Review of Exploring Creation with Chemistry, Third Edition

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When Apologia produced a new edition of *The Human Body: Fearfully and Wonderfully Made*, I reviewed it very positively (http://blog.drwile.com/?p=10876), because it was clearly an improvement over the previous edition. It doesn't matter that my name no longer appears on the cover. The important thing is that homeschooled students now have an even better resource from which to learn human anatomy and physiology. I truly wish the same could be said of the new edition of *Exploring Creation with Chemistry*. It cannot. The third edition of this book is a giant step backward compared to the previous edition. I would not recommend it for any student.

To begin with, there doesn't seem to be a reason for the new edition. There aren't any new chemistry topics in the new edition, and the science behind the topics covered has not changed since the previous edition. The new edition does teach Lewis structures differently from the first edition, but that leads to confusion, because the method used is not consistent. Sometimes, the method taught in this new edition is used to make Lewis structures, but sometimes the method taught in the previous edition is used, with no explanation and no indication that it is a different method.

A few experiments have been added, but once again, that leads to problems. For example, Experiment 11.1 is a new experiment. It is a really nice one, except the student can't do it with the lab kit that comes with the course. It requires a mass scale that is precise to 0.2 grams, and the mass scale that comes with the course is, at best, *ten times less precise* than that. In addition, the experiments were changed to include the student writing a hypothesis. This is okay, except some of the hypothesis statements don't make sense in terms of the proper application of the scientific method. For example, some ask the student to hypothesize about something that has already been taught. How do you hypothesize when you have already been told what will happen?

There also seems to be a big step backwards in terms of supporting material. For the second edition, there was a multimedia CD version of the course. For those who wanted a textbook, there was an optional multimedia CD that accompanied the text. Those resources provided videos of experiments the student couldn't do at home, animated and narrated solutions to some of the more difficult problems, and pronunciations for the difficult words. Those are gone in this new edition.

It seems that this new edition was rushed to press. Some of the new figures have things left out of them and do not match the text that is discussing them. For example, the text says that Figure 6.2 illustrates the difference in molecular motion between the three phases of matter. However, there is no motion illustrated in the figure. In addition, a term used in the second edition (purely covalent compounds) was replaced in the new edition with a new term (nonpolar covalent compounds). That new term is fine, but the old term shows up from time-to-time in the new edition, even though it is never explained. Finally, there is even a note to the layout artist that was not removed from the *Solutions and Tests Guide*.

There are two stylistic things that aren't really major but might be a problem for some students. First, the "On Your Own" problems are often pushed to the side of the page. This makes them too easy to skip. Second, the new edition replaces almost all words like "two" with the corresponding number. This can be a problem. In the old edition, when there was two of something that had a number in its name, the word "two" was used. So, for example, the old edition would say, "two electrons will go into the 1s orbital." The new edition says, "2 electrons will go into the 1s orbital." That's not wrong, but it can be confusing, since there is a number in the name of the orbital.

Despite the fact that these things are troubling, they aren't the real reason this new edition represents a giant step backwards. The real reason is that there are just too many problems with it. In reading the text and checking all the exercises except the extra practice problems, I have found well over 70 problems. This doesn't include typographical errors. I wasn't really looking for those, but I found over 60 of them. The non-typographical problems can put in one of three categories.

1. Factual errors

These errors come in many varieties. For example, Figure 3.3 represents a physically-impossible situation. It has a beam of electrons bending towards the positive side of a magnet. Magnets don't have a positive side. They have a north and south pole. Also, the way the illustration is set up, the electron beam would not bend the way it is depicted. It would bend in a direction perpendicular to what is illustrated. This is important, because the drawing violates the right-hand rule, which students learn in university-level physics.

Another example of a major error is that students are told that everything visible and invisible is made up of elements from the periodic table. Of course, that isn't correct. Some light is visible, and some is invisible; none of it is made up of elements.

The text provides biographical information on some scientists, but a few of them contain significant errors. The biographical information about Robert Boyle, for example, has three errors, including the claim that he wrote *The Wisdom of God Manifested in the Works of Creation*. That book wasn't written by Boyle. It was John Ray's masterpiece. Also, if a text is going to mention a single work by Boyle, it should be *The Sceptical Chymist*, which is Boyle's most important work.

