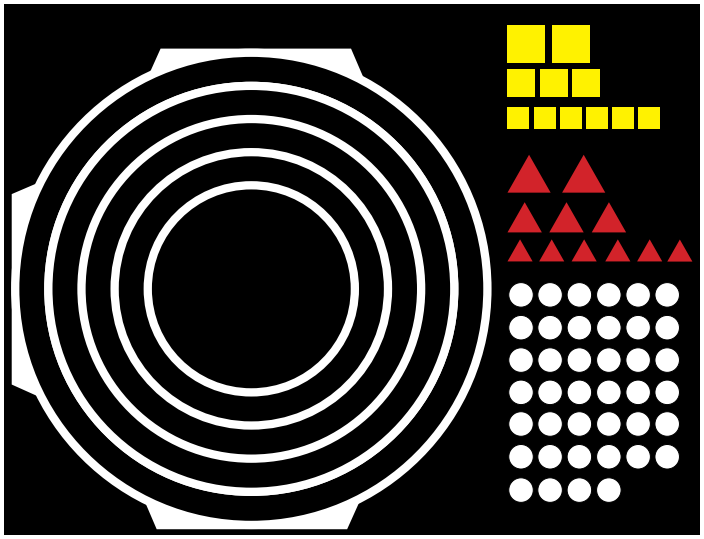
Subatomic pieces per Atomic Model:

(40) electrons

(11) protons (of three sizes/values)

(11) neutrons (of three sizes/values)

Storage Tip: Store all related subatomic pieces on the atomic model itself.



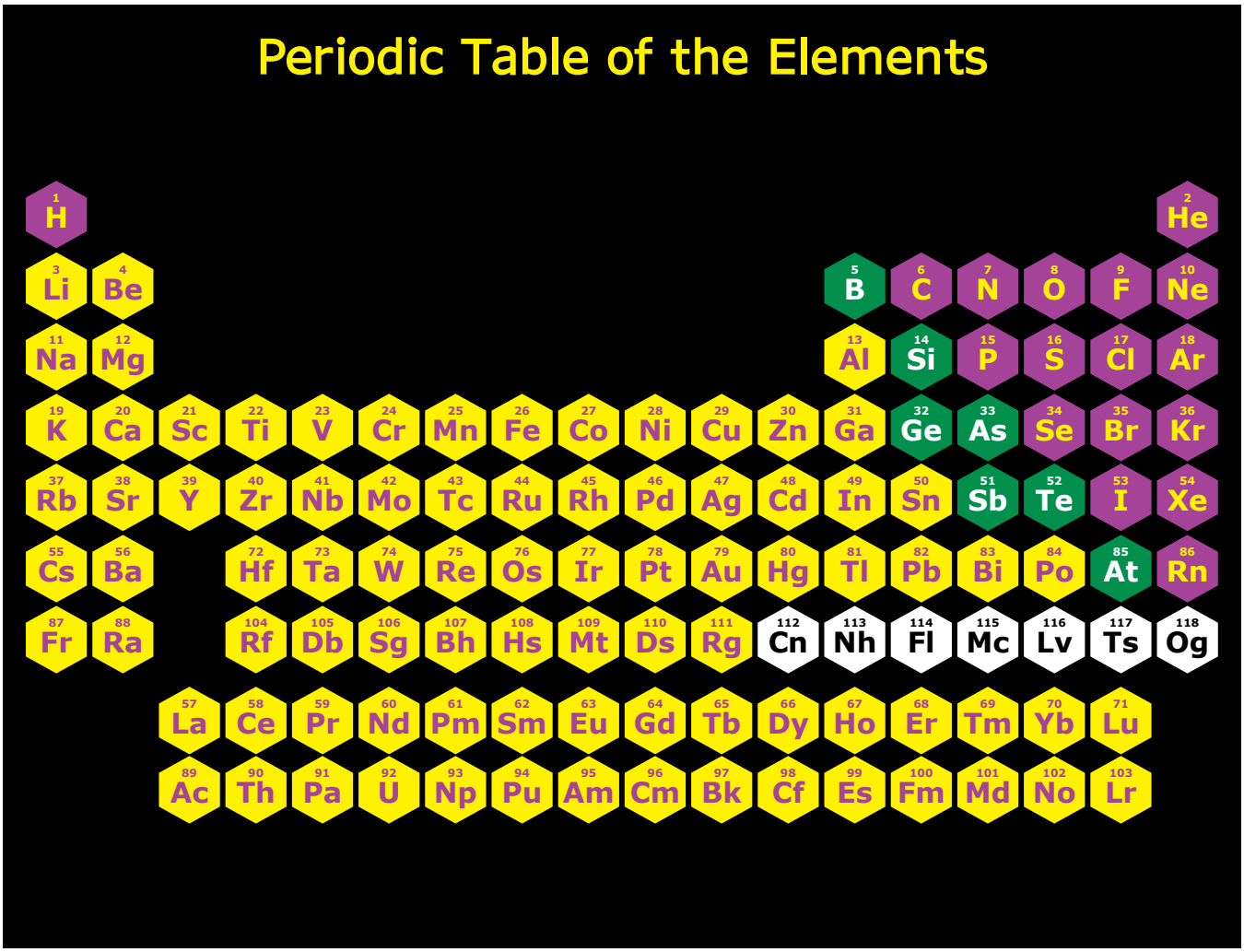
The color and tactile coding of the hexagonal pieces are intended to assist with identification and categorization. The following chart indicates the color and tactile assignments:

Color	Tactile Symbol	Classification
Purple		Nonmetal
Yellow		Metal
Green		Metalloid
White		Recently Discovered
Red		Polyatomic ions
Black		Assessment

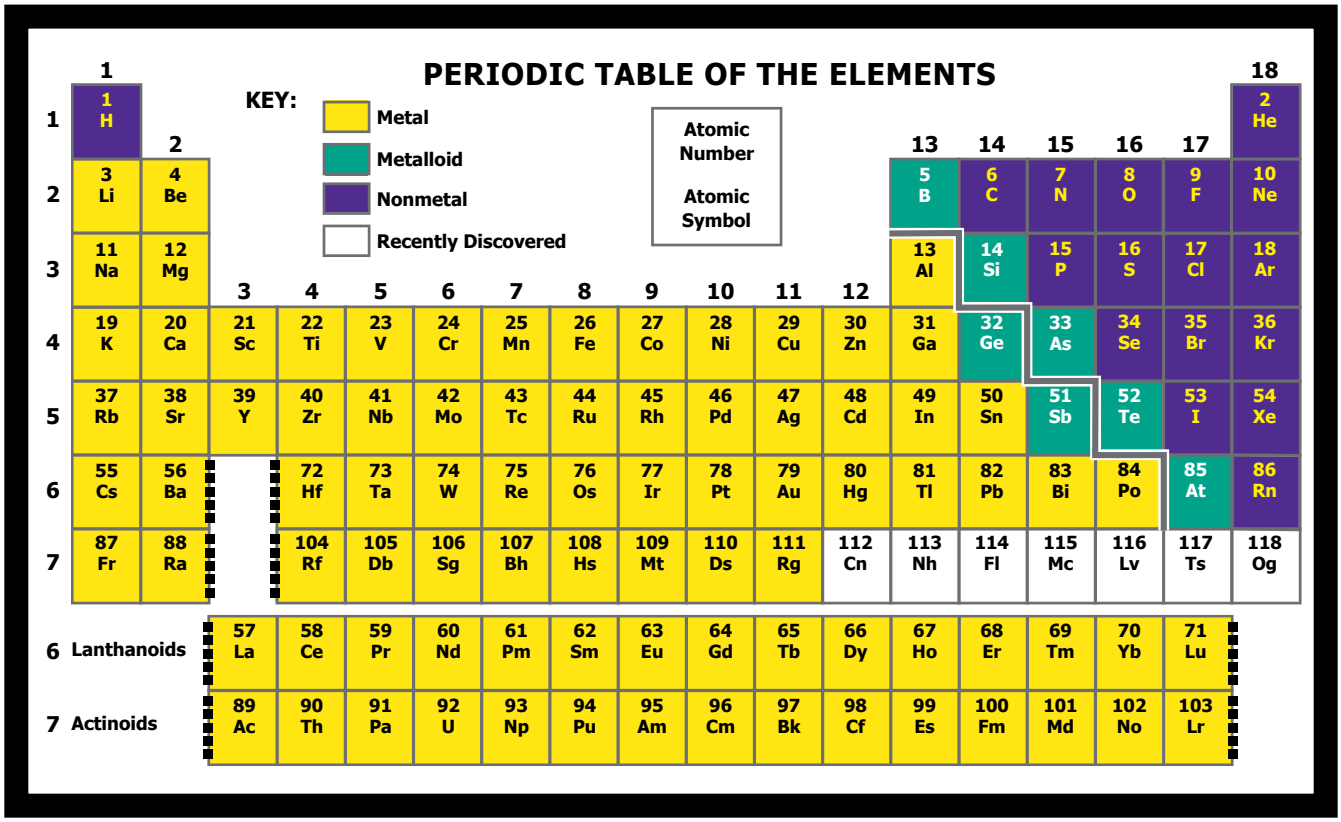
The color assignments correspond to those used on APH's *Periodic Table of the Elements Reference Chart*.

Building a Periodic Table

Azer's Interactive Periodic Table Study Set includes a minimum of one hexagonal piece for each of the elements in the periodic table. You can use these hook-backed pieces with the tri-fold board (included in the study set) to construct the entire periodic table of the elements.

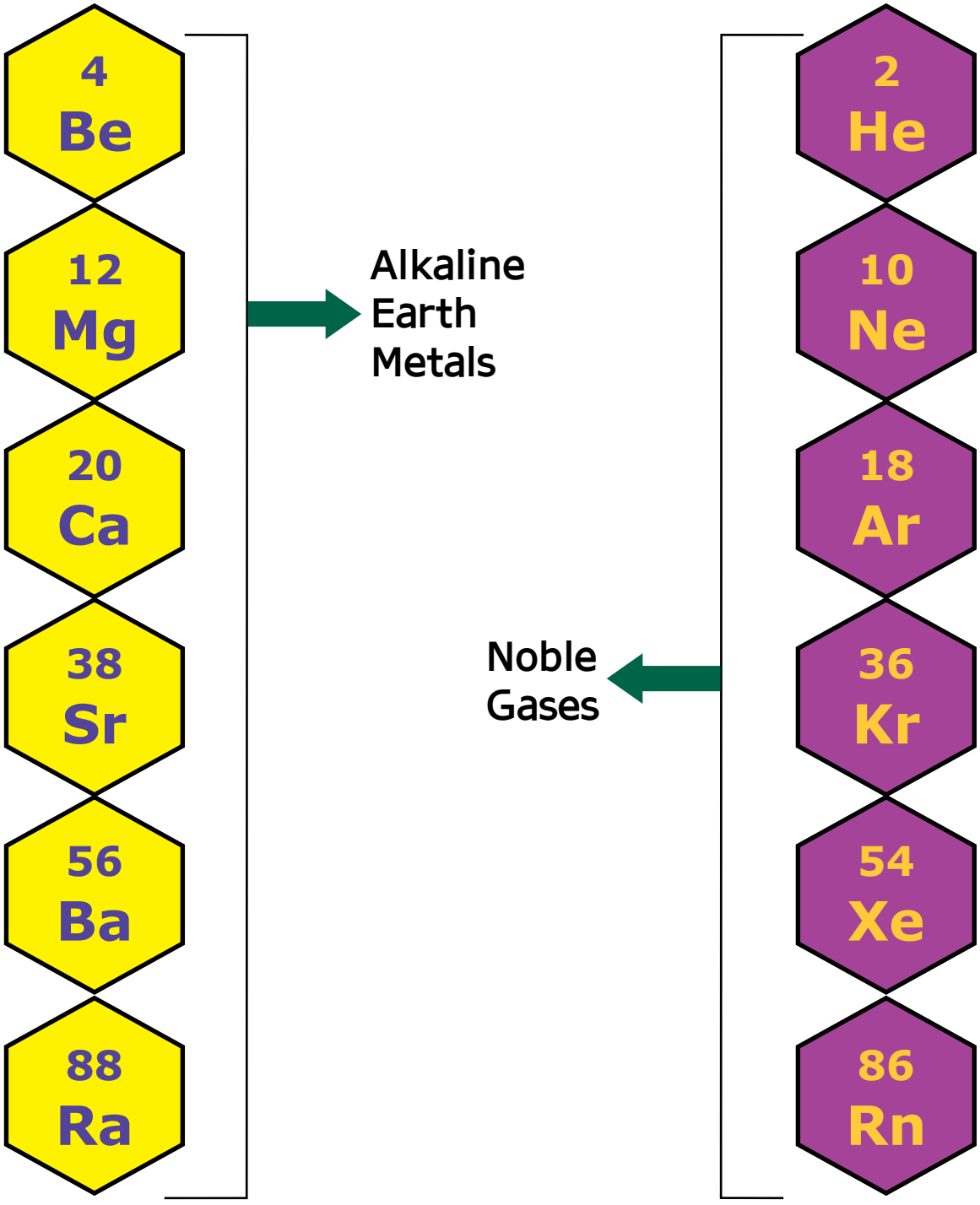


This interactive study aid is designed to complement APH's *Periodic Table of the Elements Reference Chart* (available separately). The colors of the hexagonal pieces in *Azer's Interactive Periodic Table Study Set* coordinate with the reference chart's element colors. In addition, the interactive version provides tactile indicators on the element pieces, designating each as a metal (raised horizontal bar), nonmetal (raised bump), metalloid (raised open circle), or recently discovered (raised vertical bar).



APH's *Periodic Table of the Elements Reference Chart* (available separately)

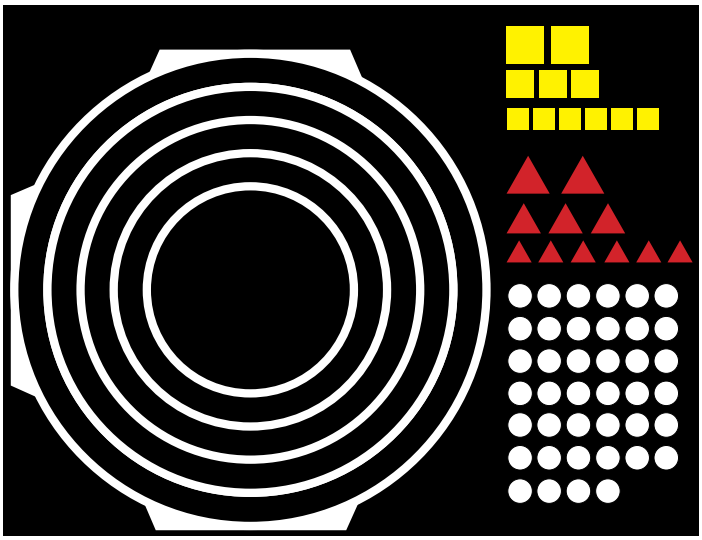
Use the materials in *Azer's Interactive Periodic Table Study Set* to familiarize the student with the periodic table and assess her knowledge of its organization. For example, ask the student to display just the noble gases and/or the alkaline earth metals.



By constructing the entire periodic table on the tri-fold board, students can learn how the elements are arranged in order of increasing atomic number. The periodic table displayed in this manner demonstrates a number of other concepts. The vertical columns of elements, or groups, consist of elements whose atoms have the same number of outer shell valence electrons and thus share similar chemical properties. The horizontal rows of elements, or periods, include elements whose atoms possess the same number of electron shells. Groups and periods show predictable trends in atomic radius, ionization energy, and electronegativity, accounting for the name of the periodic table.

Note that the complete periodic table arranged on the tri-fold board is an appropriate demonstration tool for all students, regardless of visual acuity.

