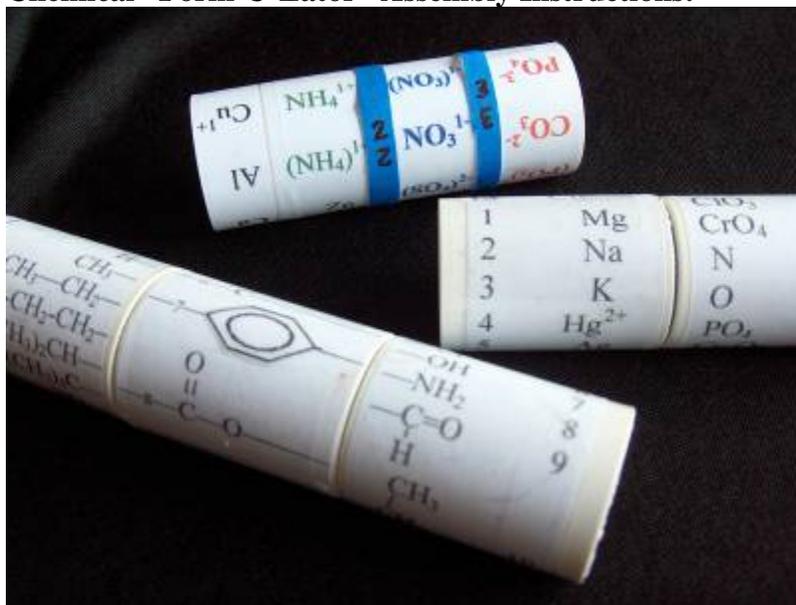


Chemical "Form-U-Lator" Assembly Instructions:



There are 3 different version of the Chemical "Form-U-Lator". The one shown above in the top middle position (Version #1) contains 2 sets of cations, 2 sets of anions, and the blue wheels containing subscripts. By manipulating the apparatus, students can construct the chemical formulas for 196 different ionic compounds. The unit shown in the middle right position of the photo (Version #2) is for quizzing students on formulas and polyatomic ions. One side contains 13 cations, numbered 1-13, and the other side contains 13 anions, also numbered 1-13. Charges are omitted (except for transition metals) on ions. Students are asked to aligned 2 numbers and then name and write correct formula from the combination of the the two. Lastly, pictured on the bottom left is the unit (Version #3) that is used for organic chemistry. It allows students to put together semi-condensed structural formulas for the purpose of naming the chemical substance. It contains several common functional groups and can be used 2 different ways...with all three pieces (as pictured) for more advanced substances, or with the middle portion removed for beginning instruction in organic nomenclature.

Version #1

Materials: (to make 30 units...class set)

- 60 1.5 inch O.D. PVC SxS coupling (\$0.33 ea./ plumbing supply @ Home Depot).
- 1 10 ft./1 in. Schedule 40 PVC electrical conduit (\$3.06/ electrical supply @ Home Depot)...this will make approx. 100 spacers to hold formulator together.
- 1 Hacksaw (to cut conduit into 1 in. spacers)
- 1 OfficeMax Full Sheet Labels (approx. \$9.00./25 8.5x11 stickers...can cut to fit/ Office Max)
- 1 InkJet Printer (colored ink)...color is not necessary but is helpful in directing students as to which ions to use at a given time.

- 1 Roll of colored laboratory label tape (for subscript wheels) or Scotch/3M blue painter's tape (paint supplies @ Home Depot)

Approximate cost < \$1.00/unit



Construction/Assembly: (the accompanying photos should help in interpretation of the assembly instructions below.)

1. Cut 1 in. spacers from 10 ft. section of Schedule 40 (1") PVC electrical conduit.(grey) using a hacksaw or similar tool. We use a band saw (VocEd Dept.) for a good clean cut. Use a sandpaper to smooth edges (debur) and avoid breathing any PVC dust.



