

Instructions and Sequence for Using the Atom Board

Bohr's atomic model is a representation of protons, neutrons, and electrons and their relationships within an atom.

Because these particles are so small and so far apart, it would be impossible to diagram an atom and still have the particles visible on your board. For this reason, the models you build here are intended only to illustrate the overall structure of the atom, without giving an accurate representation of the relative scale of the particles within the atom. The following example may help in showing the relative sizes and distances of the parts on an atom. If the nucleus were the size of a basketball, the nearest electron would be about 8 miles away. (Stanton and Stinson 1st edition, p. 8)

As you explore your board you will notice that the center is constructed to hold a small bowl (not supplied). This bowl will hold the particles that make up the nucleus of the atom. Immediately outside the nucleus, you will notice the first ring of electrons, followed by successive rings. These rings are also known as electron shells. Electron shells are named using letters, beginning with K. The first shell is ring K, and it may contain one or two electrons. The next electron shell is known as shell L and it may contain between one and eight electrons. The ring immediately after L would be named M. This shell can contain up to 18 electrons. Electron shell N may contain up to 32 electrons.

Particles:

The nucleus is made up of protons and neutrons. We have provided two sets of colored stones (30 each) to represent these particles. Usually protons are colored red, while neutrons are colored blue. Electrons are colored white. If you were constructing the atom of the element Carbon, you would begin by taking out the card that contains the information on that element. Looking at the card, you would notice that the atomic number for Carbon is 6. A stable Carbon atom would contain 6 of each of the atom particles: 6 protons, 6 neutrons, and 6 electrons.

The atom board is designed to allow your students to construct atoms for all the elements on the periodic table and most of their isotopes.

From the Periodic table curriculum (ELC-4050) and the Upper Elementary Chemistry Curriculum (ELC-4052A) the students should know the following terms:

Atomic Number

Atomic Mass

Group Number

Period Number

The atomic number is the number you will be concentrating on. Remind the students that the atomic number is the number of protons found in the nucleus of an atom. Usually it is represented by the letter Z. The atomic number is a unique identifier of a chemical element. That means that each element on the periodic table will have its very own atomic number. **No two elements have the same atomic number.** You may also want to remind them that in an atom of

neutral charge, the atomic number is equal to the number of electrons.

Be very careful not to confuse the atomic number with the mass number. The mass number is usually represented by the letter A and is the total number of protons and neutrons in the nucleus of the atom. You will notice that the atomic mass number is also located on the cards and it usually is a number that is about twice that of the atomic number.

Presentation:

Begin by selecting an atom card. For all practical purposes of this presentation, we will assume that you have chosen the Carbon (C) element card. The atomic number of the element is 6; therefore, you know that the nucleus of this element will have 6 protons. In the following you will find the sequence for a regular presentation as well as that for the more advanced students who are being introduced to isotopes. Isotope presentation will be in *italics*.

Begin by placing one proton in the nucleus.

Say: "You have the nucleus of a Hydrogen atom, but to balance the atom you must add 1 electron."

Place one electron in the K shell and say: "We now have a balanced Hydrogen atom. To change to a different element, we must add or remove protons. We want to create a Carbon atom so we will add protons."

(For isotope presentations say: "We now have a balanced Hydrogen atom. This element has 0 isotopes. To create an isotope, we must add or remove neutrons. Since this element does not have any neutrons, we cannot create any isotopes.")

Place a second proton in the nucleus.

Say: "We now have enough protons for a Helium atom." Show the Helium atom on the periodic table and say "But to make it a regular and stable atom, we must add 2 neutrons."

Add one neutron at a time in the nucleus.

(For isotope presentation, add one neutron and say: "We now have the nucleus of a Helium 3 isotope atom, but to balance the atom, we must add one 1 electron.")

Add one electron and say: We now have a balanced Helium 3 isotope atom. To change to a different element we must add or remove protons. This element has 1 isotope. To create an isotope, we must add or remove neutrons."

Place a second neutron in the nucleus and say: "We now have a balance Helium atom."