Atomic Model



Azer's Interactive Periodic Table Study Set includes an Atomic Model that is designed to introduce atomic structure to students with visual impairments and blindness. This model can, of course, be used as a learning tool with any student, regardless of visual acuity.

The interactive Atomic Model [two included with the study kit] can be used to assist the student in the following:

1) Understanding atomic structure and identifying protons, electrons, and neutrons
2) Understanding the meanings of atomic number and mass number
3) Making models of atoms and their isotopes
4) Arranging electrons in energy levels to determine the electron configuration of a particular atom and using this to:

- Locate the element in the periodic table
- Identify valence electrons
- Determine whether the element is a metal or nonmetal
- Determine the oxidation number of an element
- Demonstrate how elements combine chemically via ionic or covalent bonding

Given the atomic numbers and mass numbers of selected atoms, students can practice building atomic models. Students can use the model to demonstrate the gain or loss of electrons when atoms of different elements form ionic bonds. Covalent bonds, or sharing of electrons between two nonmetal atoms, are also easily demonstrated. Using the positive and negative numbers included with the study kit, the Atomic Model can also be used to introduce the concept of oxidation number.

The Atomic Model included in *Azer's Interactive Periodic Table Study Set* simulates the Bohr Model. Niels Bohr, a Danish scientist, proposed that the electrons in an atom are found in different energy levels and that each energy level is at a certain distance from the nucleus. Keep in mind that this model poses the following limitations that should be explained to the student, namely:

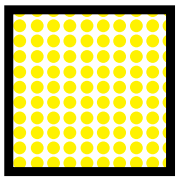
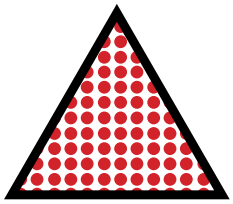
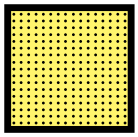
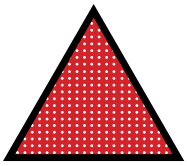
- The ratio of the size of the nucleus to the size of an atom in the Atomic Model does not represent the true ratio in actual atoms.
- Energy levels are areas where the electrons are most likely to exist. They are not preexisting physical locations for electrons as the ring structure suggests. According to the "Modern Model," the location of the electrons in an atom cannot be known.

The Atomic Model includes interactive, textured pieces that represent electrons, protons, and neutrons. The kit includes enough pieces to allow the student to build and study the atomic structures of the first 36 elements in the periodic table—from Hydrogen (in Period 1) through Krypton (in Period 4). The smooth, white circles represent electrons, the square pieces protons, and the triangular pieces neutrons.

Three different sizes of protons and neutrons are included in the study kit. The largest of each shape represents 10 (protons or neutrons), the medium size of each shape represents 5 (protons or neutrons), and the smallest of each shape represents a single proton or neutron. Below is a key indicating these values:

ELECTRONS

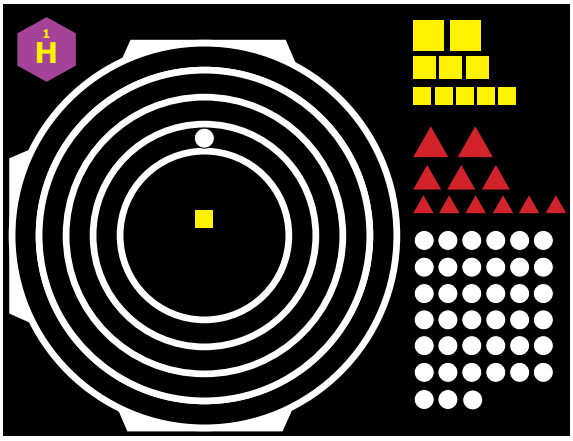
◯ = 1 electron

PROTONS		NEUTRONS
	Value 10	
bumpy texture		bumpy texture
	5	
rough texture		rough texture
	1	
smooth texture		smooth texture

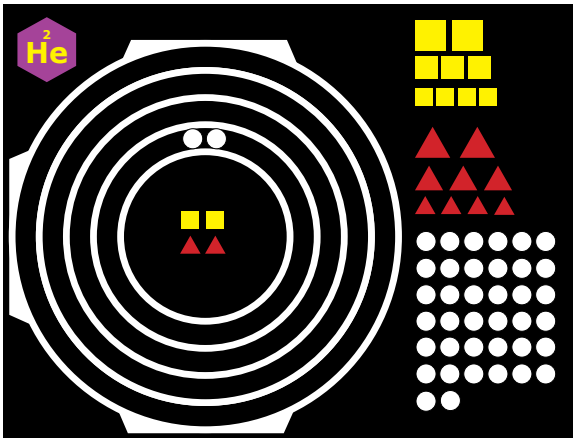
Atomic Configurations

The following are demonstrations of the atomic configuration of various elements using the Atomic Model included in *Azer's Interactive Periodic Table Study Set:*

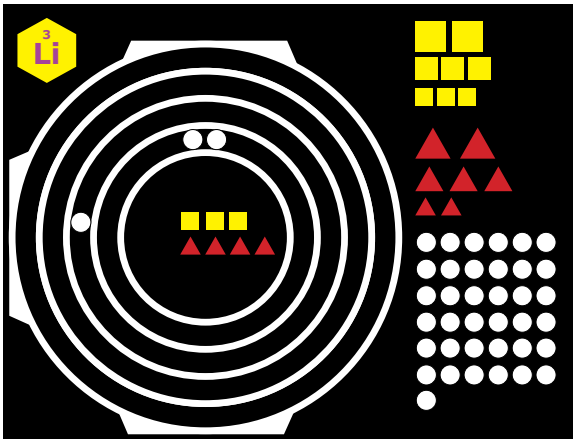
Hydrogen
Protons: 1
Neutrons: 0
Electrons: 1



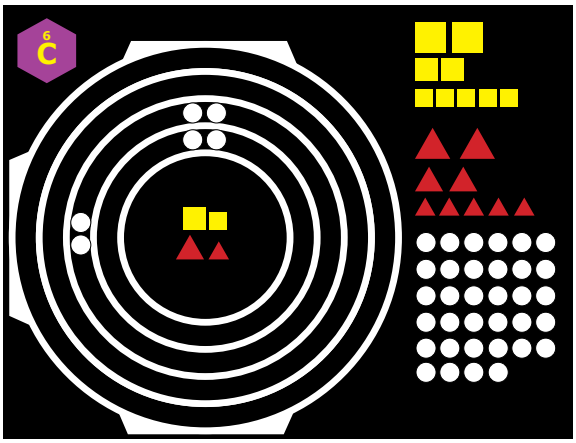
Helium
Protons: 2
Neutrons: 2
Electrons: 2



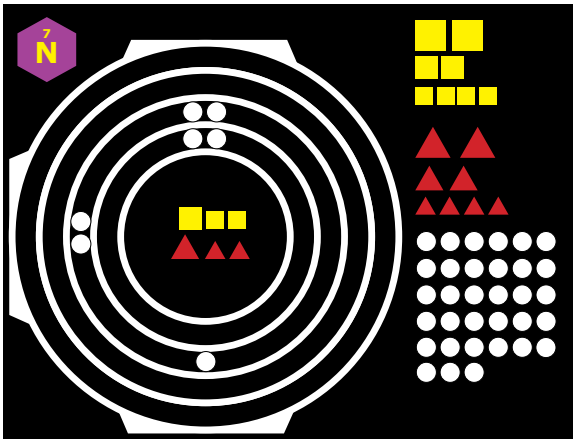
Lithium
Protons: 3
Neutrons: 4
Electrons: 3



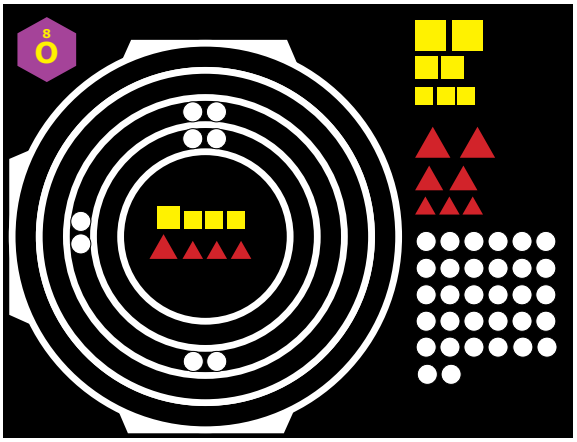
Carbon
Protons: 6
Neutrons: 6
Electrons: 6



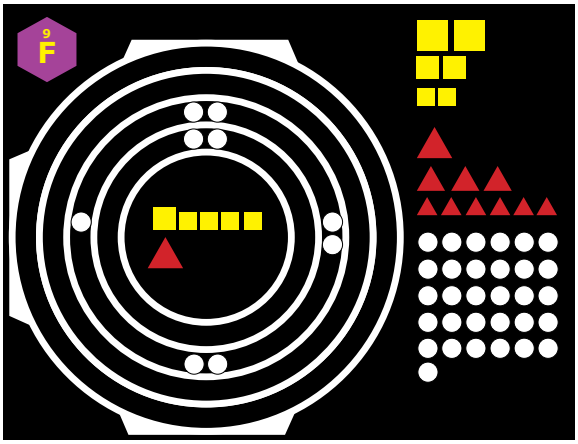
Nitrogen
Protons: 7
Neutrons: 7
Electrons: 7



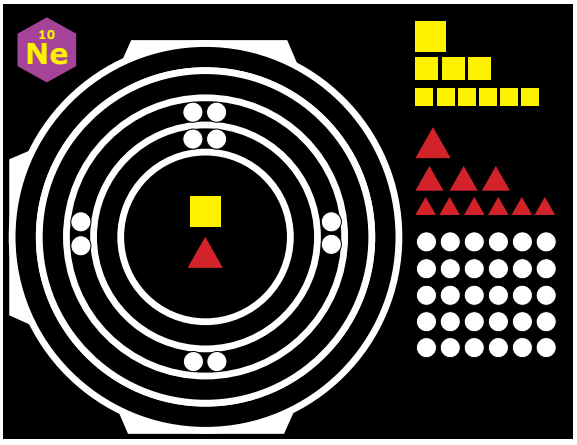
Oxygen
Protons: 8
Neutrons: 8
Electrons: 8



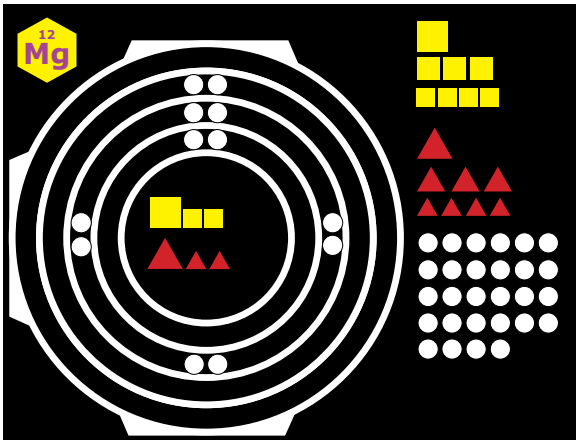
Fluorine
Protons: 9
Neutrons: 10
Electrons: 9



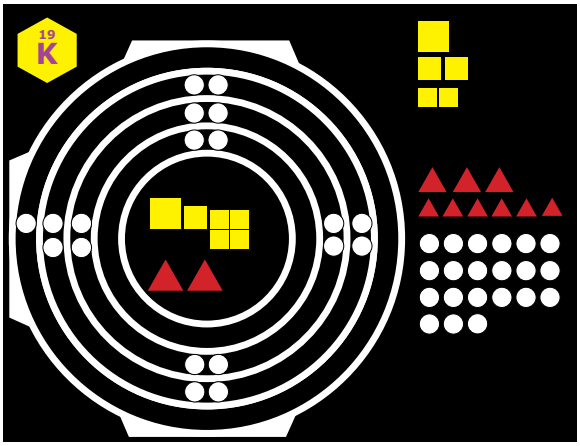
Neon
Protons: 10
Neutrons: 10
Electrons: 10



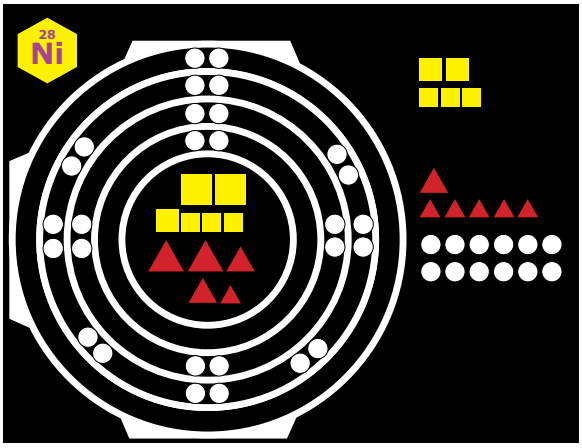
Magnesium
Protons: 12
Neutrons: 12
Electrons: 12



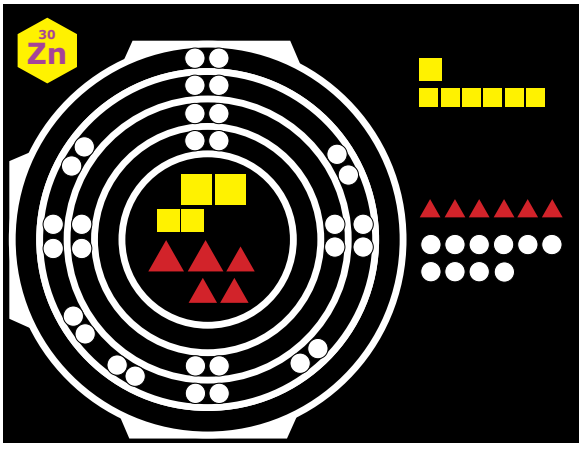
Potassium
Protons: 19
Neutrons: 20
Electrons: 19



Nickel
Protons: 28
Neutrons: 31
Electrons: 28



Zinc
Protons: 30
Neutrons: 35
Electrons: 30

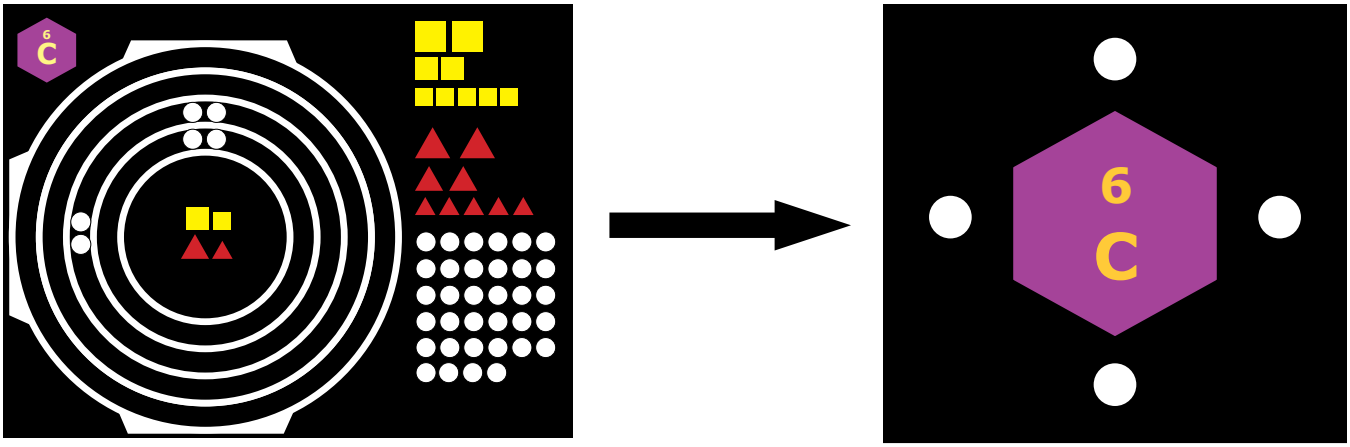


Electron Dot Diagrams

Azer's Interactive Periodic Table Study Set provides a way to illustrate electron dot diagrams. An ***electron dot diagram*** is a simple way to depict an atom's valence electrons and demonstrate its bonding behavior.

