Hydrogen CWA

The Hydrogen CWA is designed to be an open argument. The overarching question is: Should Hydrogen be located in Group 1 or Group 7? The following handouts are included:

- Prompt
- 2 reference articles – See the Science page of Aspen/SIS for information on accessing these articles if you cannot retrieve them from the following links;
    - The Proper Place for Hydrogen in the Periodic Table – Marshall W. Cronyn
      Journal of Chemical Education, Vol. 80, No. 8, August 2003, JChemEd.chem.wisc.edu
      http://www.reed.edu/reed_magazine/summer2009/columns/NoAA/downloads/CronynHydrogen.pdf
    - Trouble in the Periodic Table – Eric Scerri
      Education in Chemistry, Vol. 49, No. 1, January 2012, www.rsc.org/eic
      http://www.rsc.org/images/Scerri%20Trouble%20PT_EiC_January2012_tcm18-212413.pdf
- Content specific rubric
- Sample student response

Students should be provided the prompt. Two articles are provided for you and/or the students to reference. In addition to providing a specific CERR rubric that corresponds to this topic, a sample student response is included.

Location of Hydrogen

The periodic table that we use in chemistry is organized into groups according to atomic number, electron configurations, and chemical properties. Hydrogen is often placed at the top of Group 1, but some chemists have argued that the proper place for hydrogen is at the top of Group 7.

Using your knowledge of chemistry, create a scientific argument that clearly makes a ***claim*** about the proper placement of hydrogen on the periodic table. Use ***evidence*** to support your clam and clearly explain your ***reasoning.***

Question: Should Hydrogen be located in Group 1 or Group 7?

Location of Hydrogen: CER Rubric

	Exemplary	Proficient	Needs Improvement	Critical Area
Claim:	□ States that hydrogen should be located in Group 1 **OR** □ States that hydrogen should be located in Group 7 **AND** □ Uses precise language that corresponds to the question □ Written in complete, easy to understand sentence(s)	□ States that hydrogen should be located in Group 1 **OR** □ States that hydrogen should be located in Group 7 **AND** □ Uses language that generally corresponds to the question □ Written in complete, easy to understand sentence(s)	□ Summarizes that hydrogen could be located in either Group 1 of Group 7, but does not state which one is being argued for.	□ Does not make a claim
Evidence:	□ Provides appropriate and sufficient evidence that supports claim	□ Provides appropriate and sufficient evidence that supports claim □ May include some irrelevant/inappropriate evidence	□ Provides appropriate, but insufficient or unclear evidence to support claim. □ Missing one or more pieces of evidence below. □ May include some inappropriate evidence.	□ Does not provide evidence, or only provides inappropriate evidence (evidence that does not support claim)
	Exemplar Evidence: □ Hydrogen in Group 1 o Identifies number and location of valence electrons o Identifies that it can form an cation with +1 charge **OR** □ Hydrogen in Group 7 o Identifies high reactivity o Identifies non-metal properties including, poor conductors of heat and electricity as well as low densities, melting points, and boiling points.			
Reasoning:	□ Correctly and clearly connects **ALL** evidence to the claim □ The appropriate principles are described and organized logically, and are used to justify why the data counts as evidence. □ The response describes an application of the scientific principles beyond the context of the prompt.	□ Correctly and clearly connects **ALL** evidence to the claim □ The appropriate principles are described and organized logically, and are used to justify why the data counts as evidence.	□ The reasoning does not link all relevant evidence to the claim **OR** □ The appropriate scientific principles are not fully described or accurately used to justify why the data counts as evidence.	□ No reasoning is provided, which could include restating the evidence. **OR** □ Reasoning does not support the claim.

