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EPSC 352: EARTH MATERIALS Fall, 2009
Homework Set #1

☛ **Due Friday, September 11, 2009.**

****Show all of your work. Be sure to write the UNITS.****

4 pts Hey, What about those Electrons

1. A professor asks her students to write the **ground state electronic configuration for Mo** (atomic number 42). She gets the following answers, one of which is correct, one or more others that have some merit but are not totally correct, and one or more that is totally wrong. For each of the answers below, explain what is right or wrong about it.

$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^4 5s^2$.

$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^5 5s^1$.

$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^5 4d^5 5s^2$.

8 pts 2. Consider the geochemically abundant element silicon, Si, which has the electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^2$. Answer the lettered questions, using the three choices below.

(i) Si^{4-} and Si^{4+}
(ii) Si^{4+} only
(iii) Si^{2+}, Si^{4+}, and Si^{4-}

[2] a. What ions could Si be expected to form? Explain why or electronically how that gain or loss of electrons would be favored.

[1] b. What is/are the most common ionic state(s) of silicon in the earth's crust?

[3] c. If an element, based on its electronic structure, can have different ionic states, what factor(s) determines WHICH ionic state it exhibits in a particular case?

[2] d. For some element Q, what is the difference between the ions $\mathbf{Q^{x-}}$ and $\mathbf{Q^{x+}}$? Do not just say the sign of the charge is different; rather, explain the ramification(s) of this difference in sign.

Applying and Interpreting Data

18 pts 3. Consider what factors control the elemental substitution that can occur in minerals, i.e., solid solution.

[4] a. The words "solid" and "solution" do not seem to go with each other. Why is the term "solid solution" well chosen to describe what it represents?

[5] b. Define the term **olivine** (e.g., is this a single mineral?). Give the chemical formula(s) for **olivine**.

[5] c. Define and give the chemical formula(s) for **plagioclase**. What kind/group of mineral does it belong to?

[4] d. Refer to your text Table 3.8 (effective ionic radii) on page 49 to determine whether Ba^{2+} ions will substitute more readily for Fe and Mg ions in olivine or for Ca in plagioclase. **Explain your answer**.

6 pts 4. Compare data from your textbook Table 3.7 (page 47) and Table 3.8 (page 49).

[2] a. What is the radius given for Mn in each of those tables? (Specify the units)

[2] b. Why are the listed Mn radii different in the two tables?

[2] c. Compare several different elements between the two tables. What regularities do you see in these comparisons? Why do they occur?

23 pts 5. Use the periodic-table Web site at **http://www.webelements.com/index.html** to answer the following questions.

[2] a. Click on the element **calcium**. [For your amusement, you can click the symbol and listen to a discussion about magnesium.]
Click on the "geology" category in the left-hand menu. You will see a page showing the relative abundance of Ca in various reservoirs, such as the universe and the earth's crust. Note the abundance of Ca (in ppb) in crustal rocks, which is listed both "by weight" and "by atoms." In words, explain the meaning of 50,000,000 ppb by weight.

[2] b. Translate the above figure into weight %.

[2] c. Given the relation shown between the abundance by weight and abundance by atom, what can you say about the relative atomic weight of calcium compared to the average atomic weight of the constituents of the crust?

[2] d. Under the heading "Atom Properties" on the right menu bar, click "electron shell properties" to see the ground-state *electronic configuration* of calcium. What is the most common valence state of calcium?

[4] e. On that *electronic configuration* page, the button-controlled counter is not working right, but the colored boxes representing the sequential atomic shells do show the proper energy relationships of the different atomic orbitals**. Describe the removal of the outermost 6 electrons of calcium**, i.e., from which orbitals they successively are removed.

[4] f. Check the **ionization energies** (shown immediately above the electronic configuration: recorded as enthalpies, in units of kJ/mol) of calcium.

What does the term "ionization number" mean?

On the $kJmol^{-1}$ vs. ionization number diagram for magnesium, why is there somewhat of a jump in the trend (in ionization enthalpy vs. ionization number) between ionization numbers 2 & 3, a bigger jump between numbers 10 & 11, and a huge jump between numbers 18 & 19?

Use the Website to create different graphs of the density vs. atomic number of the elements: Under "Element properties" in the right-hand menu, click "Physics properties"; scroll down to "Bulk properties", and click on "density of solid." Move your cursor around the default chart so you can see individual data. Click on the different presentation options by 1) clicking buttons at bottom of chart or 2) clicking terms (periodicity, cityscape,...bar chart) along the left edge to see the relative densities of the elements presented as balls, bars, with connecting lines, etc.

[3] **g. Print out the chart that you think best depicts density vs. atomic number.** Attach it to your answer sheets.