Begin by constructing the atomic structure of a particular element with the Atomic Model. Then set up an electron dot diagram on the tri-fold board, including only the atom's outermost, highest energy, or "valence" electrons. See the illustrations below for an example of this transition.

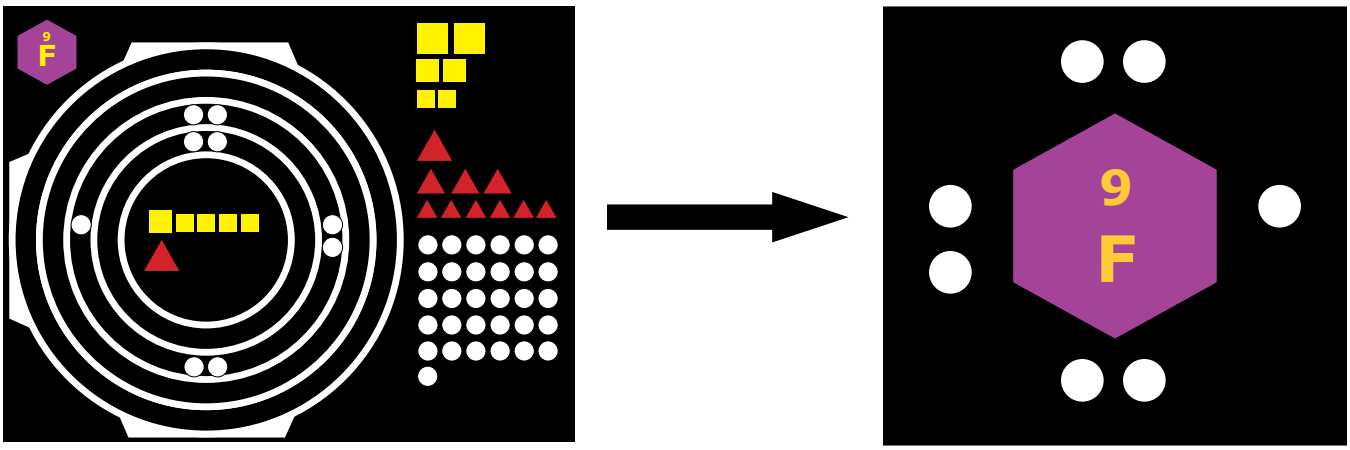
Example 1: Carbon



Atomic Structure of Carbon

Electron Dot Diagram of Carbon

Example 2: Fluorine



Atomic Structure of Fluorine

Electron Dot Diagram of Fluorine

The group to which an element belongs indicates the number of valence electrons it possesses, as shown in the chart below:

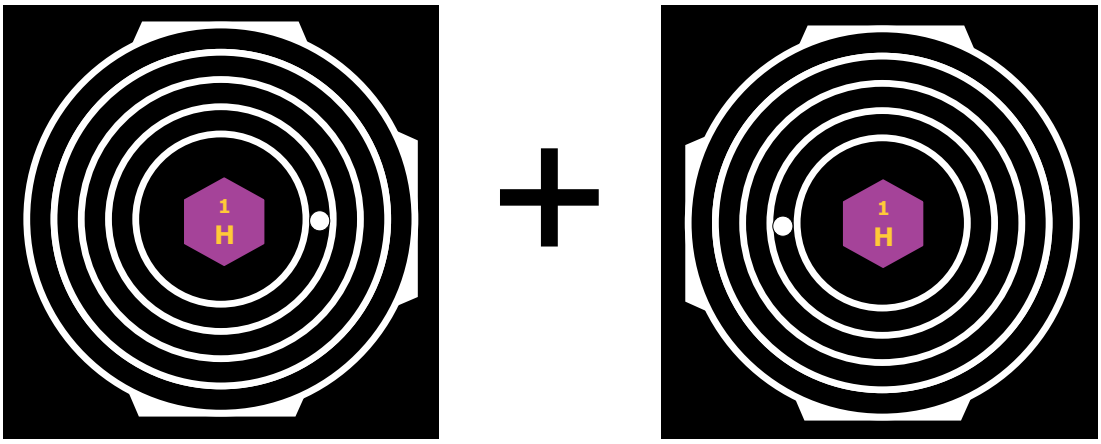
Group	Elements	Number of Valence Electrons
IA	H, Li, Na, K, Rb, Cs, Fr	1
IIA	Be, Mg, Ca, Sr, Ba, Ra	2
IIIA	B, Al, Ga, In, Tl, Nh	3
IVA	C, Si, Ge, Sn, Pb, Fl	4
VA	N, P, As, Sb, Bi, Mc	5
VIA	O, S, Se, Te, Po, Lv	6
VIIA	F, Cl, Br, I, At, Ts	7
VIIIA	He, Ne, Ar, Kr, Xe, Rn, Og	8

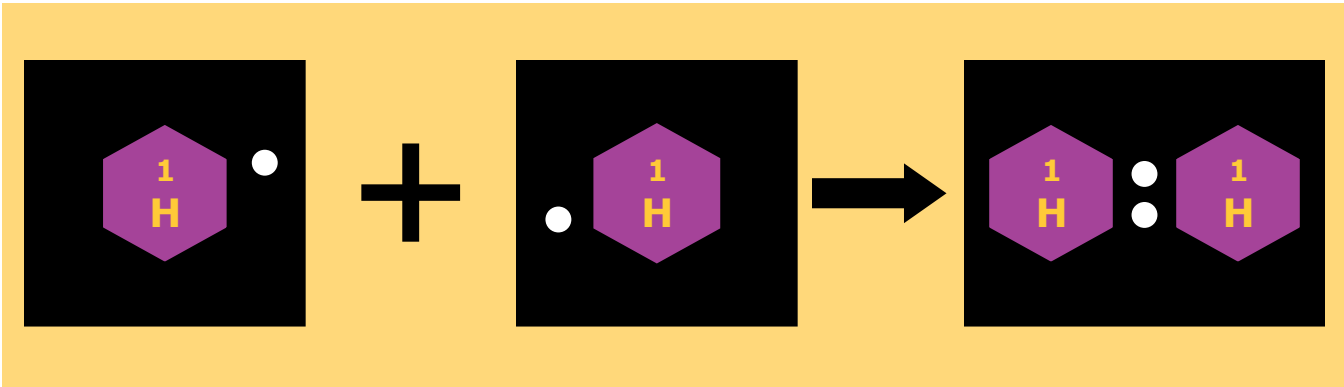
Covalent Bonds

The materials provided in *Azer's Interactive Periodic Table Study Set* can be used to illustrate covalent bonds, that is, when atoms bond by sharing electrons.

Example 1: Covalent bonding of two hydrogen atoms

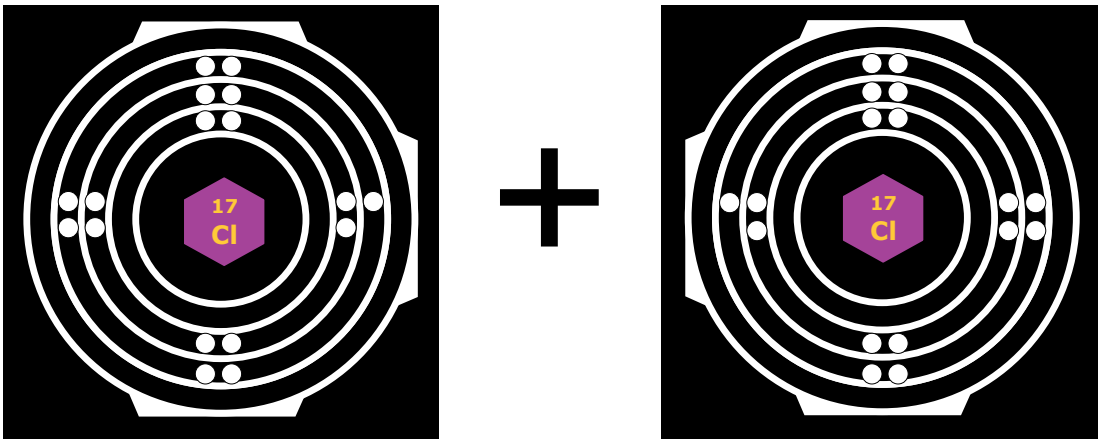
The illustration below shows covalent bonding of two hydrogen atoms. When the two atoms of hydrogen combine, the pair of electrons will be shared by both hydrogen atoms, making both of their outer energy levels complete.

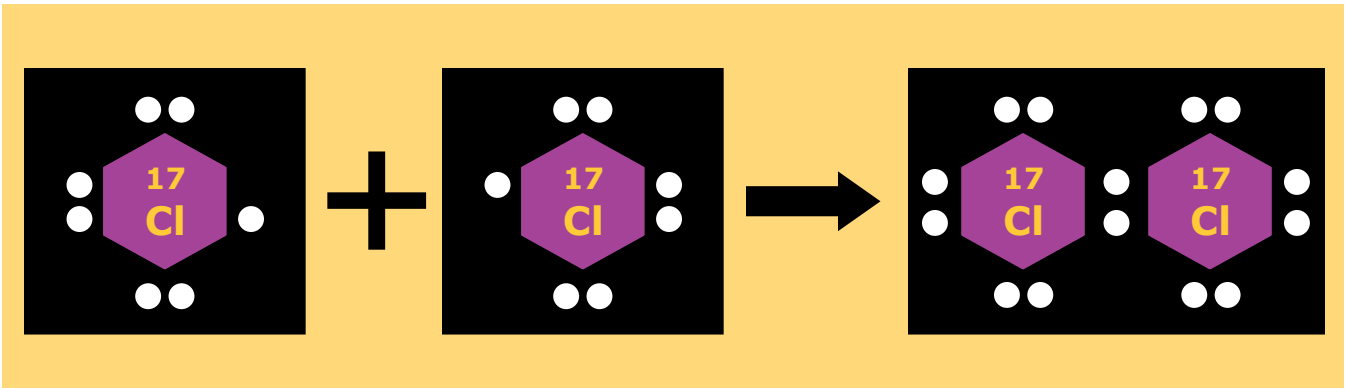




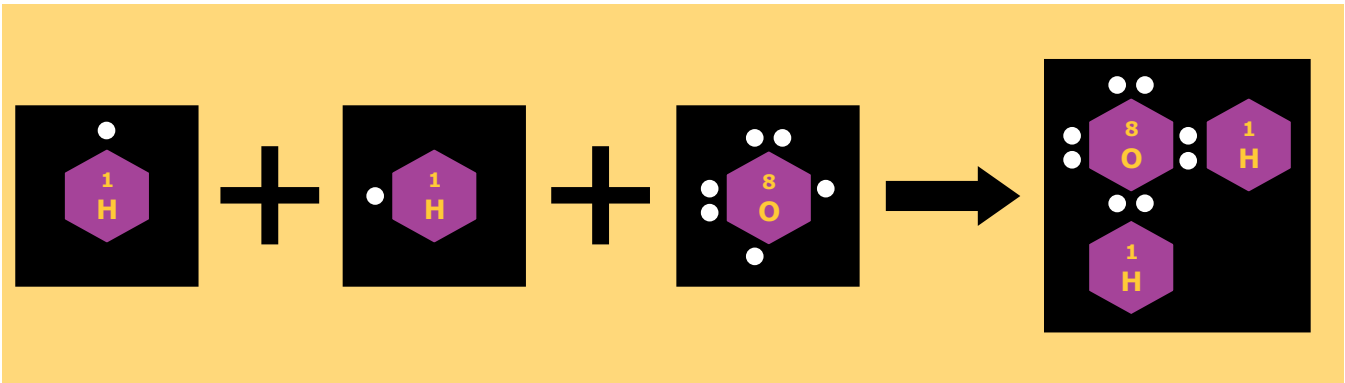
Example 2: Covalent bonding of two chlorine atoms

The illustration below shows the covalent bonding of two chlorine atoms. Since the two atoms share a pair of electrons, each atom, at one time or another, has its outer energy level complete.





Example 3: Covalent bonding of two hydrogen atoms with an oxygen atom

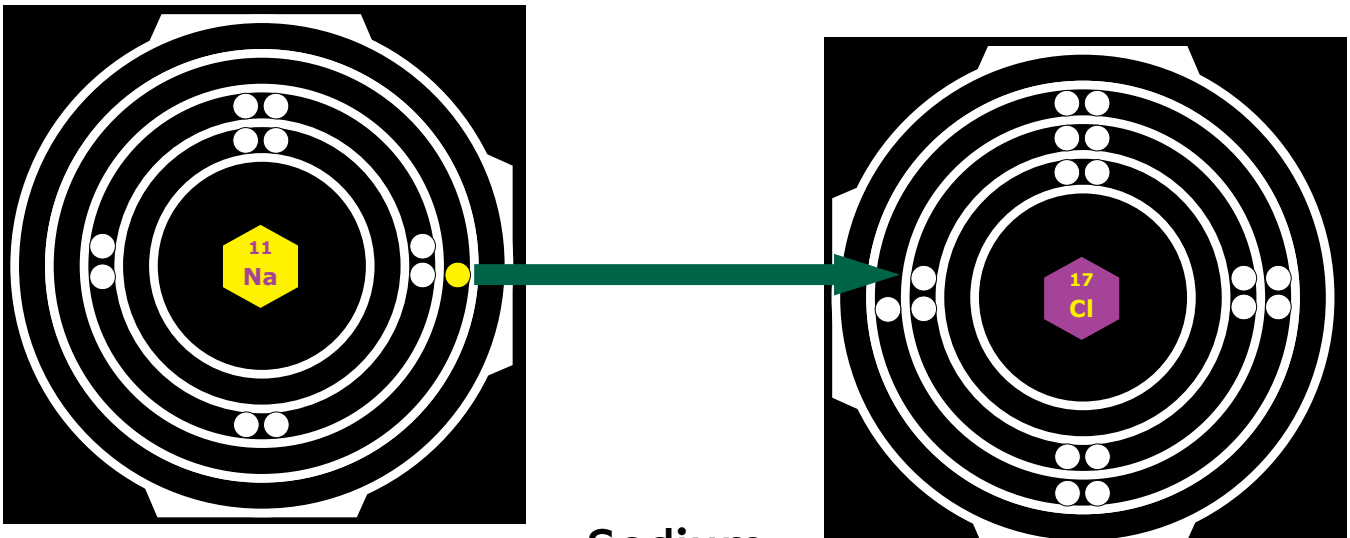


Ionic Bonds

The materials provided in *Azer's Interactive Periodic Table Study Set* can be used to illustrate an ionic bond, that is, when a bond is formed by the attraction of positively charged ions to negatively charged ions.