Say: "We now have the nucleus of a Helium atom, but to balance the atom, we must add 1 electron."

Place a second electron in shell K.

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(You will notice that shell K has two indentations that will allow you to place the electrons there. If a student asks why the indentations are placed where they are, make sure you help them understand that electrons carry a negative charge and because of where the shell is located in connection to the nucleus, the two electrons MUST have that distance between them. They are like magnets when you try to bring them together.)

Continue by placing a third proton in the nucleus.

Say: "We now have enough protons for a Lithium atom, but to make it a regular and stable atom, we must add 1 neutron."

Place a third neutron in the nucleus.

Say: "We now have the nucleus of a Lithium atom, but to balance the atom, we must add 1 electron."

(For isotope presentation say : "We now have the nucleus of a Lithium 6 isotope atom, but to balance the atom, we must add 1 electron.")

Since there are no more open spots for electrons in shell K, you must place the next electron in one of the open spots found in shell L.

Say: "We now have a balanced Lithium atom. To change to a different element we will continue to add protons. "

(For isotope presentations say: "We now have a balanced Lithium 6 isotope atom. This element has 1 isotope. To create an isotope, we can add or remove neutrons."

Add an additional neutron and say: "We now have a balanced Lithium atom. To change to a different element we will continue to add protons.")

Add one more proton.

Say: "We now have the number of protons to make a Beryllium atom, but to balance the nucleus, we will need to add another neutron."

Add one more neutron.

Say: "We now have enough protons and neutrons for a balanced Beryllium atom nucleus. To balance the atom, we must add one more electron."

Add one more electron.

Say: "We now have a balanced Beryllium atom. We will continue to add particles so that we can make a Carbon atom."

(For isotope presentations add one more proton and say: "We now have enough protons for a Boron atom, but to make it a regular and stable atom, we must add 1 more neutron.")

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Add one more proton and one more neutron.

Say: "We now have the nucleus of a Boron atom, but to balance the atom, we must add 1 more electron."

(For isotope presentations say: "We now have the nucleus of a Boron 10 isotope atom, but to balance the atom we must add 1 more electron.")

Add one more electron.

Say: "We now have a balanced Boron atom. To change it to a different element, we must add or remove protons. "

(For isotope presentations say: "We now have a balanced Boron 10 isotope atom. To change to a different element, we must add or remove protons. This element has 1 isotope. To create an isotope, we can add or remove neutrons.")

Add one more Neutron and say: "We now have a balanced Boron atom.")

Add one more proton.

Say: "We now have the nucleus of a Carbon atom but to balance it, we must add one more neutron and one more electron."

(For isotope presentations say: "We now have the nucleus of a Carbon 11 isotope atom, but to balance the atom, we must add 1 electron.")

Add one more electron and one more neutron.

Say: "We now have a balanced Carbon atom. "

(For isotope presentation add only 1 electron and say: "We now have a balanced Carbon 11 isotope atom. This element has 4 isotopes. To create an isotope, we can add or remove neutrons.

Add one more neutron and say: "We now have a balanced Carbon atom. This element has 4 isotopes. "

Add one more neutron. Count the particles in the nucleus (1, 2....13) and say: "We now have a balanced Carbon 13 isotope atom. "

Add one more neutron. Count the particles in the nucleus (1, 2 ... 14) and say: "We now have a balanced Carbon 14 isotope atom."

Add one more neutron. Count the particles in the nucleus (1, 2 ... 15) and say: "We now have a balanced Carbon 15 isotope atom.")

Isotopes:

There are 80 known elements which have at least one stable isotope. Currently there are 250 known stable isotopes. The following list shows all of the known stable isotopes.

