Inquiry-Based Activity 1: Explosive Reactions?

Student Name _____

In this activity, you will determine how *favorable* you expect several reactions to be at room temperature. That is, you will determine to what extent, based on thermodynamics, you expect these reactions to run to complete products, remain as reactants, or find an equilibrium somewhere in between. You will then observe how *rapid* these reactions are at room temperature.

Materials:

A calculator
A pencil
An oxygen atmosphere (such as the room you are in)
Samples of iron, graphite, steel, and silicon (approximately 1"x1" in size).
Optional, but fun: Extra fine steel wool and a match

Directions:

6. Predict what will happen in the following situation: Based on thermodynamic data, a student calculates that a reaction has a very large negative ΔG_{rxn} at room temperature, leading to a $K_{eq}>10^{10}$.
    a. What do you expect she will observe experimentally when she conducts the reaction in the laboratory?
        1) Essentially complete conversion of the limiting reagent to products
        2) Essentially no conversion to products
        3) A mix containing significant amounts of products and reactants
        4) It is impossible to say based on current information

    Why?

    b. What do you expect she will observe about the rate of the reaction?
        1) The reaction proceeds very rapidly, perhaps even explosively
        2) The reaction proceeds very very slowly
        3) The reaction proceeds rapidly to start, then more slowly
        4) It is impossible to say based on current information

    Why?

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7. Using the information in the table below, determine both ΔG_{rxn} and K_{eq} for each of the following reactions at 298K.

$4Fe + 3O_2 \rightarrow 2Fe_2O_3$ (Iron plus oxygen produces rust)

$C + O_2 \rightarrow CO_2$ (Carbon plus oxygen produces carbon dioxide)

$Si + O_2 \rightarrow SiO_2$ (Silicon plus oxygen produces quartz / glass)

Chemical	ΔG_f^0 (kJ/mol) ref temp 298K
C, s	0
O_2,g	0
Si, s	0
Fe_2O_3, s (one form of rust)	-741.5 *
SiO_2, s	-856.5 ^
CO_2, g	-394.4 #

Sources: *Knovel Critical Tables, ^Yaws Handbook, #Handbook of Inorganic Chemistry

8. Based on the calculations from step 2, what can you conclude about the reactions? Are they spontaneous as written? That is, based on your calculation, do you expect the forward to be favorable at room temperature? Would you anticipate appreciable amounts of reactants to remain?

9. Obtain samples of iron, carbon, and silicon from your Professor or TA. Introduce them to an oxygen atmosphere at approximately 298K. Observe. What is the apparent reaction rate?

10. *Optional:* Place a ~2" diameter piece of extra fine steel wool in a fire-resistant container (such as a Pyrex baking tray). Hold the match to the steel wool. Observe what happens. Ignoring the (relatively small) impact of the change in temperature, what is the essential difference between this case and the case in question 4? State both your observations and

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your hypothesis, and test your hypothesis by attempting to ignite the large steel sample provided for question 4.

Analysis – to do after class/lab and hand in:

4. Revisit your predictions in question 1 of Directions. Were you right? Compare your initial predictions to what actually happened.
5. If the experimental results do not match your initial predictions, come up with a new explanation of the results. In your explanations, you ***must*** pay particular attention to why your original arguments were not correct and how you had to revise your thinking to explain what happened.
6. What does this experiment suggest about the relationship between how *favorable* a reaction is and how *rapid* the reaction is? Specifically discuss your answers to questions 3 and 4 in your response. If you performed the experiment for question 5, compare the results for 4 and 5 and assess what this implies.

   Notes:

   - You should discuss your answers with at least 2 other students and agree on what happened and why.
   - Hand in your original prediction and your comparison to question 1 above, specifically noting if and how your thinking has changed with respect to the experiment. What, if anything, did you learn?
   - Remember to put your name or identifying student number on each page of your response.

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