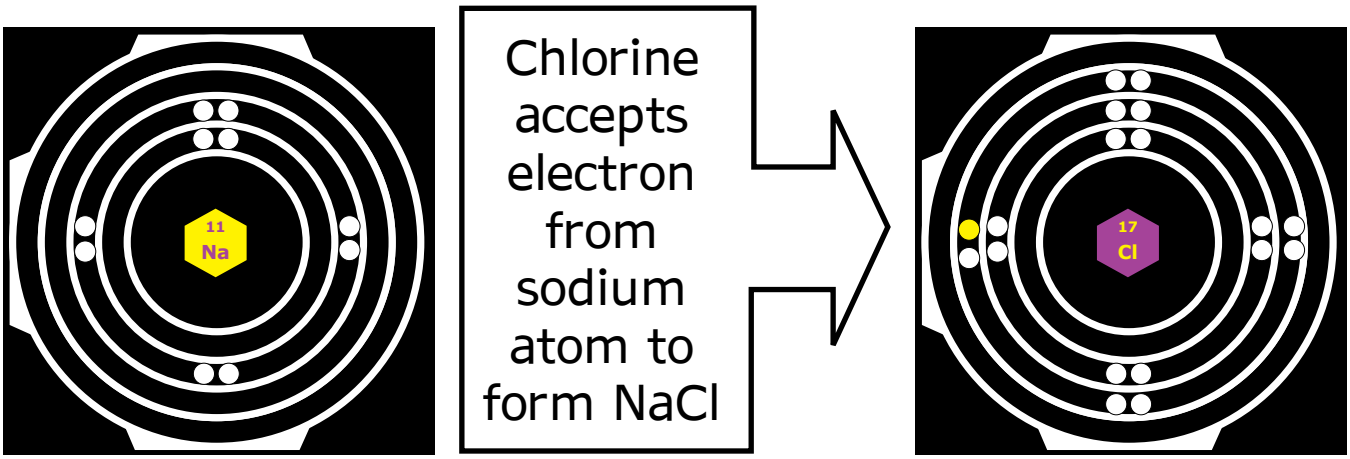
<u>Example 1</u>: Ionic bonding of sodium and chlorine to form table salt (sodium chloride)

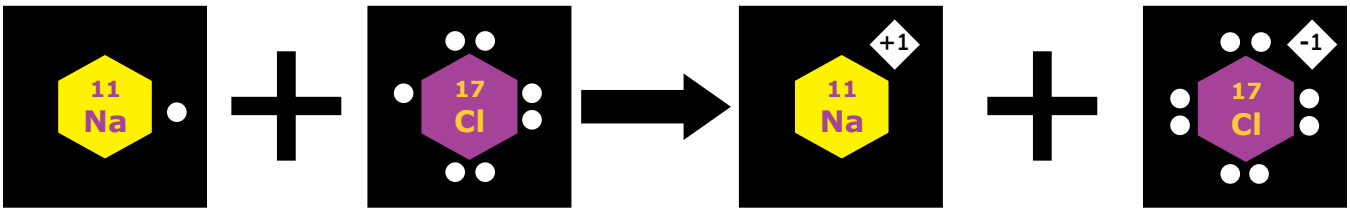
The sodium atom gives up one electron to the chlorine atom. Sodium's outermost energy level now has eight electrons and is complete. When the chlorine atom accepts the electron from the sodium atom, its outermost energy level has eight electrons and it, too, is complete. The result is NaCl, a very stable compound.



Sodium atom gives up electron to chlorine atom

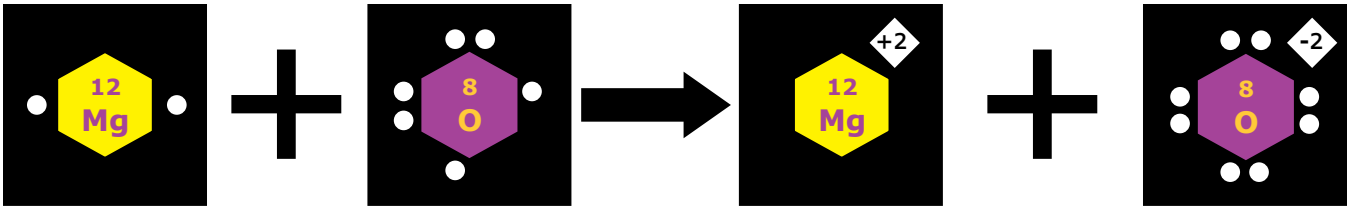
Result:





NaCl

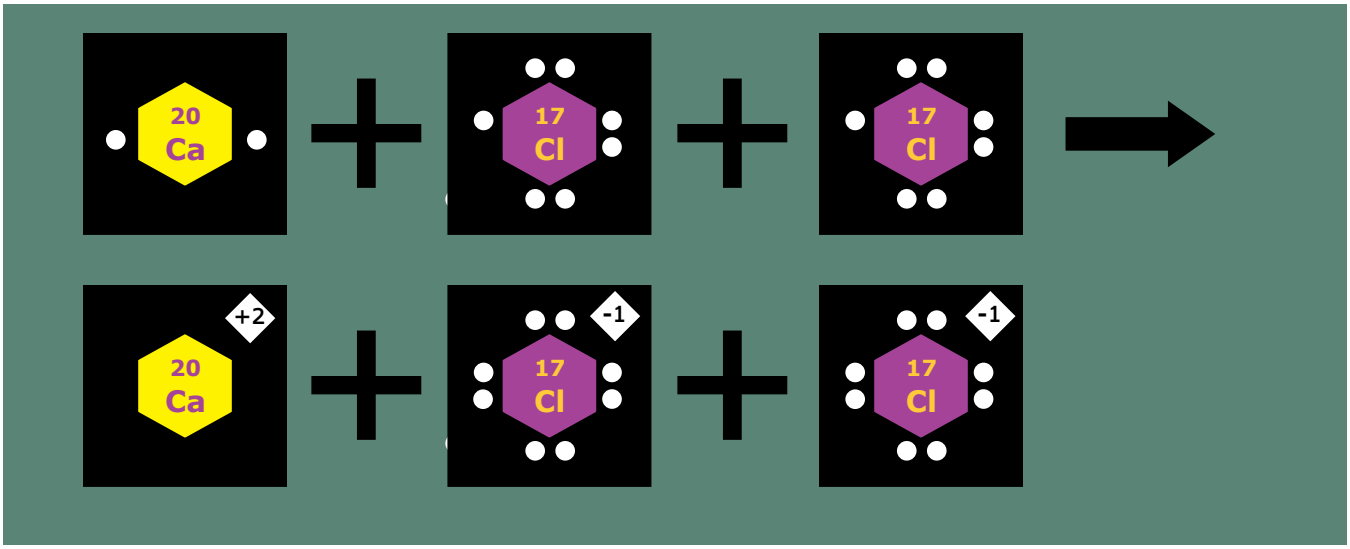
<u>Example 2</u>: Ionic bond between magnesium and oxygen atom



MgO

The magnesium atom gives up its two outermost electrons, which complete the oxygen atom's outermost energy level with eight electrons. A stable compound, magnesium oxide (MgO), is formed.

<u>Example 3</u>: Ionic bond between calcium and chlorine atoms



The calcium atom gives up the two electrons in its outermost energy level, one to each chlorine atom. The chlorine atoms' outermost energy levels are now complete. Calcium chloride ($CaCl_2$) results.

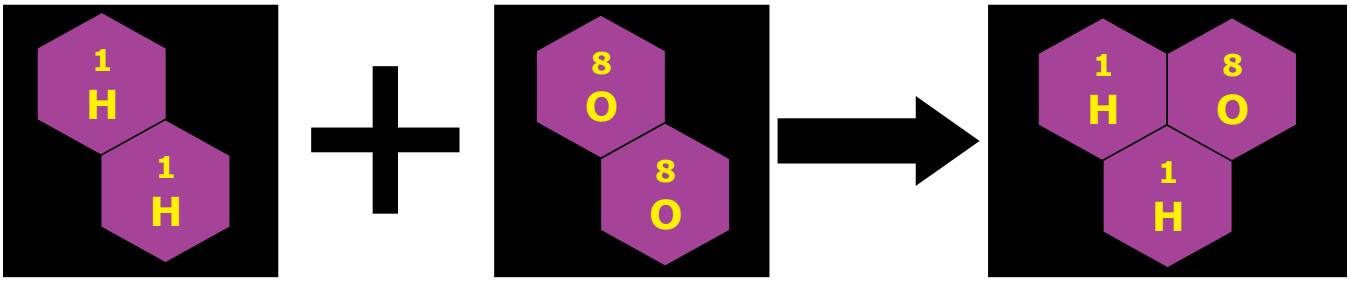
Balancing Chemical Equations

Azer's Interactive Periodic Table Study Set is ideal for demonstrating the steps involved in balancing a chemical equation. Below are a few examples of how the study set materials can be used for this purpose. Keep in mind that once the braille reader becomes comfortable balancing equations with the movable hook-backed pieces, he should be taught the braille chemistry code for solving chemical equations on paper. ***Appendix A*** in this guidebook provides a "Quick Reference to Braille Code for Chemical Notation."

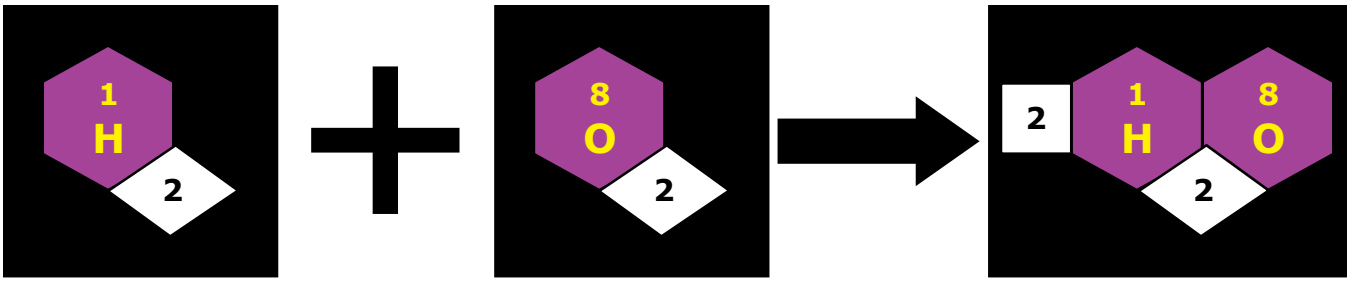
Example 1:

Step 1: Determine that the equation is unbalanced. The number of oxygen atoms is unequal on each side of the equation.

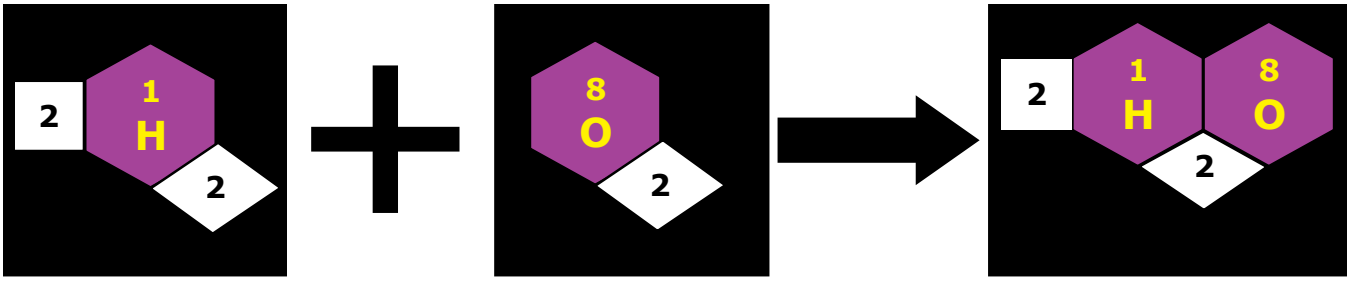
$$H_2 + O_2 \rightarrow H_2O$$



Step 2: The hydrogen atoms are balanced, but the oxygen atoms are not. Place the coefficient 2 before the water molecule on the right side of the equation to balance oxygen.



Step 3: Placing the coefficient 2 on the right caused hydrogen to become unbalanced. Balance hydrogen by placing the coefficient 2 in front of H_2 on the left side of the equation.

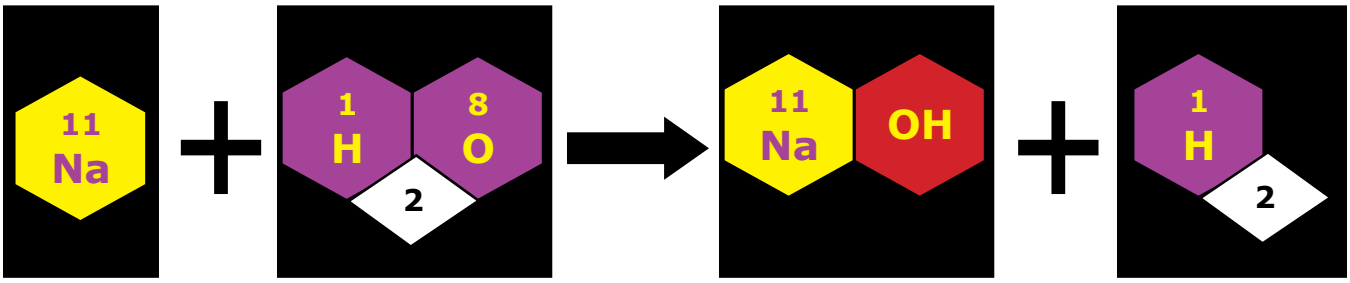


The equation is now balanced.

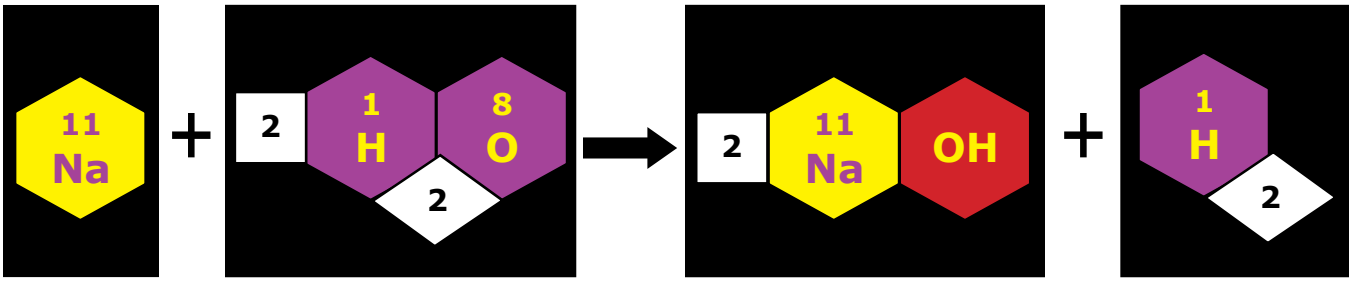
Example 2:

Step 1: Determine that the equation is unbalanced. The number of hydrogen atoms is not equal on each side of the equation.

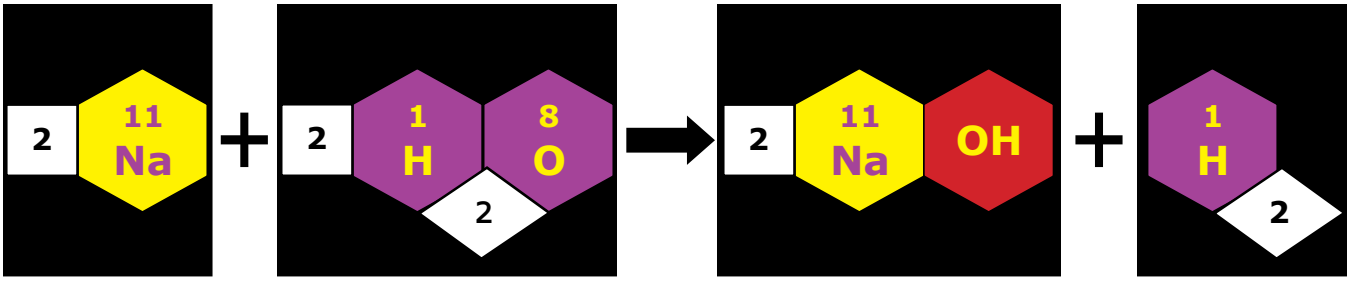
$$Na + H_2O \rightarrow NaOH + H_2$$



Step 2: Balance the hydrogen and oxygen atoms on both sides of the equation by placing the coefficient 2 before the water molecule on the left side of the equation and the coefficient 2 before NaOH on the right side.