- | | | |
|-------------------|------------------|---------------------------------|
| 1. Hydrogen-1 | 42. Calcium-42 | 83. Selenium-77 |
| 2. Hydrogen-2 | 43. Calcium-43 | 84. Selenium-78 |
| 3. Helium-3 | 44. Calcium-44 | 85. Selenium-80 |
| 4. Helium-4 | 45. Scandium-45 | 86. Bromine-79 |
| 5. Lithium-6 | 46. Titanium-46 | 87. Bromine-81 |
| 6. Lithium-7 | 47. Titanium-47 | 88. Krypton-78 |
| 7. Beryllium-9 | 48. Titanium-48 | 89. Krypton-80 |
| 8. Boron-10 | 49. Titanium-49 | 90. Krypton-82 |
| 9. Boron-11 | 50. Titanium-50 | 91. Krypton-83 |
| 10. Carbon-12 | 51. Vanadium-51 | 92. Krypton-84 |
| 11. Carbon-13 | 52. Chromium-50 | 93. Krypton-86 |
| 12. Nitrogen-14 | 53. Chromium-52 | 94. Rubidium-85 |
| 13. Nitrogen-15 | 54. Chromium-53 | 95. Strontium-84 |
| 14. Oxygen-16 | 55. Chromium-54 | 96. Strontium-86 |
| 15. Oxygen-17 | 56. Manganese-55 | 97. Strontium-87 |
| 16. Oxygen-18 | 57. Iron-54 | 98. Strontium-88 |
| 17. Fluorine-19 | 58. Iron-56 | 99. Yttrium-89 |
| 18. Neon-20 | 59. Iron-57 | 100. Zirconium-90 |
| 19. Neon-21 | 60. Iron-58 | 101. Zirconium-91 |
| 20. Neon-22 | 61. Cobalt-59 | 102. Zirconium-92 |
| 21. Sodium-23 | 62. Nickel-58 | 103. Zirconium-94 |
| 22. Magnesium-24 | 63. Nickel-60 | 104. Niobium-93 |
| 23. Magnesium-25 | 64. Nickel-61 | 105. Molybdenum-92 |
| 24. Magnesium-26 | 65. Nickel-62 | 106. Molybdenum-94 |
| 25. Aluminium-27 | 66. Nickel-64 | 107. Molybdenum-95 |
| 26. Silicon-28 | 67. Copper-63 | 108. Molybdenum-96 |
| 27. Silicon-29 | 68. Copper-65 | 109. Molybdenum-97 |
| 28. Silicon-30 | 69. Zinc-64 | 110. Molybdenum-98 |
| 29. Phosphorus-31 | 70. Zinc-66 | |
| 30. Sulfur-32 | 71. Zinc-67 | |
| 31. Sulfur-33 | 72. Zinc-68 | |
| 32. Sulfur-34 | 73. Zinc-70 | |
| 33. Sulfur-36 | 74. Gallium-69 | |
| 34. Chlorine-35 | 75. Gallium-71 | |
| 35. Chlorine-37 | 76. Germanium-70 | |
| 36. Argon-36 | 77. Germanium-72 | |
| 37. Argon-38 | 78. Germanium-73 | |
| 38. Argon-40 | 79. Germanium-74 | |
| 39. Potassium-39 | 80. Arsenic-75 | |
| 40. Potassium-41 | 81. Selenium-74 | |
| 41. Calcium-40 | 82. Selenium-76 | |
| | | 83. Selenium-77 |
| | | 84. Selenium-78 |
| | | 85. Selenium-80 |
| | | 86. Bromine-79 |
| | | 87. Bromine-81 |
| | | 88. Krypton-78 |
| | | 89. Krypton-80 |
| | | 90. Krypton-82 |
| | | 91. Krypton-83 |
| | | 92. Krypton-84 |
| | | 93. Krypton-86 |
| | | 94. Rubidium-85 |
| | | 95. Strontium-84 |
| | | 96. Strontium-86 |
| | | 97. Strontium-87 |
| | | 98. Strontium-88 |
| | | 99. Yttrium-89 |
| | | 100. Zirconium-90 |
| | | 101. Zirconium-91 |
| | | 102. Zirconium-92 |
| | | 103. Zirconium-94 |
| | | 104. Niobium-93 |
| | | 105. Molybdenum-92 |
| | | 106. Molybdenum-94 |
| | | 107. Molybdenum-95 |
| | | 108. Molybdenum-96 |
| | | 109. Molybdenum-97 |
| | | 110. Molybdenum-98 |
| | | Technetium - No stable isotopes |
| | | 111. Ruthenium-96 |
| | | 112. Ruthenium-98 |
| | | 113. Ruthenium-99 |
| | | 114. Ruthenium-100 |
| | | 115. Ruthenium-101 |
| | | 116. Ruthenium-102 |
| | | 117. Ruthenium-104 |
| | | 118. Rhodium-103 |
| | | 119. Palladium-102 |

