Suggestion: Use a World-and-Life View in the Teaching of Chemistry

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For many years I have felt that I would be able to teach college chemistry more effectively if I could relate chemistry to the world-and-life view of my students. Three years ago I began to re-structure my general chemistry course with this goal in mind. My purpose in this article is to describe my method not only for instructors who agree with my world-and-life view, but also to provide an example for others who might be interested in using a world-and-life view in teaching chemistry.

Am I claiming that the world-and-life view held by instructors and students should govern personal relations in the classroom? Yes, of course, but the point of this essay is that the world-and-life view prevailing in the chemistry classroom ought to refer to more than personal relations. The world-and-life view should help instructors and students form their attitudes toward the subject matter of chemistry.

If the World-and-Life View Is Christian

My college, along with many U.S. colleges, is a Christian college. Consequently, the world-and-life view of many instructors and students in these colleges is Christian, or, at the very least, there is sympathy for the Christian position.

In this context, what does it mean to claim that both personal relations and one's attitude toward chemistry should be determined by the Christian outlook on life? According to the Christian position, the fundamental reason people should respect each other is that God created them. As they show respect for each other, they show respect for God. But God also created everything that chemists study. Therefore, Christians ought to respect chemicals and chemical processes because God created them. I believe that it is my duty as a Christian chemistry instructor to work out the consequences of the understanding that God created chemicals and chemical processes.

To develop a Christian position, it is appropriate to begin with the Bible. Both the general theme of the Bible and specific biblical passages call for respect for creation. In the Old Testament one of the psalmists says, "The heavens declare the glory of God; the skies proclaim the work of his hands." [1] Surely there is no discontinuity between the heavens or skies and, say, acid–base neutralization or the structure of a protein. Furthermore, chemists formulate and use laws that are human attempts to describe creation, which is governed by divine law. With this relation between human law and divine law in mind, listen again to one of the psalmists, who is speaking to the Lord of the entire creation: "Your laws endure to this day, for all things serve you." [2] In the New Testament, the Apostle Paul declares that Christ, who is God, gives creation meaning: "All things were created by him and for him .... In him all things hold together." [3] It seems to me that followers of Christ must live remembering that the "all things" of the last two passages hold together because of Christ.

I have no quarrel with those who have different world-and-life views and who conclude that a world-and-life view has nothing to do with the subject matter of chemistry. Such people hold that chemistry is "neutral" in the sense that chemistry is the same if it is taught by, for example, a Muslim, a Christian, or anyone else. I do not want to speak for those who have a position different from mine, but in the next section I want to explain how my Christian faith affects my treatment of the subject matter of the first-year college general chemistry course that I teach.

Using This Approach in a Specific Course

First, a word about method. I use a well-known general chemistry text. But because the authors of that text do not in any obvious way proceed from the assumption that God created chemicals and chemical processes, I have prepared a

[1] Psalm 19:1.
[2] Psalm 119:91.
[3] Colossians 1:16–17.

syllabus for my students to use alongside the text, with chapters in the syllabus paralleling chapters generally found in first-year texts. Thus, typical syllabus chapter titles are "Atoms, Molecules, and Ions", "The Structure of the Atom", "Acid-Base Reactions", and "Chemical Reaction Rates". Class discussions focus on both the text and the syllabus. I require students to read the syllabus and test them on it.

Student response in course evaluations has been positive. Students usually indicate that the approach of the syllabus provides them with the insight they need to fit chemistry into the scheme of things. It seems to help them avoid putting the parts of their lives into separate, non-interacting compartments.

The rest of this essay is based on the content of the syllabus.

The claim that God created chemicals and chemical processes is only the starting point. After all, chemistry teachers teach "chemistry", a body of knowledge that is the result of human analysis of chemicals and chemical processes. For the purpose of this discussion, I shall refer to this analysis as a human response, always with the understanding that it is a human response to what God created. Thus, the human response concerning atoms has produced, in succession, the Dalton atom, the Rutherford atom, and the Schrodinger atom. But these developments had historical settings. Therefore, the study of chemical history is part of the study of chemistry. Also, as needed at different times in the past, there appeared subdisciplines, such as the mathematical treatment of chemical equilibria and the application of thermodynamics to chemical systems. The syllabus shows the student that the human response to creation has been developmental, with each development sufficient for the needs of the time. (The paradigm-to-paradigm progression of Kuhn[4] is the basis for some of the historical discussion. Because the syllabus is not as sophisticated as Kuhn, the word "paradigm" does not appear.)