Step 3: Finish balancing the equation by adding the coefficient 2 before the sodium atom on the left side of the equation.

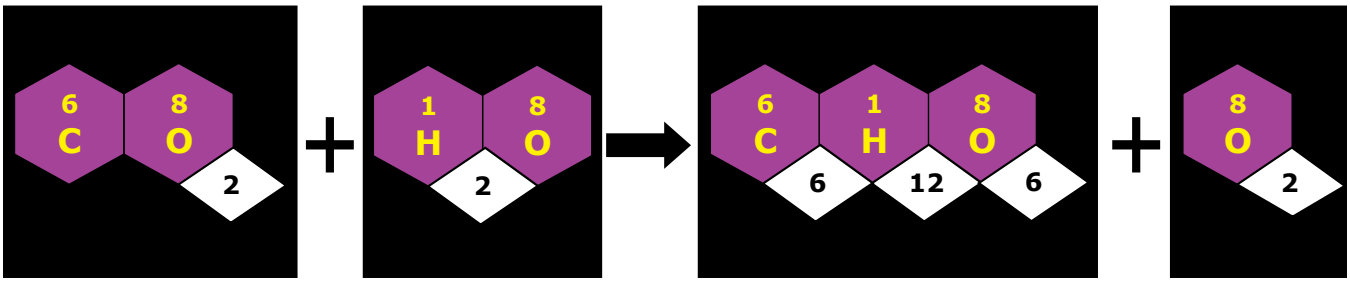


The equation is now balanced.

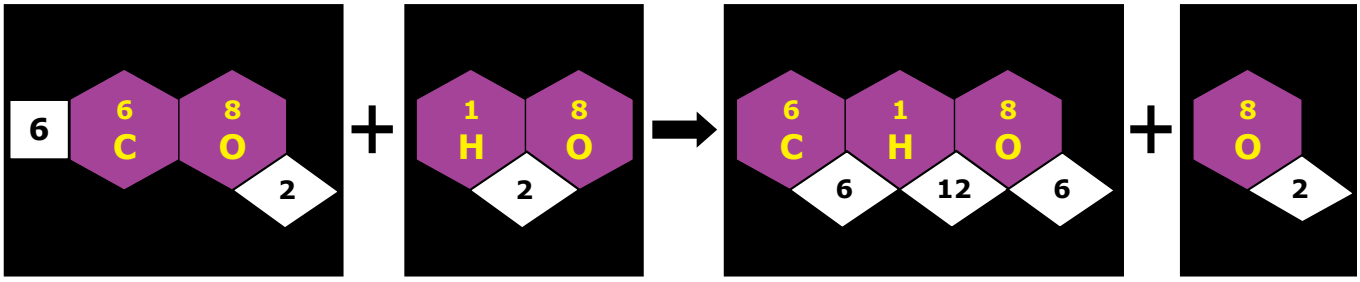
Example 3:

Step 1: Determine that the equation is unbalanced. The number of atoms of all elements is unequal on each side of the equation.

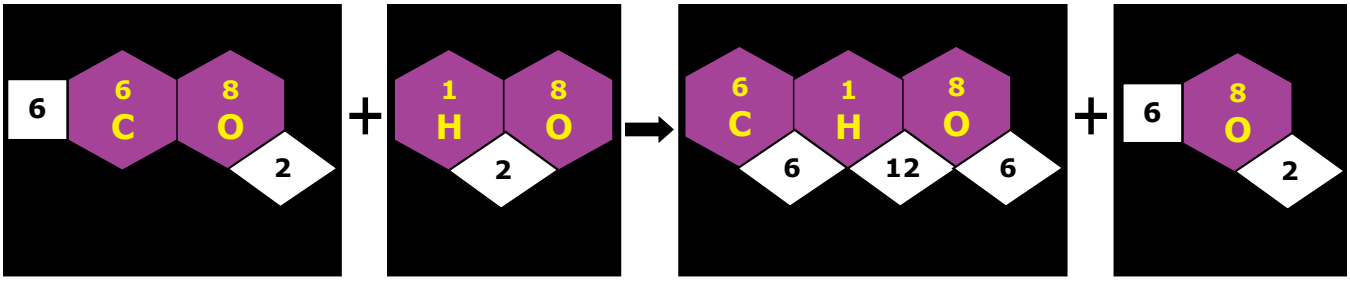
$$CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2$$



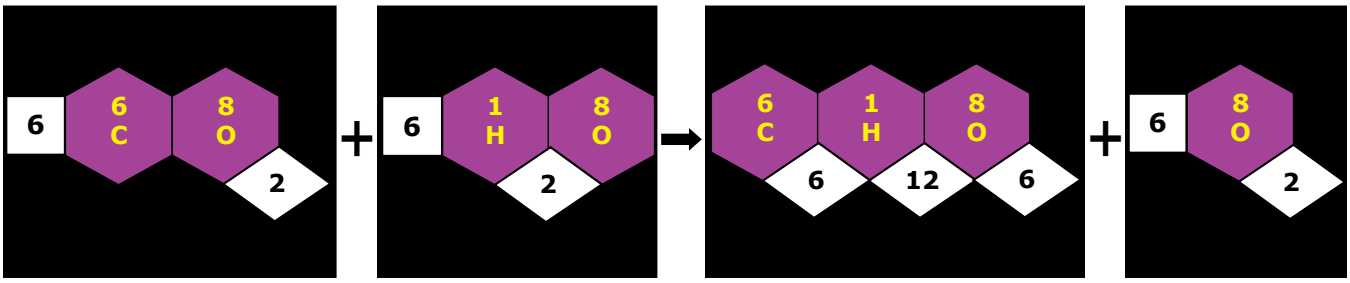
Step 2: Balance the carbon atoms by placing the coefficient 6 in front of the CO_2 on the left side of the equation.



Step 3: Balance the oxygen atoms by placing the coefficient 6 in front of the O_2 on the right side of the equation.



Step 4: Balance the hydrogen atoms by placing the coefficient 6 before the water molecule on the left side.



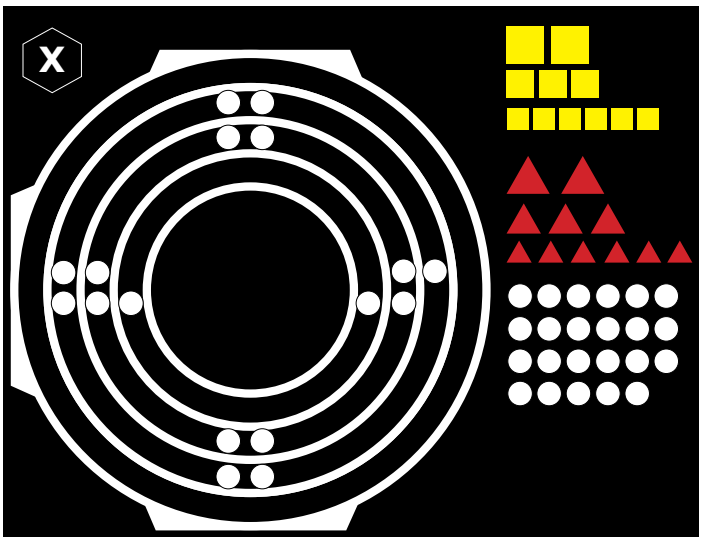
The equation is now balanced.

Assessment Sample Questions

Azer's Interactive Periodic Table Study Set includes two hexagonal pieces—**X** and **Y**—which can be used as unknowns to test students about concepts already presented.

Example A:

Present the following:

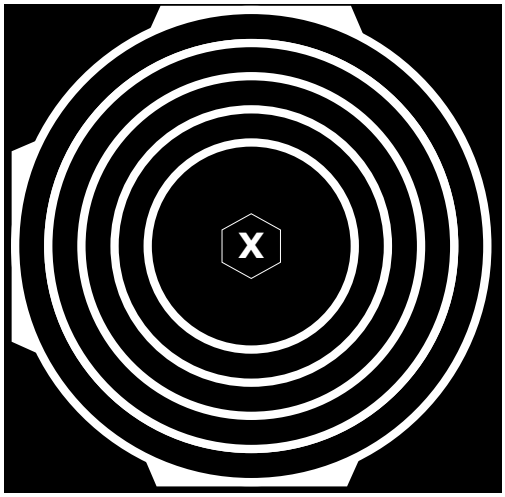


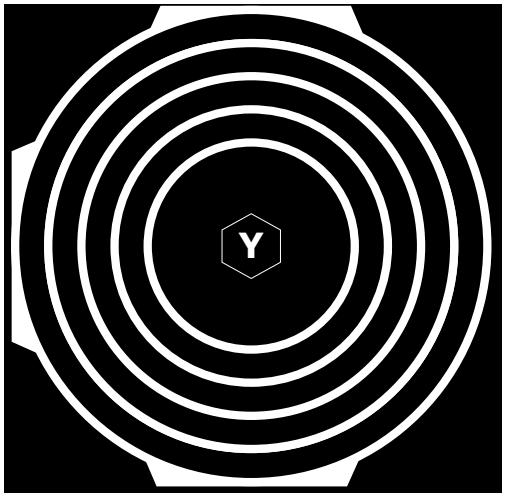
Questions to ask the student:

1. How many electrons are in an atom of element **X**?
2. How many electrons are in the first energy level of an atom of element **X**?
3. How many protons are in an atom of element **X**?
4. If there are 18 neutrons in an atom of element **X**, what is the mass number of an atom of element **X**?
5. Identify the element on the periodic table.

Example B:

Present the following:





Questions to ask the student:

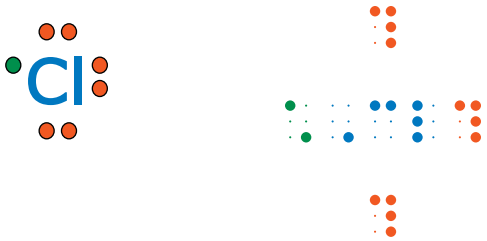
If **X** has an atomic number of 12 and **Y** has an atomic number of 15...

1. What are the electron configurations of **X** and **Y**?
2. What are the oxidation numbers of **X** and **Y**?
3. Can you identify and locate **X** and **Y** on the periodic table?
4. What compound results from the bonding of **X** and **Y**?
5. What kind of bond would occur—ionic or covalent?

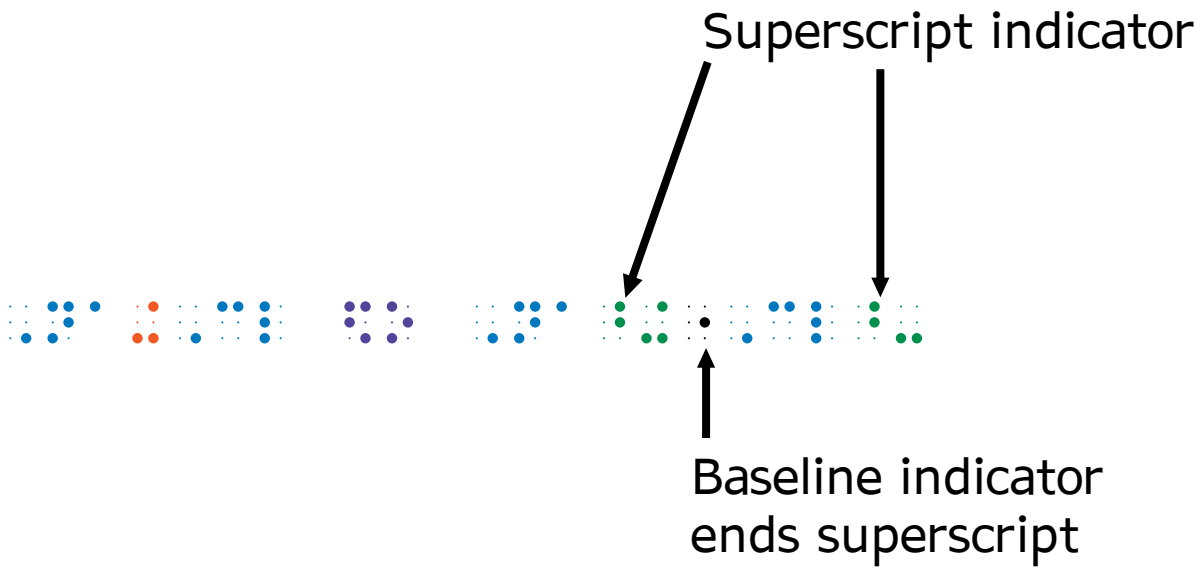
Appendix A

Quick Reference to Braille Code of Chemical Notation

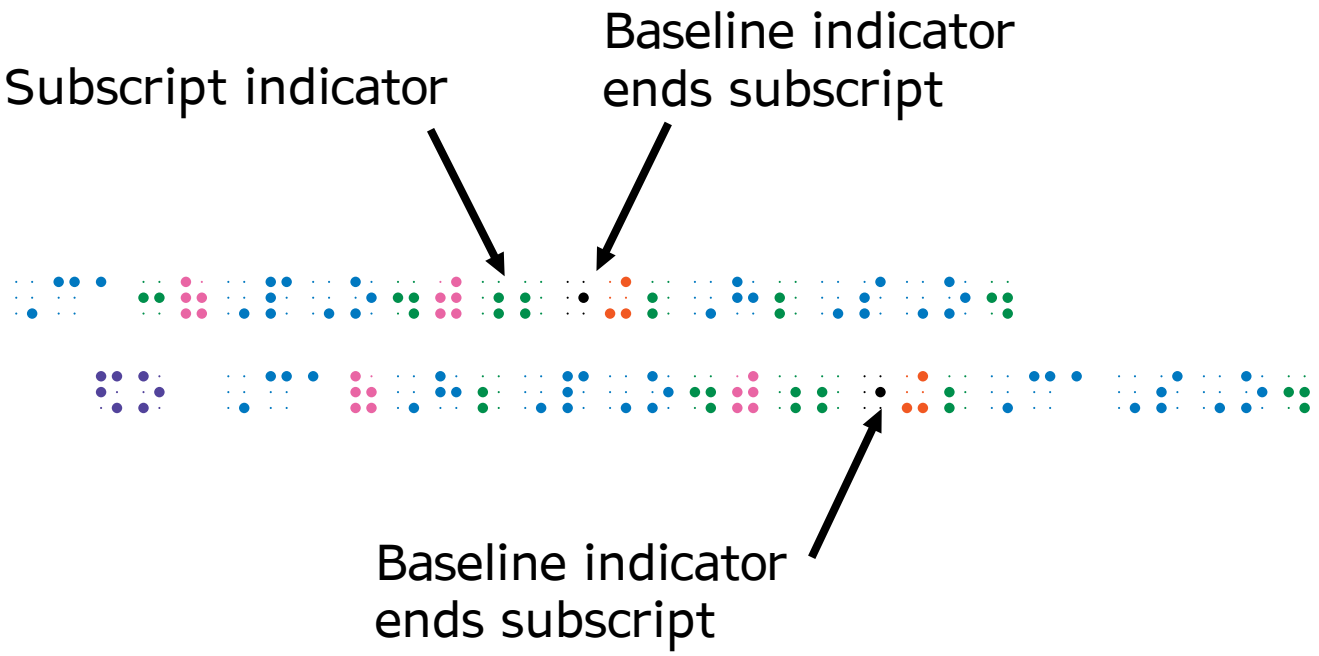
Quick Reference to Braille Code of Chemical Notation