2. Problems resulting from a change in the order of topics

This new edition introduces topics in a different order from the second edition. That, in and of itself, is not a problem, as there are many ways in which you can teach the topics related to general chemistry. However, when you rearrange topics in a book, you need to make sure the rearrangement doesn't cause problems for the student. This wasn't done, so there are times the student is expected to know things that haven't been taught yet.

For example, some chemical formulas have parentheses in them. The student must be taught how to use those parentheses when balancing chemical equations. Unfortunately, the student is not taught this technique until *two modules* after he or she is supposed to use it in some problems! In addition, the student is asked about whether or not cubes of frozen alcohol will float or sink in liquid alcohol. The answer to that question requires a knowledge of density, but density isn't discussed until three pages later. Finally, in Module #10 the student is asked to remember that the temperature of a well-mixed solution of ice and water is always at 0.00 °C. What the student is supposed to "remember" isn't taught until Module #12!

3. Problems related to forcing Christian content into the book

There is a lot of Christian content in the book that is unrelated to the subject being discussed. For example, the text has some special sections, one of which is called "first reactions," which is a very clever title for a section that appears at the beginning of each module of a chemistry course. For Module 2, the section starts out, "Adam was permitted to name things created by God. We continue to exercise that honor in science." What does that mean? Is there some other way things could be named? Do we "exercise that honor" in science but not in other disciplines? How does this relate to the topics discussed in the module?

This edition also has sections called "salt and light" that highlight different scientists who are Christians, but most of them do not relate to the topic being discussed. In addition, there are times when specific scientists are named in the text, but they are not given a "salt and light" section, even when they are Christians. This makes no sense. If you are going to highlight scientists who are Christians, they should at least relate to the topic being discussed. The last "salt and light" section, for example, highlights someone who is not even a chemist (Dr. William Phillips). He is a physicist, and he has nothing to do with electrochemistry, which is the topic of the last module!

While I do not recommend this edition for any student, I recognize that some parents have already bought this new edition, and some will continue to buy it, as many consider their options limited. If you end up using this text, please look through the detailed list of all the issues I have found. If nothing else, please correct the errors. That way, your student's confusion will be reduced somewhat.

Detailed list of all issues that I found

Problems:

Student Text

1. On the back cover, there are three quotes praising the book. *None of them* are about this edition. They are about the previous editions. For the sake of honesty, that should be noted.
2. On page 5, the failure of the Mars Climate Orbiter is discussed. The text says, "One team of engineers had used metric units in its calculations, while another team had used English units in executing an engine burn." The term "executing" should be replaced with "calculating the effects of." The units weren't used in the engine burn. They were used in a program that calculated what would happen after the engine burn had been done.
3. On page 6, the text says, "In both the English and metric systems, time is measured in seconds. That is a good thing, isn't it? We know of only one way to measure time!" That's not true. There are many units we use to measure time, and most of them (such as minute, hour, day, month, and year) *are not metric*.
4. On pp. 15 and 16, the text uses an "x" for multiply. If nothing else, it should be the multiply symbol (×) so it is not confused for a variable (x). This happens throughout the text. In the previous edition, the "·" symbol is used for multiplication, which is standard in most texts.
5. On page 47, Experiment 2.1, the student is asked to hypothesize the answer to a question for the experiment. However, the student has already been told the answer, so there is no hypothesizing going on.
6. On page 59, Dalton is referred to as the father of modern chemistry. That title is usually given to Robert Boyle (indeed, the book gives him that title as well on page 387) or Antoine Laurent Lavoisier. Dalton is generally referred to as the father of modern atomic theory.
7. On page 64, Experiment 2.2, the student is given the hypothesis. The other experiments have asked the student to come up with one.
8. On page 86, Figure 3.3 is wrong in two ways: (1) Magnets do not have a positive and negative side. They have a north and south pole. *The poles of a magnet do not behave like charges*! A magnet, for example, can only exert a force on moving charges. It cannot exert a force on stationary charges. If its poles were like charges it would be able to do that. (2) If the experiment were set up this way, the beam would not bend down, as shown in the figure. It would bend out of the paper or into the paper. A horseshoe magnet has a straight magnetic field between its poles, so in this figure, the magnetic field is up or down. The beam is moving from right to left. When a magnet exerts a force on a moving charge, the force is *perpendicular to both the magnetic field and the motion of the charge* ($\mathbf{F} = \mathbf{v} \times \mathbf{B}$, where **F, v,** and **B** are vectors). The direction of the force is determined by the right-hand rule, something all physics majors learn at university. Based on the right-hand rule, the beam will move out of or into the paper, depending on which of the magnet's poles is north.
9. On page 102, the biography of Morley is wrong in three ways. (1) Morley didn't help Michelson measure the speed of light. Michelson did that in 1879, and Morley's collaboration with Michelson didn't start until sometime after 1881, most likely 1885. What Morley did with Michelson was to construct a better interferometer to see if the earth's motion affected the speed of light. That's the famous Michelson-Morley experiment, and it did not involve measuring the speed of light. It involved measuring interference in light

