Student Name

Periods 1-2 Chemistry Lab
“Paper Ionic Compounds”
Mr. Miller
December 4, 2023

QUESTION/PROBLEM

Given a list of ions, what are the possible names and formulas for all of the ionic compounds that can be formed using those ions? The use of paper cut into male and female pieces with the ionic charge of the ions will be used to demonstrate the formation of the compounds.

DATA

To determine the charge of the Cations, their location on the periodic table must be determined. Potassium, Calcium, and Iron are all metals with Potassium being located in the Alkali Metals (Group 1), Calcium being located in the Alkaline Earth Metals (Group 2), and Iron being a Transition Metal. Metals will lose their electrons to become positively charged Cations. Potassium being an Alkali Metal, has only 1 valence electron in the 4th energy level indicated by its electron configuration ($K = [Ar]4s^1$). When Potassium becomes an ion it will lose that one electron to become K^+. Calcium being an Alkaline Earth Metal, has 2 valence electrons in the 4th energy level indicated by its electron configuration ($K = [Ar]4s^2$). When Calcium becomes an ion it loses those two electrons to become Ca^{+2}. Iron is a transition metal. Transition metals can have several oxidation numbers (charges). The Roman Numeral in the parentheses gives the positive charge on a transition metal ion. Therefore, Iron (I) is Fe^+, Iron (II) is Fe^{+2}, and Iron (III) is Fe^{+3}.

The name of anions gives a lot of information about the ion. Monatomic anions end in –ide and come from a single atom off of the periodic table. Chloride comes from the non-metal element Chorine, which has an electron configuration of $Cl = [Ne]3s^23p^5$. When non-metals become anions, they gain electrons to fill their s & p orbitals and obtain an octet of 8 valence electrons. Chlorine has 7, and will gain one more electron to become Cl^-. Sulfate and Phosphate both contain an –ate ending which indicates they are oxyanions which contain a non-metal element along with oxygen atoms. Their formulas must be obtained from a textbook or chart. Sulfate is a Sulfur atom along with four oxygen atoms with a -2 charge (SO_4^{-2}) and Phosphate is a Phosphorous atom along with four oxygen atoms with a -3 charge (PO_4^{-3}).

Ion	Potassium	Calcium	Iron (I)	Iron (II)	Iron (III)	Chloride	Sulfate	Phosphate
Symbol	K^+	Ca^{+2}	Fe^+	Fe^{+2}	Fe^{+3}	Cl^-	SO_4^{-2}	PO_4^{-3}
Color	Yellow	Orange	White	White	White	Pink	Green	Blue

Ionic compounds are electrically neutral combinations of + charged cations and – charged anions. Each electron gained by an anion has to come from an electron given up by a cation. These numbers must be equal and if they are not, more of one or both ions will be required to create the neutral compound. Their names are just the cation followed by the anion.

HYPOTHESIS

The possible ionic compounds will be each of the cations being paired with each of the anions. With the 8 ions given that means there will be 15 possible ionic compounds:

1) It will take 1 Potassium cation to cancel with one Chloride anion = KCl
2) It will take 2 Potassium cations to cancel with one Sulfate anion = K_2SO_4
3) It will take 3 Potassium cations to cancel with one Phosphate anion = K_3PO_4
4) It will take 2 Chloride anions to cancel with one Calcium cation = $CaCl_2$
5) It will take 1 Sulfate anion to cancel with one Calcium cation = $CaSO_4$
6) It will take 2 Phosphate anions to cancel with 3 Calcium cations = $Ca_3(PO_4)_2$
    a. 2 Phosphates will take 6 electrons, which requires 3 Calciums giving up 2 electrons each
7) It will take 1 Iron (I) cation to cancel with one Chloride anion = FeCl
8) It will take 2 Iron (I) cations to cancel with one Sulfate anion = Fe_2SO_4
9) It will take 3 Iron (I) cations to cancel with one Phosphate anion = Fe_3PO_4
10) It will take 2 Chloride anions to cancel with one Iron (II) cation = $FeCl_2$
11) It will take 1 Sulfate anion to cancel with one Iron (II) cation = $FeSO_4$
12) It will take 2 Phosphate anions to cancel with 3 Iron (II) cations = $Fe_3(PO_4)_2$
    a. 2 Phosphates will take 6 electrons, which requires 3 Iron (II) cations, giving up 2 electrons each
13) It will take 3 Chloride anions to cancel with 1 Iron (III) cation = $FeCl_3$
14) It will take 3 Sulfate anions to cancel with 2 Iron (III) cations = $Fe_2(SO_4)_3$
    a. 3 Sulfates will take 6 electrons, which requires 2 Iron (III) cations, giving up 3 electrons each
15) It will take 1 Phosphate anion to cancel with 1 Iron (III) cation = $FePO_4$

	Chloride = Cl^-	Sulfate = SO_4^{-2}	Phosphate = PO_4^{-3}
Potassium = K^+	KCl	K_2SO_4	K_3PO_4
Calcium = Ca^{+2}	$CaCl_2$	$CaSO_4$	$Ca_3(PO_4)_2$
Iron (I) = Fe^+	$FeCl$	Fe_2SO_4	Fe_3PO_4
Iron (II) = Fe^{+2}	$FeCl_2$	$FeSO_4$	$Fe_3(PO_4)_2$
Iron (III) = Fe^{+3}	$FeCl_3$	$Fe_2(SO_4)_3$	$FePO_4$