$Na + Cl \rightarrow Na^{+}Cl^{-}$



$$Ca_3(PO_4)_2 + 2H_2SO_4 \rightarrow Ca(H_2PO_4)_2 + 2CaSO_4$$



For a complete listing of the special symbols and rules used in the *Braille Code for Chemistry Notation* (1997), visit: http://www.brl.org/chemistry/rule02.html

Appendix B

Skills Checklist

Skills Checklist

Student's name: _____

Instructor's name: _____

Directions: Use the following rating scale to indicate the student's current level of understanding of each skill/ concept:

1 - Beginning level of performance

2 - Developing level of performance

3 - Mastered/Accomplished level of performance

Objective/Skill: Arrange element categories (e.g., noble gases) on the felt board.	Date:	Date:	Date:	Date:
	Rating:	Rating:	Rating:	Rating:
Comments:				

Objective/Skill: Distinguish between metal and nonmetal elements.	Date:	Date:	Date:	Date:
	Rating:	Rating:	Rating:	Rating:
Comments:				

Objective/Skill: Identify elements on the periodic table that are classified within lanthanide and actinide series.	Date:	Date:	Date:	Date:
	Rating:	Rating:	Rating:	Rating:
Comments:				

Objective/Skill: Distinguish between naturally occurring and human-made elements on the periodic table.	Date:	Date:	Date:	Date:
	Rating:	Rating:	Rating:	Rating:
Comments:				

Objective/Skill: Distinguish between radioactive and nonradioactive elements on the periodic table.	Date:	Date:	Date:	Date:
	Rating:	Rating:	Rating:	Rating:
Comments:				

Objective/Skill: Identify the location of subatomic particles in an atom.	Date:	Date:	Date:	Date:
	Rating:	Rating:	Rating:	Rating:
Comments:				

Objective/Skill: Arrange electrons in energy levels to determine electron configurations.	Date:	Date:	Date:	Date:
	Rating:	Rating:	Rating:	Rating:
Comments:				

Objective/Skill: Determine oxidation number of an element.	Date:	Date:	Date:	Date:
	Rating:	Rating:	Rating:	Rating:
Comments:				

Objective/Skill: Identify an element's valence electrons.	Date:	Date:	Date:	Date:
	Rating:	Rating:	Rating:	Rating:
Comments:				

Objective/Skill: Build an electron dot diagram of a selected element.	Date:	Date:	Date:	Date:
	Rating:	Rating:	Rating:	Rating:
Comments:				

Objective/Skill: Demonstrate how elements combine through ionic bonds.	Date:	Date:	Date:	Date:
	Rating:	Rating:	Rating:	Rating:
Comments:				

Objective/Skill: Demonstrate how elements combine through covalent bonds.	Date:	Date:	Date:	Date:
	Rating:	Rating:	Rating:	Rating:
Comments:				

Objective/Skill: Balance simple chemical equations.	Date:	Date:	Date:	Date:
	Rating:	Rating:	Rating:	Rating:
Comments:				

Objective/Skill: Balance complex chemical equations.	Date:	Date:	Date:	Date:
	Rating:	Rating:	Rating:	Rating:
Comments:				

Permission is given to make copies of this checklist as needed. An electronic file of the "Skills Checklist" is also provided for free download on APH's Web site.

Appendix C

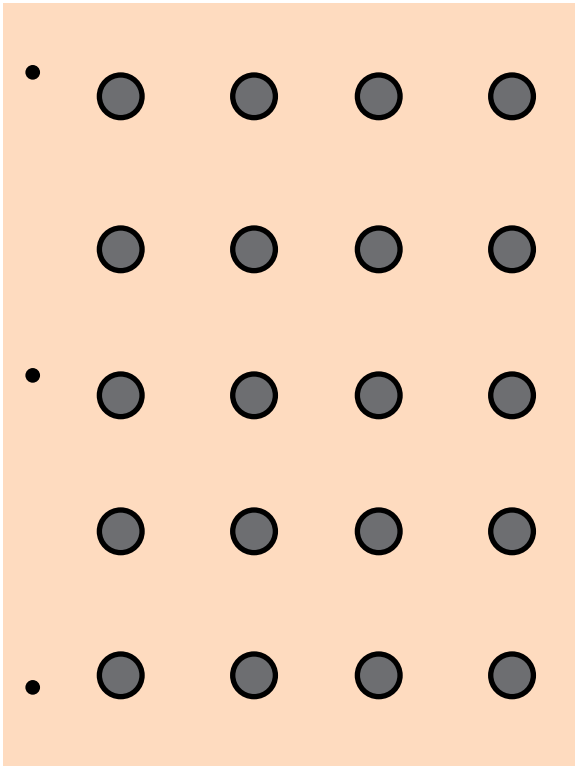
Binder Storage of Elements and Accessories

APPENDIX C

Binder Storage of Elements and Accessories

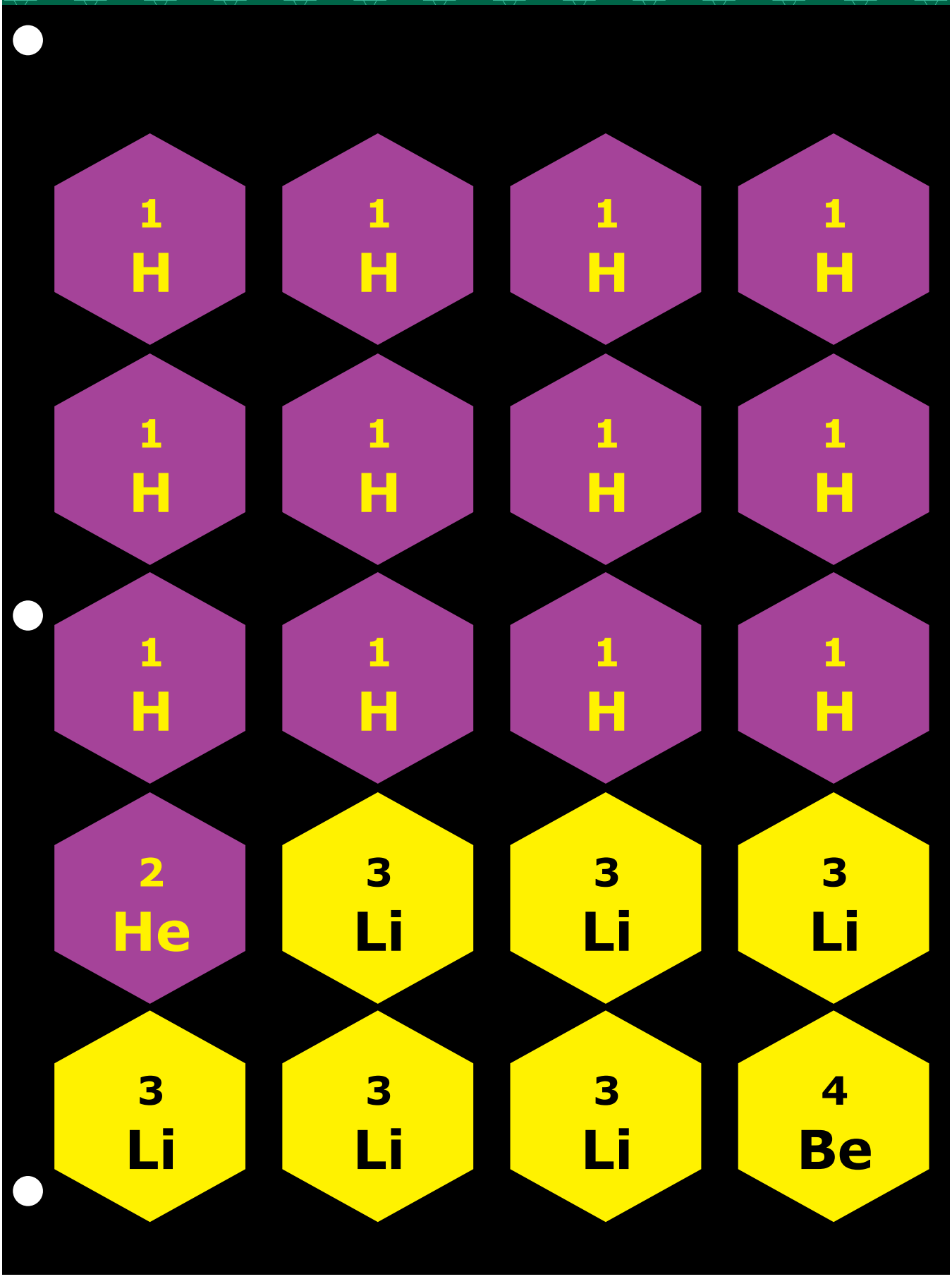
Azer's Interactive Periodic Table Study Set provides a large binder and multiple panels to conveniently store the numerous pieces. Three different storage panels are included with the binder as follows:

- (7) black, 3-hole punched, 8.5 x 11-in. panels. Each panel accommodates 20 hexagonal shapes. Position loop-backed circles on the panels using the 20-hole punched template.
- (1) 8.5 x 11-in. double-sided felt panel
- (1) loop-covered inside-back binder panel—especially useful for storing the smaller pieces (plus signs, coefficient numbers, etc.).

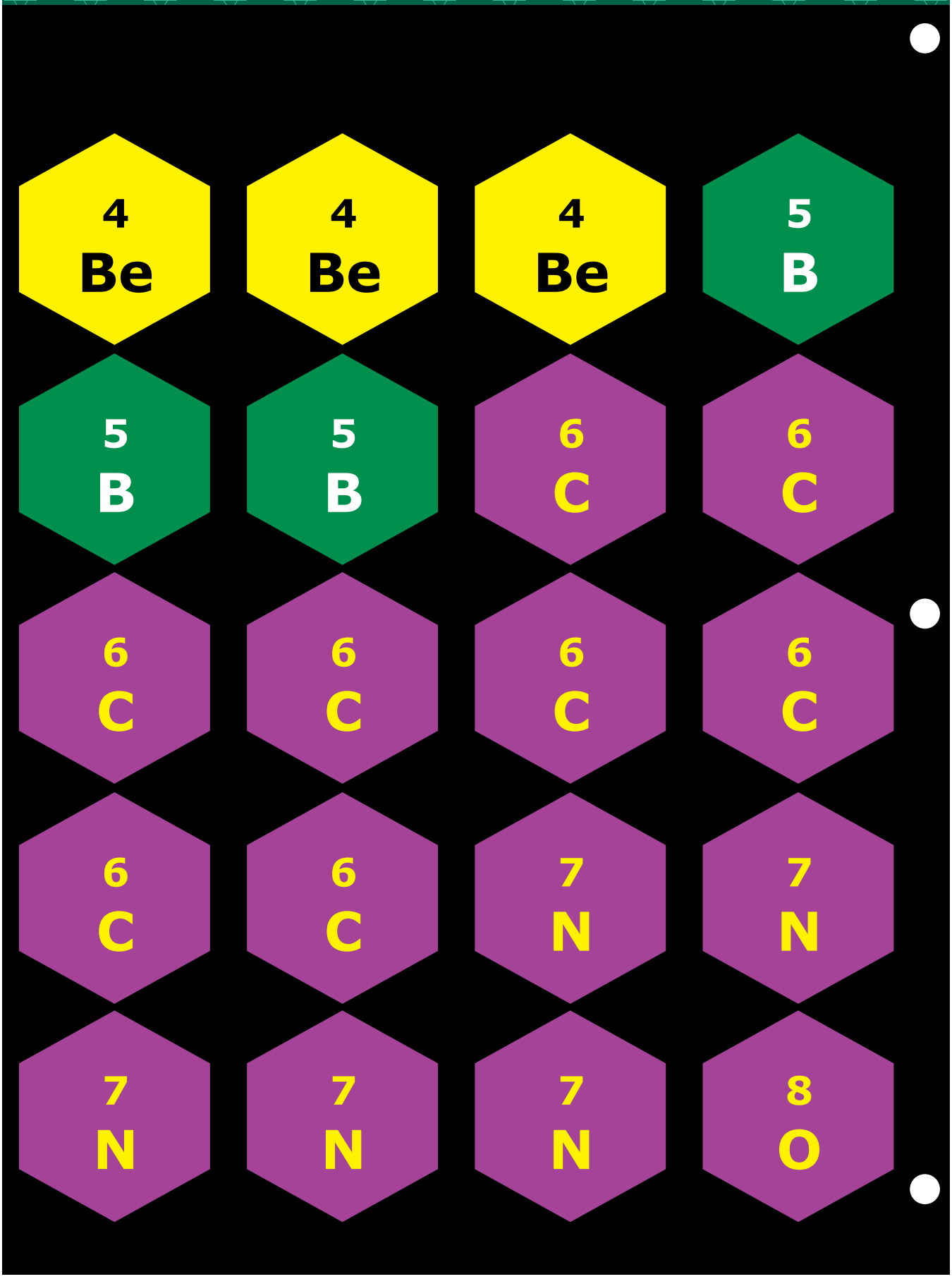


The following pages demonstrate a suggested style to store and organize the interactive, hook-backed study set pieces whereby all the element pieces are sorted in ascending order by atomic number. As there is no right or wrong way to store all of the parts in the binder, the organization of the interactive pieces should be determined by the teacher and/or student based upon personal preference and convenience for locating needed pieces.