2. Use 1 spacer to hold 2 1.5 in. O.D. PVC couplings together. (white)
3. Join 2 (or 3) white couplings with a grey spacer. You now have the workings of a "formulator". (See photos of 3 different versions at the top of page)
4. One side of the unit is for 2 sets of cations (7 ions/set) and the other is for 2 sets of anions (7 ions/set). ***If you are doing the ion templates on a computer, each ion should have a 22 font and should be double spaced. This will allow for the ions to fit comfortably around the wheel.*** These ions can be printed on computer labels (8.5x11) and cut to fit or you can print the ion sets on regular paper, cut to fit, and secure with

clear packing tape. This also serves to keep the ink protected from your fingers when you use the unit.

Suggested ion sets:

Cation Sets (black and green)

Black: Na, Ca, Al, Cu¹⁺, Cu²⁺, Pb²⁺, Pb⁴⁺

Green: Zn, K, Mg, NH₄¹⁺, (NH₄)¹⁺, Fe²⁺, Fe³⁺

Anion Sets (red and blue)

Red: Cl, PO₄³⁻, (PO₄)³⁻, CO₃²⁻, (CO₃)²⁻, MnO₄¹⁻, (MnO₄)¹⁻

Blue: Br, N, O, NO₃¹⁻, (NO₃)¹⁻, SO₄²⁻, (SO₄)²⁻

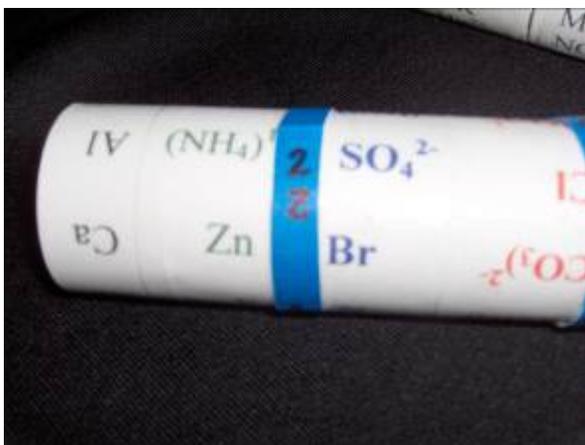
*the ion sets are color coded, making it easier to direct students in the use of the formulator.

5. Construct the subscript wheels using regular white computer paper (as backing) and colored tape. Wrap a 1 inch wide strip of paper around the PVC tube and then cover with 2 or 3 rotations of colored tape. The wheel should fit loosely...too tight and it doesn't rotate nicely, too loose and it falls off the formulator! Remove the tape wheel from the PVC tube and label with subscripts (2,3,4). Trim to fit and slide it back onto the PVC tube. Repeat to make a 2nd subscript wheel.

6. You now have constructed your very own formulator.

Example of Use:

1. Grab the formulator with 2 hands...the cations in your left hand and the anions in your right. By twisting the unit, ions can be aligned cation to anion.
2. Adjust the formulator as instructed...for example, green cations with blue anions. (photo below) The unit may already be put together in this way or it might have to be taken apart and adjusted. This is quite simple...just pull the unit apart in the middle, move the spacer if necessary, and adjust as instructed. Once you have the green cations with the blue anions...
3. Construct the formula for ammonium sulfate. Rotate the unit until the desired ions are side by side (in the middle of the unit). Rotate the blue subscript rings into position to accurately construct the chemical formula. If no subscripts are needed the blue rings can be pushed to either side of the unit, out of the way. (*polyatomic ions are included with/without parenthesis)