<table>
<tr><th></th><th>Exemplary</th><th>Proficient</th><th>Needs Improvement</th><th>Critical Area</th></tr>
<tr><td></td><td colspan="4">Exemplar Reasoning:
□ Hydrogen in Group 1
o Valence electrons: Number and Location:
▪ Explain how the atomic number is related to the number of electrons and electron configuration.
▪ Explain that Hydrogen's outermost atomic orbital is s, and that it can hold a maximum of 2 electrons.
▪ Explain that Hydrogen has only 1 electron in its outermost atomic orbital, which is called a valence electron.
▪ Explain that all of the elements is Group 1, including hydrogen, have one valence electron in the s atomic orbital
o Cation with +1 charge:
▪ The Group 1 elements donate one electron because it leaves a completely full p atomic sublevel, which is more stable.
▪ Hydrogen donates an electron when it is found in an acid. Acids donate a hydrogen to water, to form H_3O^+. As the concentration of H_3O^+ increases, the pH becomes more acidic.

□ Hydrogen in Group 7
o High Reactivity:
▪ Explain why ions become cations: to become more stable, which happens when they have a completely full (or half full) atomic orbital.
▪ Explain how hydrogen forms a cation
▪ Explain how Group 7 elements form cations.
▪ Explain that being so close to having a completely full atomic orbital makes it highly reactive.
▪ Explain that this is also why hydrogen and the Group 7 elements exist as diatomic molecules at standard conditions.
o Non-metallic properties:
▪ These physical properties are characteristics of non-metals, of which Hydrogen and the Group 7 elements are all classified.</td></tr>
<tr><td>Rebuttal</td><td>□ A rebuttal to (an) alternative explanation(s) is provided that critiques the quality of the alternative evidence or reasoning.</td><td>□ A rebuttal of (an) alternative explanation(s) is provided that critiques the quality of the alternative evidence or reasoning.
<u>AND</u>
□ Includes some evidence or reasoning that is inappropriate to the rebuttal.</td><td>□ A rebuttal of (an) alternative explanation(s) is provided that critiques the quality of the alternative evidence or reasoning.
<u>AND</u>
□ The appropriate evidence and reasoning provided in the rebuttal is not sufficient.</td><td>□ Does not include a rebuttal
<u>OR</u>
□ Makes an inaccurate rebuttal</td></tr>
<tr><td></td><td colspan="4">Exemplar Rebuttals:

□ Rebuttal to Group 7:
o <u>Alternative claim</u>: Some people may argue that hydrogen should be in Group 7 because they have similar properties.
o <u>Critique of alternative evidence</u>: However, hydrogen has a lower and electron affinity, whereas the Group 7 elements have some of the highest.</td></tr>
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	Exemplary	Proficient	Needs Improvement	Critical Area
	Exemplar Rebuttals (continued): □ Rebuttal to Group 1: ○ Alternative claim: Some people may argue that hydrogen should be in Group 1 because it is highly reactive and all the elements in Group 1 are also highly reactive. ○ Critique of alternative evidence: However, they are wrong because hydrogen most often either forms an anion by gaining one electron or becomes a covalent compound. While, like the other Group 1 elements, it can form a cation by losing one electron, this occurs less often. ○ Critique of alternative reasoning: Moreover, the outcome for losing one electron is different for hydrogen as compared to the other group 1 elements. Namely, when hydrogen loses one electron it is left with zero electrons because it only had one electron to begin with. This means that it has an empty atomic orbital. In comparison, the other Group 1 elements tend to lose an electron because when they do so their outermost atomic orbital is full. Therefore, while hydrogen can form a cation, it more often forms an anion and hydrogen does not become more stable when it donates an electron.			
Conventions:	□ Writing contains no grammatical or spelling errors. □ Writing is clear, concise, and persuasive.	□ Writing contains very few grammatical or spelling errors. □ Writing is clear, mostly concise, and well developed.	□ Writing is fairly clear, with some grammatical or spelling errors. □ Writing could be more concise.	□ Writing is difficult to follow, with many grammatical errors and no clear structure. □ Writing is either too wordy or too incomplete

Location of Hydrogen: Ideal Student Response

Group 1:

C: Hydrogen should be located in Group 1.

E1: This is because hydrogen and the Group 1 elements have one valence electron in the s atomic orbital.