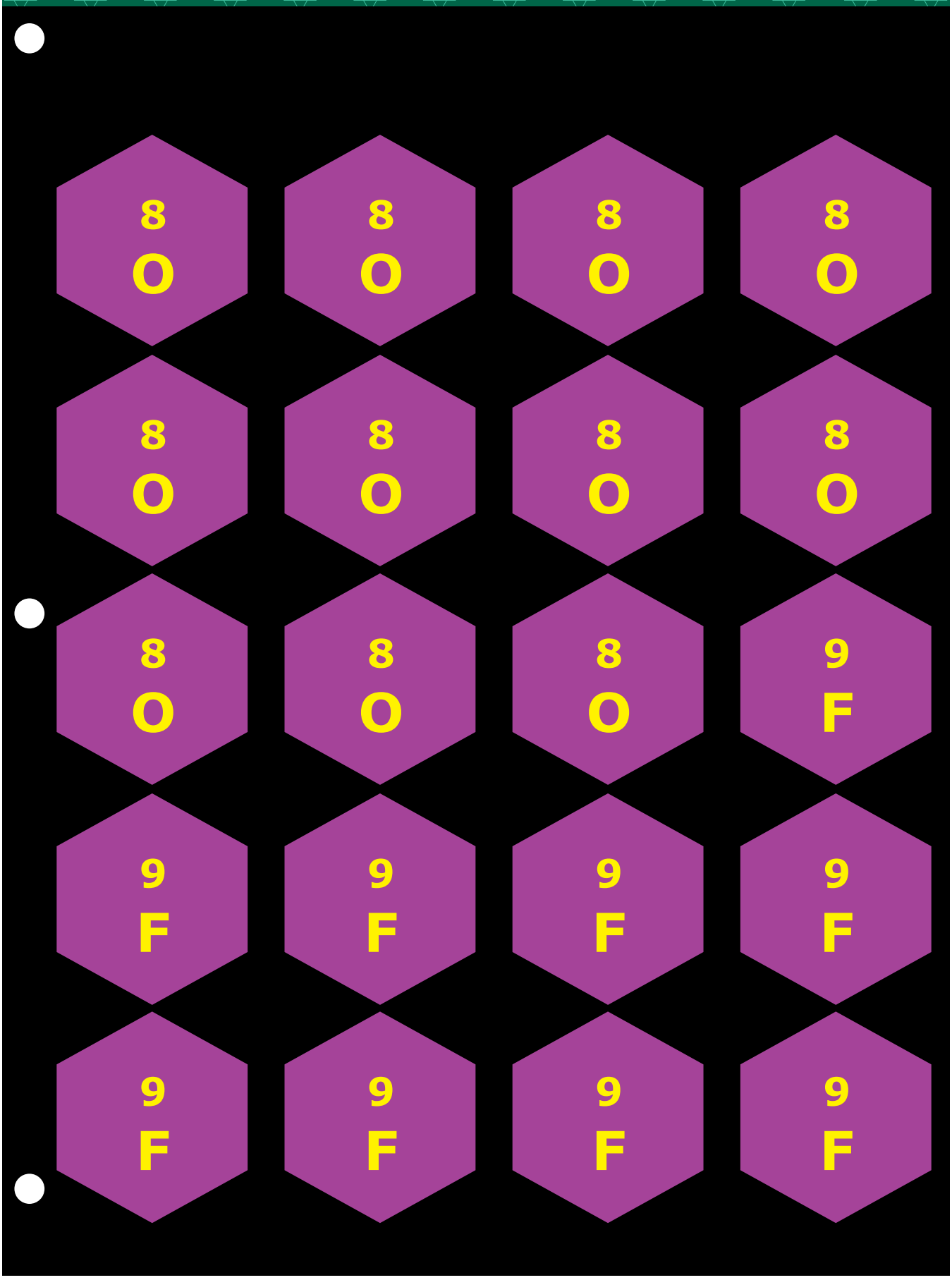
Front of Panel 1



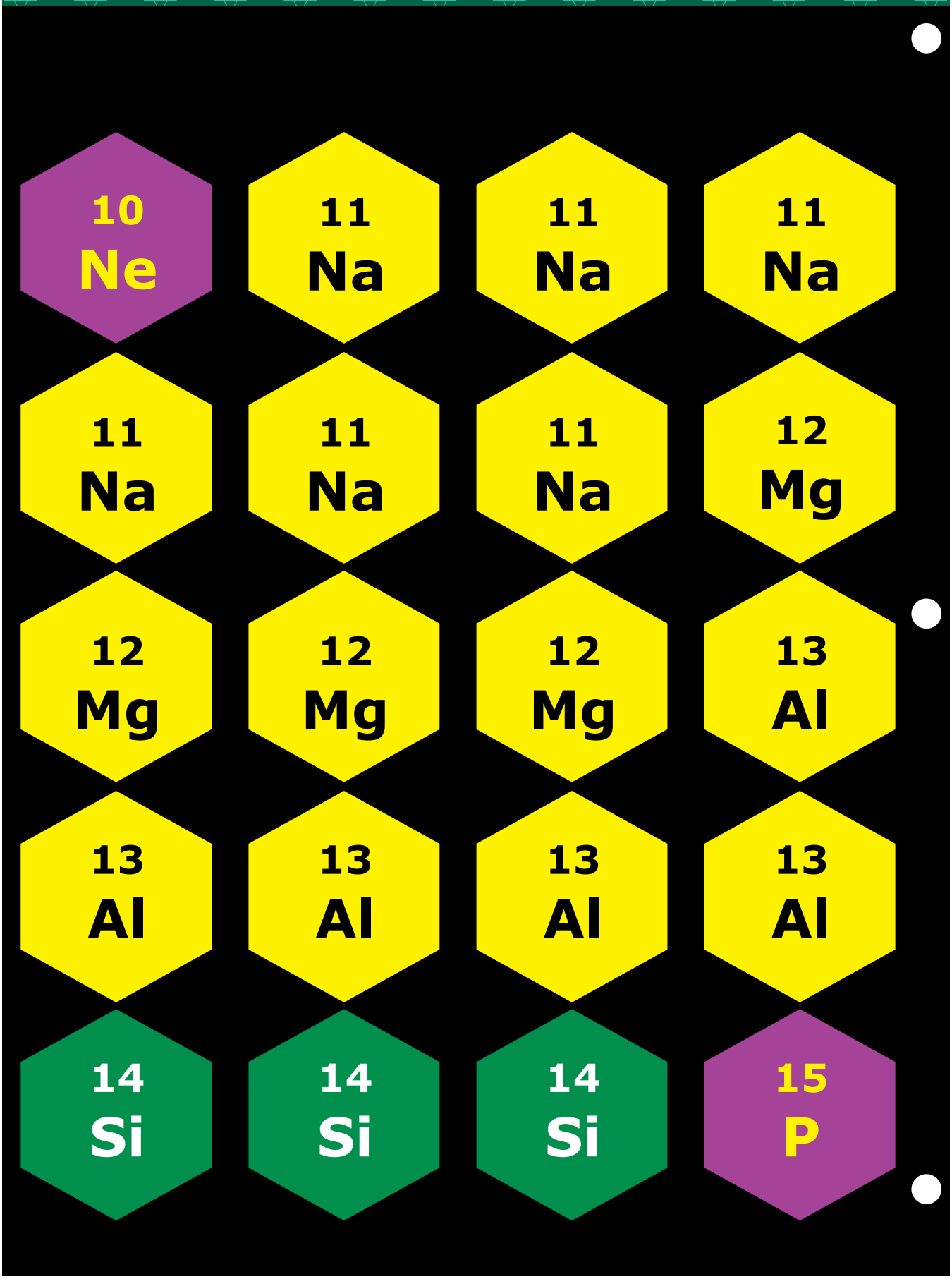
Back of Panel 1



Front of Panel 2



Back of Panel 2



Front of Panel 3

15 P	15 P	16 S	16 S
16 S	16 S	16 S	16 S
16 S	17 Cl	17 Cl	17 Cl
17 Cl	17 Cl	17 Cl	17 Cl
17 Cl	17 Cl	18 Ar	19 K

Back of Panel 3

19 K	19 K	19 K	19 K
19 K	20 Ca	20 Ca	20 Ca
20 Ca	21 Sc	22 Ti	23 V
24 Cr	24 Cr	24 Cr	24 Cr
25 Mn	25 Mn	25 Mn	25 Mn

Front of Panel 4

26 Fe	26 Fe	26 Fe	26 Fe
27 Co	27 Co	27 Co	27 Co
28 Ni	28 Ni	28 Ni	28 Ni
29 Cu	29 Cu	29 Cu	29 Cu
29 Cu	29 Cu	30 Zn	30 Zn

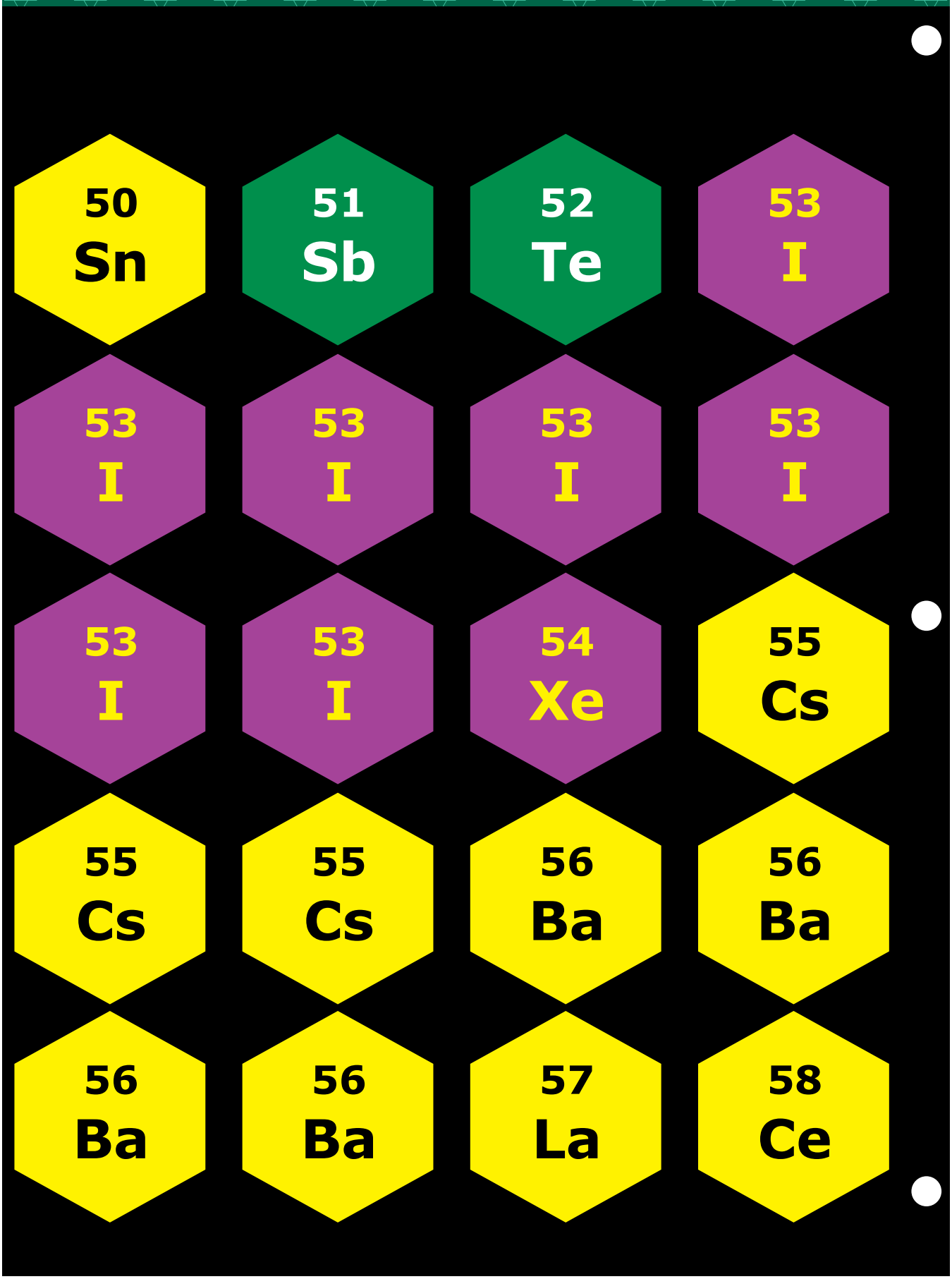
Back of Panel 4

31 Ga	31 Ga	32 Ge	32 Ge
33 As	33 As	33 As	34 Se
34 Se	34 Se	35 Br	35 Br
35 Br	35 Br	35 Br	35 Br
35 Br	36 Kr	37 Rb	37 Rb

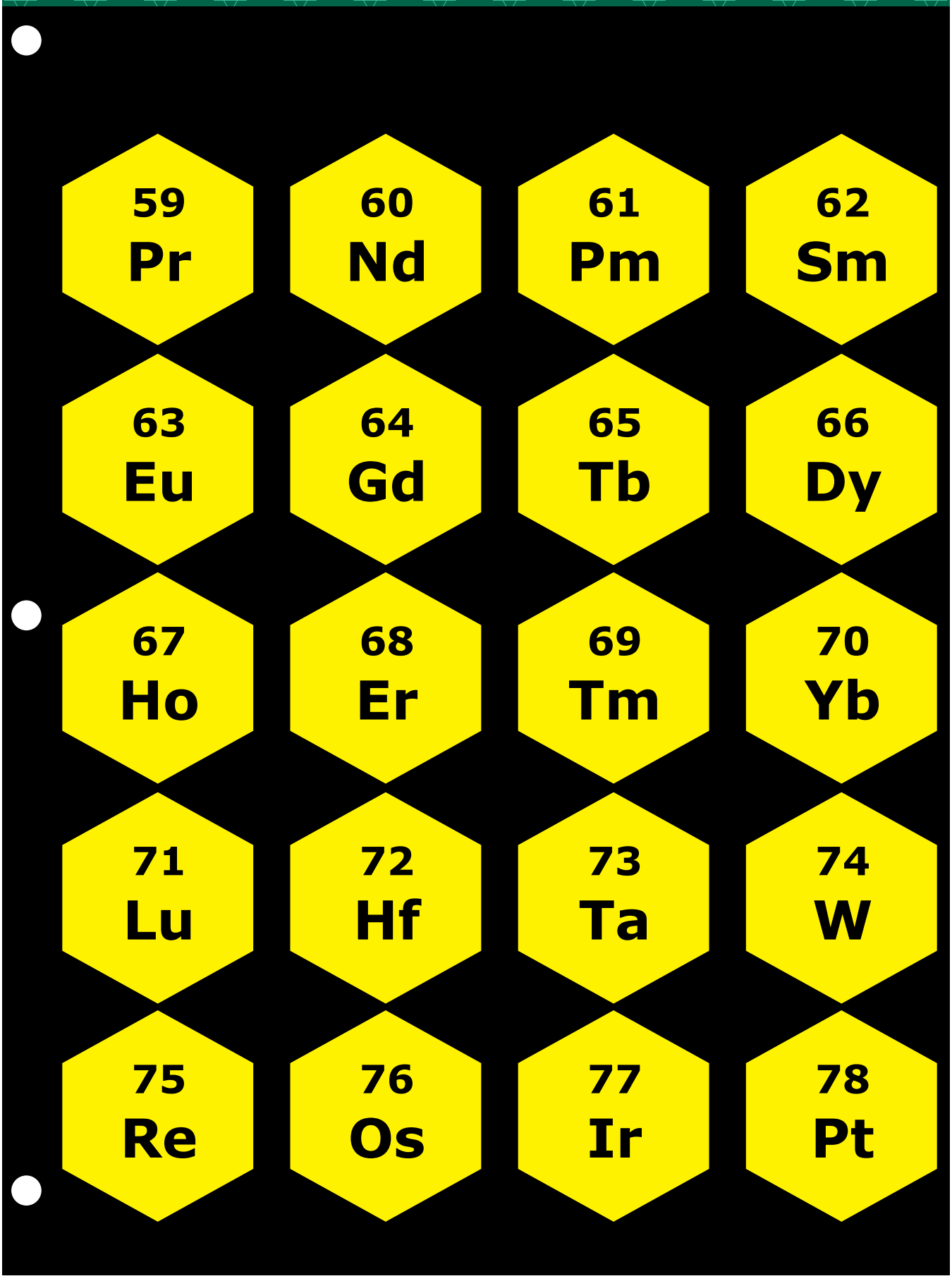
Front of Panel 5

37 Rb	38 Sr	38 Sr	38 Sr
38 Sr	39 Y	40 Zr	41 Nb
42 Mo	43 Tc	44 Ru	45 Rh
46 Pd	47 Ag	47 Ag	47 Ag
48 Cd	49 In	50 Sn	50 Sn

Back of Panel 5



Front of Panel 6

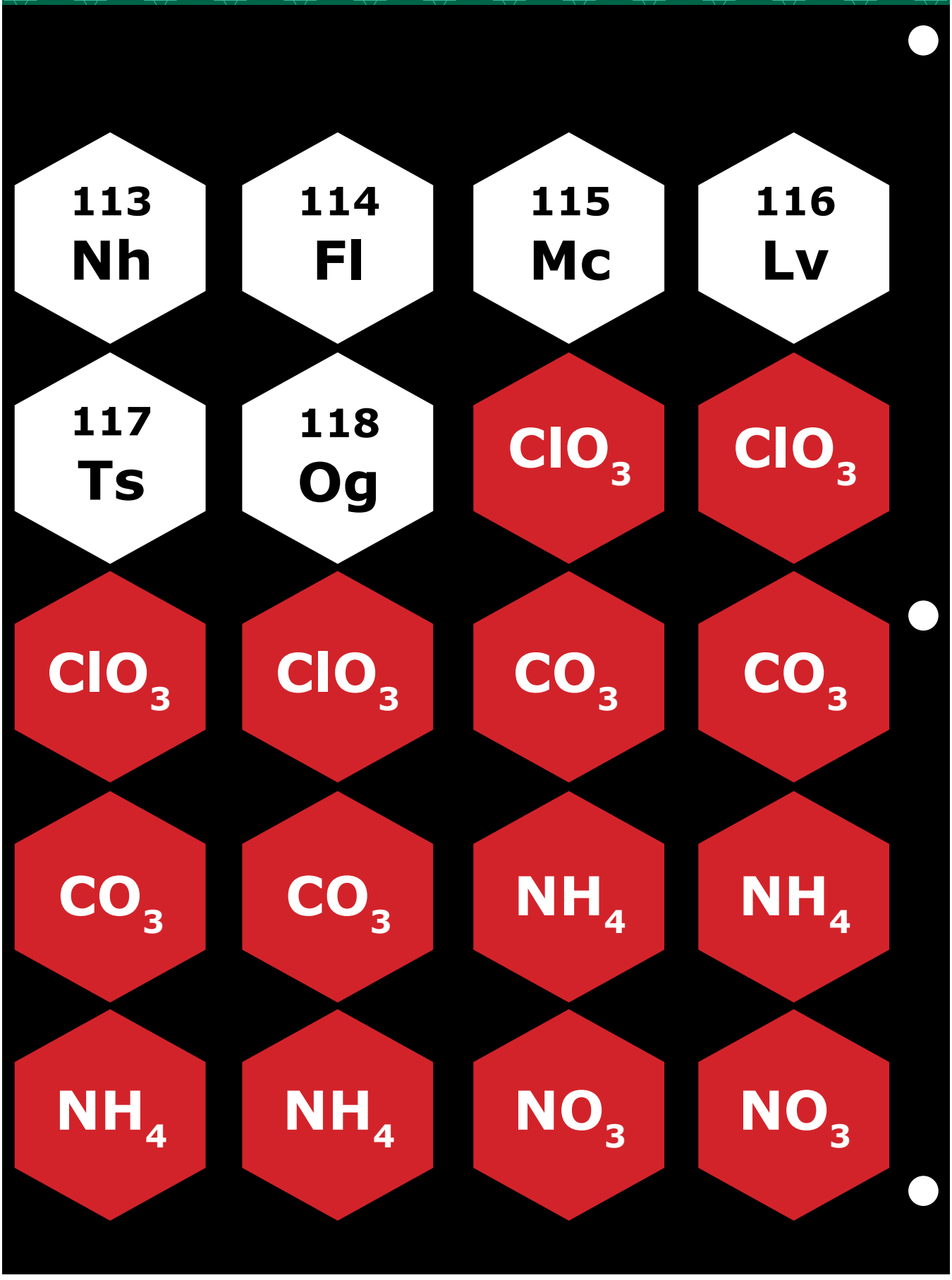


Back of Panel 6

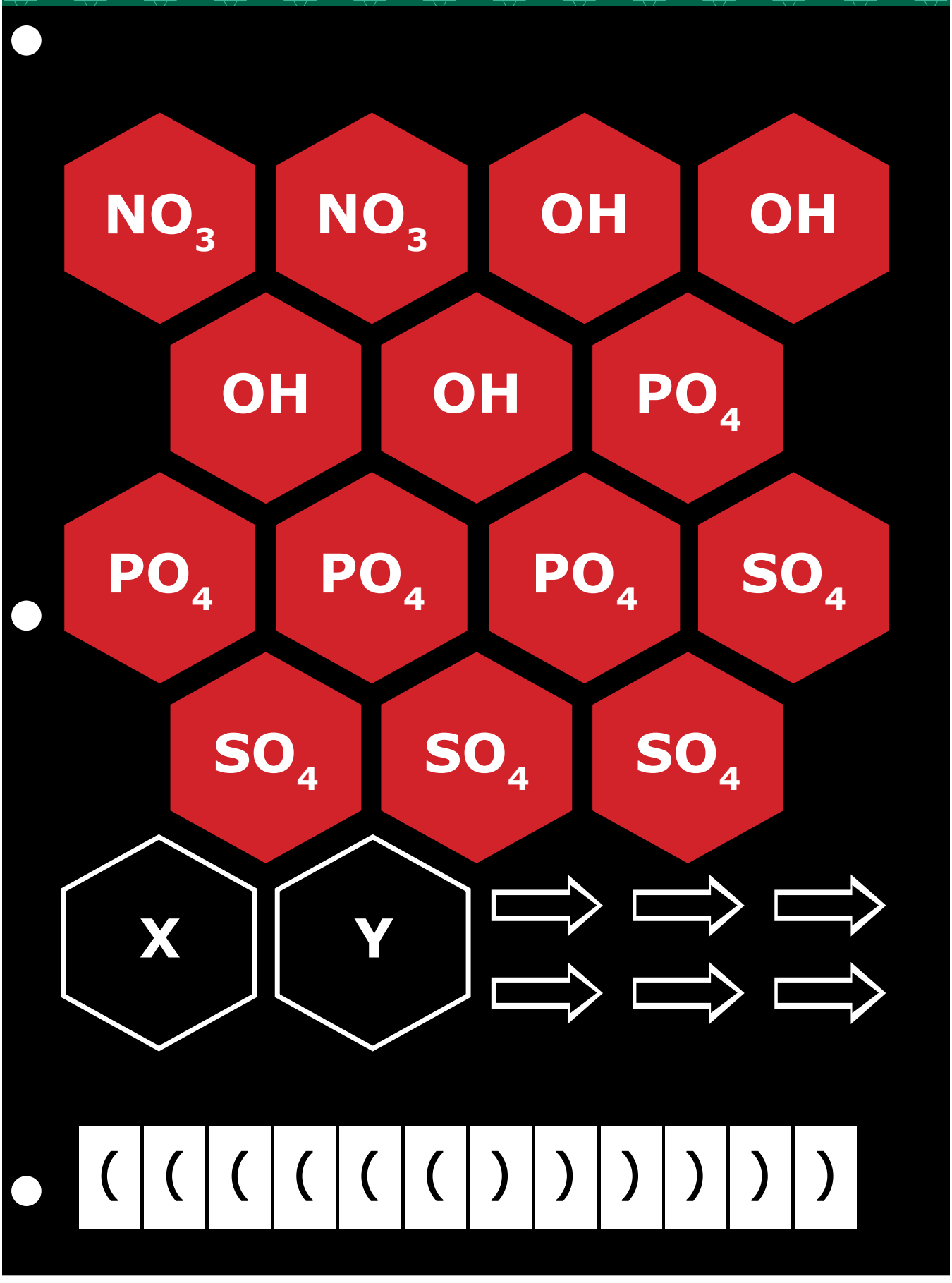
Front of Panel 7

93 Np	94 Pu	95 Am	96 Cm
97 Bk	98 Cf	99 Es	100 Fm
101 Md	102 No	103 Lr	104 Rf
105 Db	106 Sg	107 Bh	108 Hs
109 Mt	110 Ds	111 Rg	112 Cn

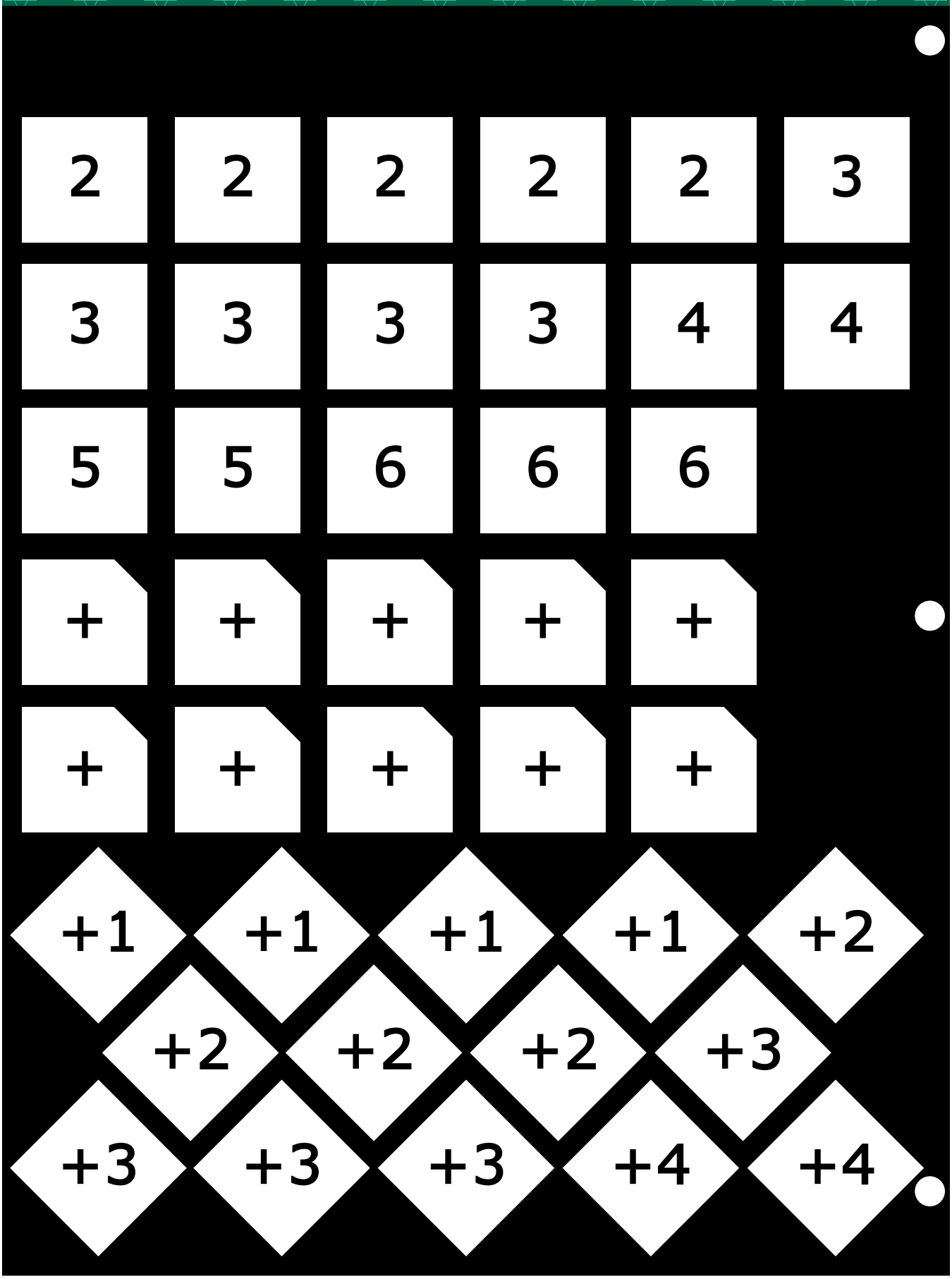
Back of Panel 7



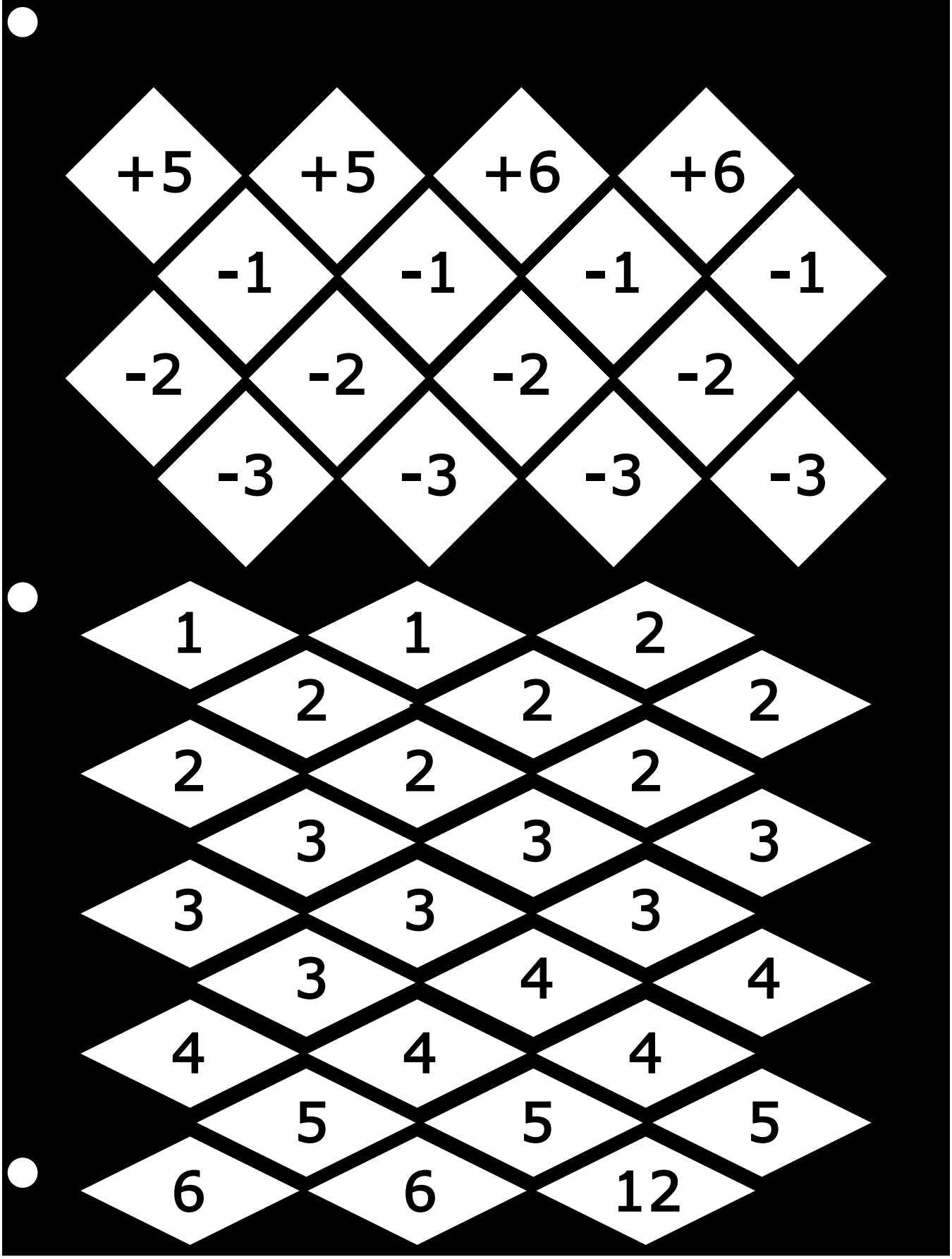
Front of Felt Panel



Back of Felt Panel



Inside-Back Binder Cover