Another matter I emphasize because God created chemicals and chemical processes is the orderliness of chemistry. Of course, every textbook recognizes, and every chemist realizes that chemistry is orderly. But it seems to me that usually textbooks do not make the point nearly as emphatically as they might. As a Christian who believes that God created chemicals and chemical processes, I believe that there is no other option besides an orderly creation: God does not contradict himself. As the decades pass, chemical developments show more and more clearly that the phenomena of chemistry hang together. This general tendency is precisely what Christians would expect. I do not, however, claim that the orderliness that chemists discover is proof of the validity of the Christian position. Rather, orderliness is just what one would expect if the Christian position is true.

With others, I stress such matters as the unification of chemistry—enabling us to see its orderliness—brought about by the periodic classification, the application of thermodynamics to chemistry, and quantum theory. But I attempt to show orderliness in other ways also. Thus, I show that the amazing diversity among chemical phenomena is almost always explained by bonding of one kind or another. Perhaps the bond is between the atoms of a molecule or between the atoms or ions of a crystal; the bond might be a weak or a strong bond between molecules in the liquid of the gas phase. Take away all these kinds of bonds, and diversity almost vanishes. But bonding is in principle understood. Therefore, the orderliness of chemistry, expected because God created, lies behind such diverse phenomena as the existence of glasses, the cleaning properties of soaps, the functioning of transistors, the colligative properties, the properties of alloys, the brittleness of salts, the reason many reactions are slow, and the unusual and useful properties of water.

To emphasize the orderliness of chemical phenomena, the syllabus shows that coulombic attraction and repulsion, whether between chemical species or between electrons and nuclei, constitute the fundamental reason for essentially all chemical reactions. In one sense, then, all reactions are acid–base reactions. (This approach is related to the Usanovich classification of acids and bases.) For the sake of convenience, however, chemists use definitions that are more restrictive. Thus, it is convenient to consider the class of redox reactions to be a separate category, even though those reactions are not in principle different from other acid–base reactions.

The orderliness of creation has a consequence not usually considered. It determines the nature of the human response to creation. I believe, on the basis of what the Bible teaches, that God created the human race with the duty and the ability to explore creation. It is not surprising that the human response to creation is itself orderly. Thus, the possibility of chemical progress was limited until trivial names were replaced by meaningful systems of nomenclature. Furthermore, chemists' frequent resort to approximation methods, such as the use of oxidation numbers, valence bond theory, and molecular orbital theory, are ingenious attempts to attack otherwise extremely difficult problems in an orderly, albeit approximate, way.

In other words, I attempt to teach chemistry in a somewhat larger context than is usually the case. The treatment of many subjects usually taken up in the first-year course is therefore different. I shall describe two not mentioned above.

Textbooks often refer to certain exotic ideas, such as the uncertainty principle, which play a role in atomic theory. Because these ideas fascinate students, I am able to use them in bringing out some of the main ideas of the course. For example, the uncertainty principle demonstrates that there may be a natural limitation to human knowledge, that is, to the human response to creation. Discussion of this principle is therefore an aid in explaining what is meant by "human response".

The deleterious effect of certain chemicals on the environment is another subject ordinarily covered in first-year courses. However, part of my treatment is probably different. I explain in the usual way the chemistry of the environmental harm due to lead in automotive fuel and industrially generated substances that are at least partially responsible for acid rain. Chemists generally state that these practices are bad because they harm children, who are building bones, and lakes whose pH becomes too low to support life. At this point, however, I want to tell my students more. There is a deeper reason for condemning these practices. They are wrong because they harm that which God created, in this case children and lakes. To harm creation is to offend God, the creator. This is one way my students learn that in their future chemical work they are to serve God. Their eyes are lifted above the horizon: in the final analysis, they are to serve God, not creation.

[4] Kuhn, T. S. *The Structure of Scientific Revolutions*, 2nd ed.; Univ. of Chicago: Chicago, 1970.