R1: The atomic number for hydrogen is 1, which indicates the number of electrons. With 1 electron, its electron configuration is $1s^1$. This means that its outermost atomic orbital is s, which can hold a maximum of 2 electrons. It also means that Hydrogen has only 1 electron in its outermost atomic orbital (1s), which determines the number of valence electrons. Similarly, all of the elements in Group 1 also have one valence electron in the s atomic orbital. For instance, Lithium is atomic number 3. With 3 electrons, its electron configuration is $1s^2 2s^1$. The outermost atomic orbital (2s) contains 1 electron. Because hydrogen and all of the elements in Group 1 have one valence electron in the s atomic orbital, hydrogen should be placed in Group 1.

E2: Hydrogen is also similar to the other Group 1 elements because they can form a cation with a +1 charge.

R2: The Group 1 elements donate one electron because it leaves a completely full p atomic sublevel, which is more stable. For instance, Li^{1+} has an electron configuration of $1s^2$. By donating the $2s^1$ electron, its outermost atomic orbital (1s) now contains the maximum number of electrons (2), which makes it very stable. Hydrogen becomes a cation with a +1 charge when it is a part of an acid. Specifically, acids donate a hydrogen ion, H^+, to water, to form H_3O^+. This occurs because acids disassociate in water. For instance, in water, the HCl molecule separates according to the reaction: $HCl \rightarrow H^+ + Cl^-$, or $HCl + H_2O \rightarrow Cl^- + H_3O^+$.

Rebuttal 1: Some people may argue that hydrogen should be in Group 7 because they have similar properties. However, hydrogen has a lower electronegativity (ability of an atom to attract electrons to itself) and electron affinity (amount of energy that is released when an electron is added to a neutral atom), whereas the Group 7 elements have some of the highest.

Group 7:

C: Hydrogen should be located in Group 7 because the physical properties of hydrogen are similar to those of Group 7.

E1: First, hydrogen and the Group 7 elements are both highly reactive.

R1a: This is because atoms form ions so that they become more stable, which happens when they have a completely full (or half full) atomic orbital. Because hydrogen has an atomic number of 1, it has 1 electron and its electron configuration is $1s^1$. Moreover, it only needs to gain one electron to completely fill the s atomic orbital; therefore it can form an anion with a -1 charge. As is also the case with hydrogen, all the elements in Group 7 form anions by gaining one electron. For instance, Fluorine is atomic number 9, and its electron configuration is $1s^2 2s^2 2p^5$. It, therefore, has 5 electrons in its outermost atomic orbital (2p). Since p sublevels are completely full when they contain 6 electrons, Fluorine only needs one more electron to be completely full and thus stable. Because the other Group 7 elements in addition to Fluorine and Hydrogen only need one more electron to become stable, they are highly reactive.

R1b: These properties that make hydrogen and the Group 7 elements highly reactive is also why hydrogen and the Group 7 elements exist as diatomic molecules at standard conditions. The exception to this is astatine, whose diatomic nature is uncertain.

E2: Second, hydrogen and the group 7 elements are poor conductors of heat and electricity and have low densities, melting points, and boiling points.

R2: These physical properties are characteristics of non-metals, of which Hydrogen and the Group 7 elements are all classified.

C: Because hydrogen and the group 7 elements have similar properties, including a high reactivity, poor conductors of heat and electricity, and low densities, melting points, and boiling points, hydrogen should be located in Group 7.

Rebuttal 1: Some people may argue that hydrogen should be in group 1 because it is highly reactive and all the elements in group 1 are also highly reactive. However, they are wrong because hydrogen most often either forms an anion by gaining one electron or becomes a covalent compound. While, like the other group 1 elements, it can form a cation by losing one electron, this occurs less often. Moreover, the outcome for losing one electron is different for hydrogen as compared to the other group 1 elements. Namely, when hydrogen loses one electron it is left with zero electrons because it only had one electron to begin with. This means that it has an empty atomic orbital. In comparison, the other Group 1 elements tend to lose an electron because when they do so their outermost atomic orbital is full. Therefore, while hydrogen can form a cation, it more often forms an anion and hydrogen does not become more stable when it donates an electron. Consequently, hydrogen is more similar to the group 7 elements.