Bibliography

Benton, Y. (2005). *An online, interactive periodic table of elements*. Retrieved June 6, 2005, from http://www.chemicalelements.com/show/name.html

Braille Authority of North America. (1998). *Braille code of chemical notation, 1997*. Louisville, KY: American Printing House for the Blind.

International Union of Pure and Applied Chemistry. (2017). *IUPAC Periodic table of the elements*. Retrieved September 27, 2017, from https://iupac.org/what-we-do/periodic-table-of-elements/

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. Washington, DC: The National Academies Press. Retrieved September 25, 2017, from https://www.nextgenscience.org/

Pearson Education, Inc. (2003). *Concepts and challenges: Physical science* (4th ed.). Parsippany, NJ: Globe Fearon.

Special thanks to Samir Azer, Science Teacher at the Kentucky School for the Blind, who was the inspiration behind the development of this study kit. Through the use of interactive print and tactile elements, students gain hands-on understanding of an atom's structure, the Periodic Table of the Elements, and balancing chemical equations.

Karen J. Poppe
Tactile and Visual Designer/Author

AMERICAN PRINTING HOUSE

1839 Frankfort Avenue, Louisville, Kentucky 40206
502-895-2405 • 800-223-1839
www.aph.org • info@aph.org

Azer's Interactive Periodic Table Study Set
(NEMETH Version)