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120.	Palladium-104	165.	Barium-137	205.	Ytterbium-168
121.	Palladium-105	166.	Barium-138	206.	Ytterbium-170
122.	Palladium-106	167.	Lanthanum-139	207.	Ytterbium-171
123.	Palladium-108	168.	Cerium-136	208.	Ytterbium-172
124.	Palladium-110	169.	Cerium-138	209.	Ytterbium-173
125.	Silver-107	170.	Cerium-140	210.	Ytterbium-174
126.	Silver-109	171.	Cerium-142	211.	Ytterbium-176
127.	Cadmium-106	172.	Praseodymium-141	212.	Lutetium-175
128.	Cadmium-108	173.	Neodymium-142	213.	Hafnium-176
129.	Cadmium-110	174.	Neodymium-143	214.	Hafnium-177
130.	Cadmium-111	175.	Neodymium-145	215.	Hafnium-178
131.	Cadmium-112	176.	Neodymium-146	216.	Hafnium-179
132.	Cadmium-114	177.	Neodymium-148	217.	Hafnium-180
133.	Indium-113			218.	Tantalum-180m
134.	Tin-112		Promethium - No stable isotopes	219.	Tantalum-181
135.	Tin-114			220.	Tungsten-182
136.	Tin-115			221.	Tungsten-183
137.	Tin-116	178.	Samarium-144	222.	Tungsten-184
138.	Tin-117	179.	Samarium-150	223.	Tungsten-186
139.	Tin-118	180.	Samarium-152	224.	Rhenium-185
140.	Tin-119	181.	Samarium-154	225.	Osmium-187
141.	Tin-120	182.	Europium-153	226.	Osmium-188
142.	Tin-122	183.	Gadolinium-154	227.	Osmium-189
143.	Tin-124	184.	Gadolinium-155	228.	Osmium-190
144.	Antimony-121	185.	Gadolinium-156	229.	Osmium-192
145.	Antimony-123	186.	Gadolinium-157	230.	Iridium-191
146.	Tellurium-122	187.	Gadolinium-158	231.	Iridium-193
147.	Tellurium-123	188.	Gadolinium-160	232.	Platinum-192
148.	Tellurium-124	189.	Terbium-159	233.	Platinum-194
149.	Tellurium-126	190.	Dysprosium-156	234.	Platinum-195
150.	Iodine-127	191.	Dysprosium-158	235.	Platinum-196
151.	Xenon-124	192.	Dysprosium-160	236.	Platinum-198
152.	Xenon-126	193.	Dysprosium-161	237.	Gold-197
153.	Xenon-128	194.	Dysprosium-162	238.	Mercury-196
154.	Xenon-129	195.	Dysprosium-163	239.	Mercury-198
155.	Xenon-130	196.	Dysprosium-164	240.	Mercury-199
156.	Xenon-131	197.	Holmium-165	241.	Mercury-200
157.	Xenon-132	198.	Erbium-162	242.	Mercury-201
158.	Xenon-134	199.	Erbium-164	243.	Mercury-202
159.	Xenon-136	200.	Erbium-166	244.	Mercury-204
160.	Caesium-133	201.	Erbium-167	245.	Thallium-203
161.	Barium-132	202.	Erbium-168	246.	Thallium-205
162.	Barium-134	203.	Erbium-170	247.	Lead-206
163.	Barium-135	204.	Thulium-169	248.	Lead-207
164.	Barium-136			249.	Lead-208

Ions

An ion is an atom which has lost or gained one or more electrons from the outermost shell. A negatively charged ion has more electrons in its electron shells than it has protons in the nucleus. Such an ion is known as an anion.

