VI. Stability Problems

Nuclear Stability

0. Draw a Bohr Model of a ^{12}C (pronounced “carbon 12”) atom.

1. What aspect of atomic structure seems inconsistent with your knowledge of basic physics?

2. Identify three aspects of nuclear structure that result in more stable nuclei. Which of these three items is quantitatively most important in making predictions about the stability of a broad range of nuclei?

3. What eventually happens to unstable nuclei?

4. a) Fill in the table below for the subatomic particle composition of the indicated nuclides.

	^{18}F	^{19}F	^{20}F	^{20}F radioactively decays to: $^{20}Ne^{+}$
p^{+}	_____	_____	_____	_____
n	_____	_____	_____	_____
e^{-}	_____	_____	_____	_____

b) The ^{20}F nucleus is unstable and decays radioactively (by β^{-} [called “beta”] particle emission) to form $^{20}Ne^{+}$. A β^{-} particle has the same charge and mass as an electron. Write a chemical equation below showing how the nucleons of the ^{20}F nucleus changed during the reaction.

c) *(Challenging problem)* The ^{18}F nucleus is also unstable. When it decays, it emits an unusual subatomic particle called a positron β^{+}. This particle has the same mass as the beta particle, but the opposite charge. Use the Law of Conservation of Charge to determine the nucleon changes that occur during positron emission, and what the product of positron decay by ^{18}F would be.

5. What is the Chart of Nuclide Stability?

6. Order the nuclide in part a) from least stable to most stable (first to last), indicating why you chose the order you did. Then do a separate ranking for the nuclides in part b).

a) ^{40}Ca ^{37}Ca ^{41}Ca

b) ^{242}Pu ^{243}Pu ^{29}S ^{32}S

Electronic Stability

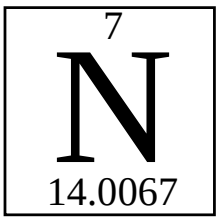
0. a) In what groups (the vertical columns in the Periodic Table) are the representative elements found. (See Orbital Filling Periodic Table in Supplemental Information section if unsure.)

b) State the name of the guiding principle that determines electronic stability (of the representative elements).

1. a) Write the electronic configuration of Ca.
   b) How many valence e^- does Ca have?
   c) Is Ca the most stable form of calcium (under normal conditions)? Explain briefly.
   d) What form of calcium would be more stable than Ca?
   e) Write an equation for a chemical reaction showing how Ca could be converted into a more stable form.

2. Will we have sufficient time in the class to decide whether Fe^{2+} is more than Fe or Fe^{3+}? (Note: This will also apply to the other transition metals.)

3. Use the symbol (from the Periodic Table) shown at right to answer the following:



   a) What is the name of the element shown?
   b) How many protons are present in an atom of this element?
   c) In what group is the element found?
   d) How many valence electrons does an atom of this element contain?
   e) How much does the average atom of this element weigh?
   f) Why did question e) above, use the phrase "average atom?"
   g) Go to Wikipedia on the www. Enter Table of Nuclides in the search engine. Click on ^{15}N. What is the % natural abundance of ^{15}N.
   h) Does the answer to g) make sense if the weight of one atom of ^{14}N is 14.00307 amu. Explain.
   i) Given the following masses per subatomic particles:
   $p^+ = 1.0073$ amu
   $n = 1.0087$ amu
   $e^- = 0.0054858$ amu
   What is the sum of the weights of the particles in a ^{14}N atom?
   j) Compare your answer in I) to the actual weight of an ^{14}N atom listed in h). What principle does this difference illustrate?

4. a) Who (briefly) was Dmitri Mendeleev?
   b) Did the Periodic Table look the same in Mendeleev's time as it does now? If not, how is it different?
   c) Why (briefly) do scientists think Mendeleev's work was a significant scientific contribution?