Honors Chemistry Lab 17: Transition Metals , Alloys, and Magnetism

The d-block transition metals have great importance in our lives. The d-block simply means that the elements' d-orbitals are the last to get occupied according to the Aufbau principle. The transition metals give off electrons from their outer s orbital, but most can lose a multiple number of d orbital electrons. Because of this many of the d-block metals have multiple oxidation numbers. A good example is copper which has two common oxidation states +1 and +2. In essence, the physical properties of these metals depend on the number of unpaired electrons in the d-block. Transition metals, for the most part, are good conductors. They are also malleable, ductile, lustrous, and silver-white in color. Metals have another great characteristic, they easily mix. This is because all the d-block metals have about the same atomic size. This allows them to replace one another easily in a crystal lattice. When two or more metals mix, or replace one another, we call the new metal an alloy. Brass is a good example of an alloy, which comes from copper and zinc combined. Another notable characteristic of these metals is that they can act as catalysts and this activity is ascribed to their ability to adopt multiple oxidation states and to form complexes. Recall that we added manganese(II) oxide to the exploding pumpkin demonstration to speed up the evolution of pure oxygen gas. Lastly, these metals also exhibit varying degrees of magnetism, and again, this amazing property is predicated on the number of unpaired electrons. Magnetic properties are frequently associated only with iron, but many other compounds, including liquids and gases exhibit magnetic properties. The magnetic properties of a material depend on the pairing of electrons in an atom. If there are unpaired electrons present, the atom will be attracted to a magnetic field. Such behavior is called paramagnetism. If the atoms in the material contain only paired electrons, then it will be slightly repelled by a magnet. This phenomenon is called diamagnetism. Some metals, particularly iron, cobalt and nickel have unpaired electrons but also align themselves to form small magnets within themselves. These metals remain magnetic even after the magnetic field is removed. This property is called ferromagnetism. Paramagnetism and diamagnetism are important concepts that can help teach the basics of atomic theory (orbital diagrams and Hund's rule) and bonding theory (valence bonds and Lewis structures). The purpose of this lab is to explore the various chemical and physical properties of the transition metals. During this lab we will specifically explore the concept of metal alloys and magnetism. Remember to always read before you proceed.

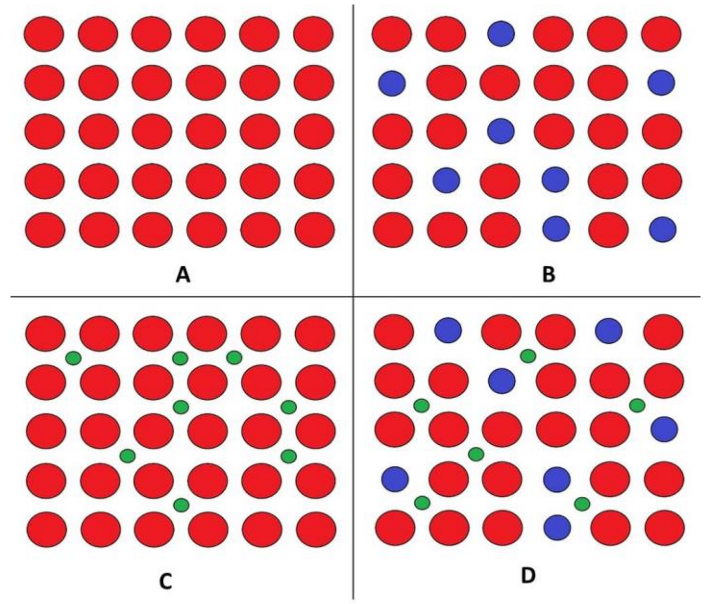
Part 1: Penny Alloy- Read through entire procedure before starting the this section and create a data table suitable for the qualitative data that you will assimilate during this section of the lab.

Procedures: Please read through the suggested procedures. I would encourage you to modify these procedures after you have completed the protocol once. Explore various methods for obtaining the "perfect" penny. Obtain a penny that is dated on or before 1981. Place the penny in a beaker containing 0.5 M HCl for approximately two minutes. Multiple groups can place their pennies in the same beaker. This will remove the outer oxidation layer. Record your observations. Remove the penny from the HCl using forceps and place it in a clean, dry ~150 mL beaker. Add 20 mL of 3M NaOH and 1/2 small scoop of powdered zinc directly on top of the penny in the beaker. Place the beaker on a hotplate and heat to a near boil. Use extreme caution with the corrosive NaOH, it can cause burns. DO NOT BOIL. Continue heating until you have "plated" the penny with zinc (~5 minutes). Remove the penny with forceps and rinse it in tap water. This will cool and rinse the penny of excess zinc. Record your observations. Obtain some crucible tongs and ignite a Bunsen burner. Use the tongs to heat the penny (both sides) rotating above the flame for about 1 minute, or until you notice the color change. Alternatively, you may choose to use a hotplate to heat both sides of the penny. Immediately remove the penny once the color has changed and rinse it in cold tap water. Closely examine the penny and record your observations. Clean up according to Flinn safety protocol #27B and dispose chemicals in the large waste disposal beak at my bench. Do not discard in trash. Flip the penny to see who gets to keep it.

Part 2: Paramagnetic Metal ions

Procedure: Locate the magnetic apparatus with the four blue cards labeled Zn^{2+}, Ca^{2+}, Mn^{2+}, Cu^{2+}.Write the full electron configurations for all four cations. Next sketch the shorthand orbital diagrams for all four cations. Carefully hold the neodymium magnet up to all for samples without actually touching the samples. Write down your observations for all four cations. Please keep all electronic devices away from the magnets.

Part 1: Post Lab Questions: (this section should come directly after the qualitative data)



Q1. Compare the color of the penny after each step. What common metals do these colors resemble?

Q2. What are the distinguishing characteristics of a metal alloy? Differentiate between interstitial and substitutional alloys and create an analogy to describe each type? Which type of alloy do you think was created in this lab?

Q3. Examine the schematic diagram to the right. Based on your answers for #2, label letters A-D.

Q4. Is making an alloy a chemical or physical change? Justify your response.

Q5. Described how metallic bonds are formed and be sure to describe the movement of electrons.

Part 2: Post Lab Questions: (this section should come directly after the qualitative data from part 2)

Q6. Consider your observations and electron configurations for all four cations. Which two cations do you feel exhibited paramagnetism? Which two cations do you feel exhibited diamagnetism? Please justify your response.

Q7. Considering your answer to Q6, there should be greater degree of paramagnetic behavior exhibited by one of the two species. Attempt to explain this difference using the orbital diagrams you sketched in part 2.