A positively charged ion is an atom that has less electrons than it has protons. Such an ion is known as a cation.

Using the atom board, you can show how and why an atom might have a positive charge or a negative charge by adding or removing electrons. Remember, if you change the number of protons you actually change the element. The atom doesn't become positively charged by having gaining more protons. Instead, it becomes positively charged by losing electrons.

Following is a list of common ions. Each ion is symbolized by the element's formula, a superscript number, and a positive (+) or negative (-) symbol. The superscript number symbolizes the amount of charge that element has while the (+) or (-) symbolizes whether it is a cation or an anion.

Common Cations

Common Name	Formula	Historic Name
<i>Simple Cations</i>		
Aluminium	Al^{3+}	
Barium	Ba^{2+}	
Beryllium	Be^{2+}	
Cadmium	Cd^{2+}	
Caesium	Cs^{+}	
Calcium	Ca^{2+}	
Chromium(II)	Cr^{2+}	Chromous
Chromium(III)	Cr^{3+}	Chromic
Chromium(VI)	Cr^{6+}	Chromyl
Cobalt(II)	Co^{2+}	Cobaltous
Cobalt(III)	Co^{3+}	Cobaltic
Copper(I)	Cu^{+}	Cuprous
Copper(II)	Cu^{2+}	Cupric
Copper(III)	Cu^{3+}	
Gallium	Ga^{3+}	
Helium	He^{2+}	(Alpha particle)
Hydrogen	H^{+}	(Proton)
Iron(II)	Fe^{2+}	Ferrous
Iron(III)	Fe^{3+}	Ferric
Lead(II)	Pb^{2+}	Plumbous
Lead(IV)	Pb^{4+}	Plumbic
Lithium	Li^{+}	
Magnesium	Mg^{2+}	
Manganese(II)	Mn^{2+}	Manganous

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Manganese(III)	Mn^{3+}	Manganic
Manganese(IV)	Mn^{4+}	Manganyl
Manganese(VII)	Mn^{7+}	
Mercury(II)	Hg^{2+}	Mercuric
Nickel(II)	Ni^{2+}	Nickelous
Nickel(III)	Ni^{3+}	Nickelic
Potassium	K^{+}	
Silver	Ag^{+}	
Sodium	Na^{+}	
Strontium	Sr^{2+}	
Tin(II)	Sn^{2+}	Stannous
Tin(IV)	Sn^{4+}	Stannic
Zinc	Zn^{2+}	

Common Anions

Formal Name	Formula	Alt. Name
<i>Simple Anions</i>		
Arsenide	As^{3-}	
Azide	N_3^-	
Bromide	Br^-	
Chloride	Cl^-	
Fluoride	F^-	
Hydride	H^-	
Iodide	I^-	
Nitride	N^{3-}	
Oxide	O^{2-}	
Phosphide	P^{3-}	
Sulfide	S^{2-}	
Peroxide	O_2^{2-}	

Bonds

Chemical bonds are the processes which are responsible for the attractive forces between atoms and various other molecules. Bonds create stability between atoms and ultimately through them we have chemical compounds. Without chemical bonds there wouldn't be any molecules and none of the things that we see around us would exist.

Following are the descriptions of the most common bonds that students will most often find and use. However, we are mentioning other types of bonds that are known to chemists today. These other types of bonds are supplied only as examples. If your students wish to explore more of these ideas, encourage them to do so.

Covalent bonds: Found within most organic compounds, they are characterized by the sharing of pairs of electrons between atoms.

Polar covalent bonds: have characteristics of both covalent bonds and ionic bonds. They exist because of the slight differences in polarity that exist in molecules.

Ionic bonds: can often be found between metal and non-metal ions. Ionic bonds depend on the ionic charge that various elemental atoms might have. In short this type of bond is formed by the attraction between two oppositely charged ions.

Other types of bonds:

Coordinate covalent bonds

Bent bonds

Three and four center bonds

One and three electron bonds

Aromatic bonds

Banana bonds

Metallic bonds