4. The formulator can be used to construct 196 different chemical combinations.

Version #2

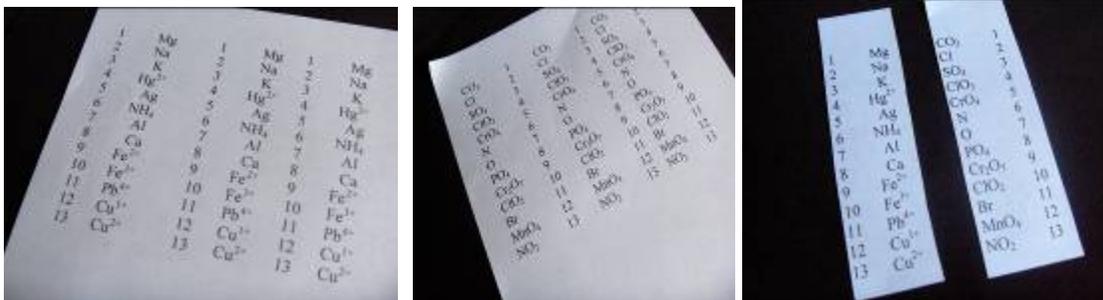
Construction/Assembly: (the accompanying photos should help in interpretation of the assembly instructions below.)

1. Cut 1 in. spacers from 10 ft. section of Schedule 40 (1") PVC electrical conduit.(grey) using a hacksaw or similar tool.
2. Use 1 spacer to hold 2 1.5 in. O.D. PVC couplings together. (white)
3. Join 2 white couplings with a grey spacer. You now have the workings of a "formulator".
4. One side of the unit has the formulas/symbols for 13 cations and the other has 13 anions. *If you are doing the ion sets on a computer, each ion should have a 24 font and should be single spaced. This will allow for the ions to fit comfortably around the wheel.* These ions can be printed on computer labels (8.5x11) and cut to fit or you can print the ion sets on regular paper, cut to fit, and secure with clear packing tape. This also serves to keep the ink protected from your fingers when you use the unit.

Suggested ion sets:

Cations:

Na, Ca, Al, Cu¹⁺, Cu²⁺, Pb²⁺, Pb⁴⁺, Zn, K, Mg, NH₄¹⁺, Fe²⁺, Fe³⁺, Hg²⁺, Ag



Anions:

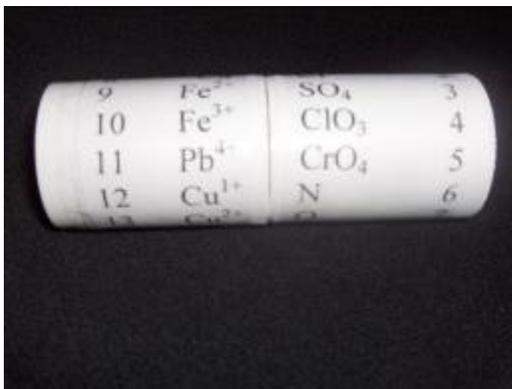
Cl, PO₄³⁻, CrO₄²⁻, CO₃²⁻, MnO₄¹⁻, ClO₃¹⁻, Br, N, O, NO₃¹⁻, SO₄²⁻, ClO₂¹⁻, NO₂¹⁻

*only put charges on cations with multiple charges, omit charges on all anions.

6. You now have constructed your very own quiz formulator.

Example of Use:

1. Grab the formulator with 2 hands...the cations in your left hand and the anions in your right. By twisting the unit, ions can be aligned cation to anion.
2. Adjust the formulator as instructed...for example,
3. Rotate the unit until the cation #10 is aligned beside anion #4. (Fe³⁺, ClO₃¹⁻)