EXPERIMENT

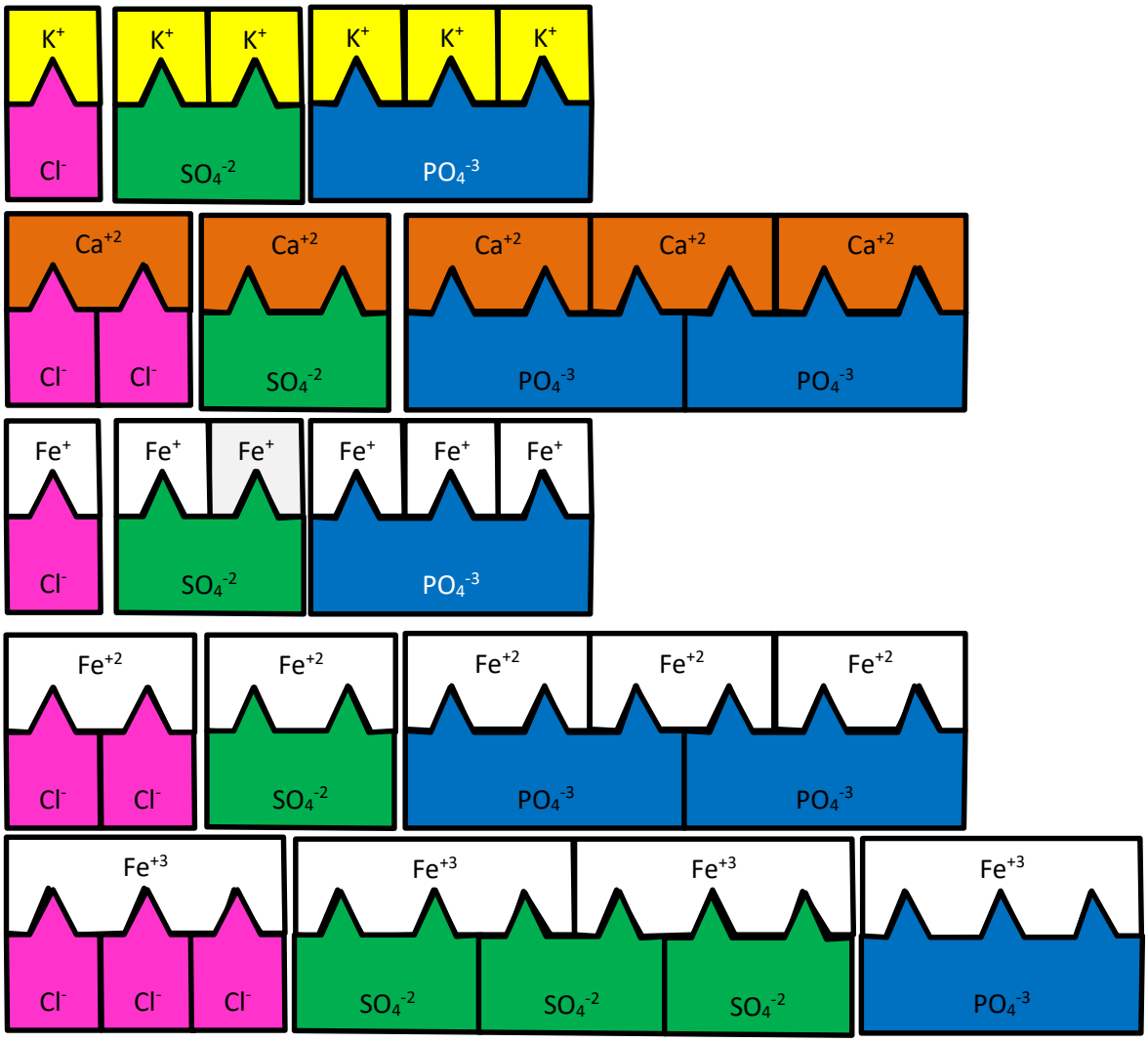
The cations will be cut as female pieces out of the colored paper that is given in the data section

- +1 will be 1 inch long with a single notch at ½ of an inch
- +2 will be 2 inches long with notches at ½ inch from each end
- +3 will be 3 inches long with notches at ½ inch from each end and directly in the center

The anions will be cut as male pieces out of the colored paper that is given in the data section

- -1 will be 1 inch long with a single protrusion at ½ of an inch
- -2 will be 2 inches long with protrusions at ½ inch from each end
- -3 will be 3 inches long with protrusions at ½ inch from each end and directly in the center

Each cation will be matched with each anion until all notches match with a protrusion.



ANALYSIS

Each of the 5 cations is matched with each of the 3 anions giving 15 ionic compounds that are electrically neutral. In some cases, multiple ions are required. Each of the protrusions has a notch that matches with it. These compounds are named with the cation first followed by the anion second:

1) Potassium Chloride
2) Potassium Sulfate
3) Potassium Phosphate
4) Calcium Chloride
5) Calcium Sulfate
6) Calcium Phosphate
7) Iron (I) Chloride
8) Iron (I) Sulfate
9) Iron (I) Phosphate
10) Iron (II) Chloride
11) Iron (II) Sulfate
12) Iron (II) Phosphate
13) Iron (III) Chloride
14) Iron (III) Sulfate
15) Iron (III) Phosphate

CONCLUSION

The diagrams all match the predicted compounds and ratios. The mathematical canceling of charges matches with the physical matching of charges. Formulas for ionic compounds can be determined by finding a common multiple charge of both the cation and anion and determining how many of each ion is required to get to that charge.

BE SURE TO USE THE R.E.R.U.N. METHOD OF WRITING CONCLUSIONS FROM THE WEBSITE AND WHAT WE HAVE DISCUSSED IN CLASS WITH EACH LAB REPORT TO GET FULL CREDIT