[4] **h. Use your text Table 3.6 (electron configurations) on pages 44-45 together with the density graph to explain the density trends seen for elements Z = 1 through 54.**

18 pts 5. Refer to the first several (numbered) pages of your hand-outs to answer these questions.

[3] a. What does the term **trace element** mean?

[4] b. How can "traces" of elements be important to you as simply a member of the general populace? (Consult the Web if you want.)

[4] c. What is the difference between the behavior of **trace elements** and **major elements** in terms of whether they form "their own minerals"? Why is there this difference?

[4] d. Why don't trace elements typically form their own minerals? How is it that they sometimes do form their own minerals – under what circumstances?

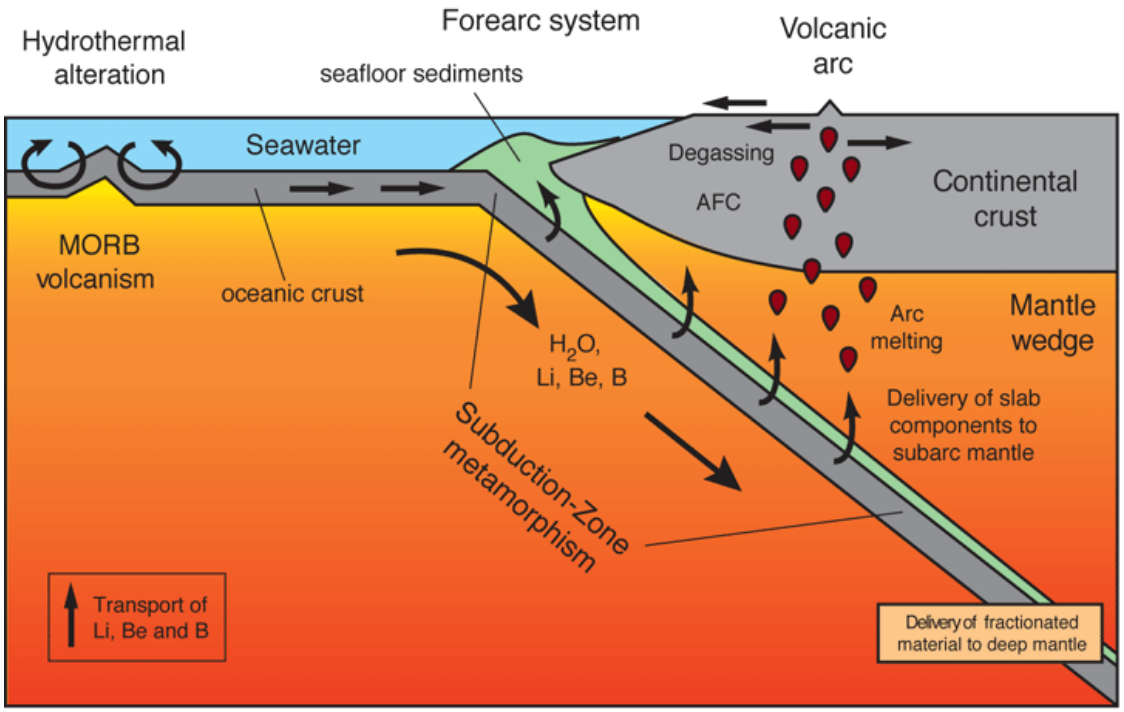
[3] e. In what way can the incorporation of a small amount (let's say less than 1 wt.%) of an element change the mineral into which it is incorporated?

15 pts 6. Consider pages 5-7 in your hand-outs to answer these questions.

[4] a. What determines the "minimum minable" concentration of an element? Be sure to include environmental issues in your discussion.

[3] b. Name some "everyday" metals (i.e., NOT hafnium and tantalum) whose minimum minable concentrations are more than 1000X their average crustal concentrations.

[4] c. HOW do such "pockets" of high concentration form in the earth's crust? (Consider, for instance, the image below.)



[4] d. Your hand-outs show the wt.% necessary for each of numerous elements to be economically mined. Is it generally true that there are more ore deposits of those elements that need the lowest wt.%'s in order to be economic? [Hint: Think about "what it takes" to form an ore deposit.]

8 pts 7.a. Consider element Q. Briefly discuss 2 factors that would cause the effective radius of ion Q to change; explain why the change would occur and in which direction (i.e., increase or decrease in ionic radius).

[4]

[4] b. Refer to the periodic table of atomic radii below. Consider only Groups Ia, IIa, IIIa,..VIIa.

Why do the atomic radii consistently increase downward in each column, yet decrease across each row (viewing only the entries in the a-columns, not the transition elements)?