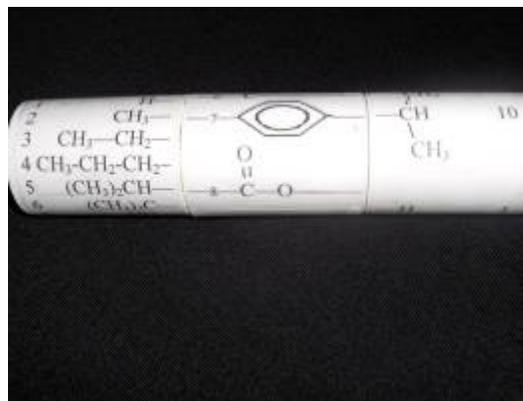
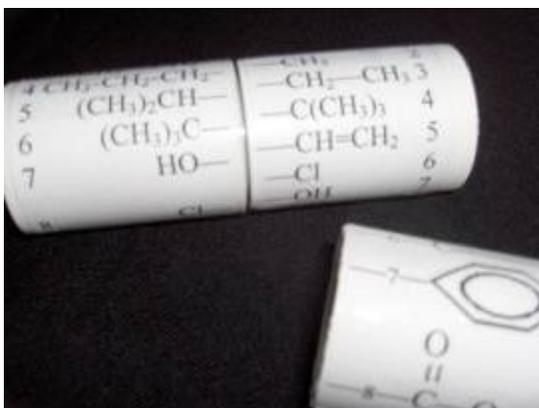


Write the correct chemical formula and name for this combination of ions. Use subscripts and parenthesis as needed.

4. The formulator can be used to construct 169 different chemical combinations.

Version #3

This version of the formulator can be used to quiz students on their knowledge of functional groups and organic nomenclature. It is designed to take full advantage of kinesthetic learning.



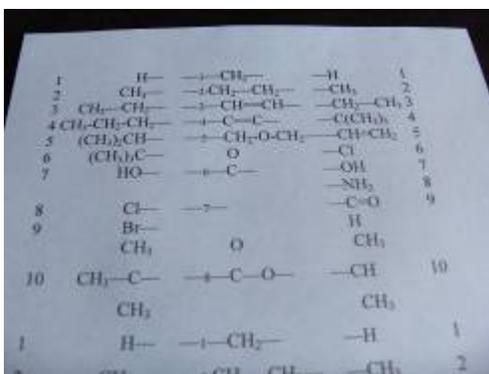
Materials: (to make 30 units...class set)

- 90 1.5 inch O.D. PVC SxS coupling (\$0.33 ea./ plumbing supply @ Home Depot).
- 1 10 ft./1 in. Schedule 40 PVC electrical conduit (\$3.06/ electrical supply @ Home Depot)...this will make approx. 100 spacers to hold formulator together.
- 1 Hacksaw (to cut conduit into 1 in. spacers)
- 1 OfficeMax Full Sheet Labels (approx. \$9.00./25 8.5x11 stickers...can cut to fit/ Office Max)
- 1 InkJet Printer (colored ink)...color is not necessary but is helpful in directing students as to which ions to use at a given time.

Approximate cost > \$1.00/unit

Construction/Assembly: (the accompanying photos should help in interpretation of the assembly instructions below.)

1. Cut 60 1 in. spacers from 10 ft. section of Schedule 40 (1") PVC electrical conduit.(grey) using a hacksaw or similar tool.
2. Use 2 spacers to hold together 3 pieces of 1.5 in. O.D. PVC couplings. (white)
3. You now have the workings of an organic “nomenclator”.
4. Affixing the templates...The outside wheels contain smaller substituent pieces (CH₃, OH, H, etc.) while the center wheel has many of the functional group pieces (ether, benzene ring, alkyne, etc.) *If you are making the templates on a computer, each template should have approx. a 22 font and should be 1.5 spaced. This will allow for the templates to fit comfortably around each wheel.* These templates can be printed on computer labels (8.5x11) and cut to fit or you can print the templates on regular paper, cut to fit, and secure with clear packing tape. This also serves to keep the ink protected from your fingers when you use the unit.



5 Adhere the 3 templates to the couplings, put the “nomenclature” back together, and align the 3 wheels in any of the many possible combinations.

Example of Use:

Grab the formulator with 2 hands. By twisting the unit, pieces of organic formulas can be aligned which result in a complete organic formula. These formulas can now be named, identified in terms of functional group, etc.

Templates:

Attached