beams going different directions. (2) The text claims that the speed of light measurement was important for Einstein. That's not true. The fact that the light beams' interference didn't change indicated there is no ether (or the ether is at rest in earth's frame of reference), and *that's* what caused Einstein to develop special relativity. (3) The text says Michelson was an atheist. Historians routinely refer to him as an agnostic (see John D. Barrow, *The Book of Nothing: Vacuums, Voids, and the Latest Ideas About the Origins of the Universe*, Random House Digital, Inc. 2002, p. 136)

10. On page 109, Experiment 3.2, the hypothesis instruction is not related to the experiment. The instruction reads, "Write down your hypothesis about what will happen to our eyes if we stare at one color for 60 seconds." In the experiment, you stare at a red object for 60 seconds and then quickly remove the object, replacing it with blank, white paper. Afterwards, you report what you see. The instruction should read, "Write down your hypothesis about what will happen *to what we see* if we stare at one color for 60 seconds *and then replace the object with a blank, white sheet of paper*."
11. On page 132, the statement "everything visible and invisible in our universe is created from the elements it [the periodic table] displays." is wrong. Light is not made up of elements. Some light is visible, and some is invisible.
12. On page 143, the discussion keeps talking about ionic compounds that contain a *transition metal*, but the example is tin, which is not a transition metal. In the same way Table 4.2 on page 144 contains tin and lead, neither of which are transition metals. However, the text below talks about them as if they are transition metals.
13. On page 147, Example 4.4 asks "Which element has the highest ionization energy." The answer given is, "Because ionization energy increases from left to right and decreases from top to bottom, fluorine has the highest ionization energy." This is false. The ionization energy of helium is 24.6 eV, and the ionization energy of neon is 21.6 eV. These are both higher than fluorine's ionization energy, which is 17.4 eV. This, of course, makes sense, given the trend the text cites (The element farthest to the right and highest on the table is helium, not fluorine, and neon is to the right of fluorine). This is a problem because it equates ionization energy with electronegativity. Fluorine has the highest *electronegativity*, because it "wants" electrons more than any other atom. Many students (and some teachers) think electronegativity and ionization energy are essentially the same (the atoms that "want" electrons the most will hold on to their electrons the tightest). However, the noble gases (like helium and neon) don't "want" any more electrons, but they hold very tightly to the electrons they have, because they have the ideal electron configuration and therefore don't want any changes in their electrons.
14. On pages 153 and 154, the text discusses how to build Lewis structures. The text teaches a five-step method for making Lewis structures, which is different from how the second edition teaches it. However, in the example that follows (Example 4.5), those steps aren't used. The example uses the method from the second edition, even though that method isn't discussed. Then, the solution to the "On Your Own" (OYO) problem 4.12 uses the five-step method discussed in this edition. This problem is further compounded on pp. 156-157, where the text discusses how to make Lewis structures with double and triple bonds. There, it is explained using the method from the second edition. However, in the example that follows (Example 4.6) and the OYO problems (4.13 and 4.14), the five-step method taught in this edition is used to solve the problems. The practice problems, extra practice problems, and quarterly test are solved using the method from the second edition (the test

doesn't have worked-out solutions for Lewis structures). Nowhere is it mentioned that two different methods are being used. The text just switches between the methods. This will be very confusing for students!

15. On page 159, the top illustration is wrong. It should have a double bond between one of the O's and the C. Whichever O has the double bond should have one less lone electron pair.
16. On page 159, the next-to-last illustration is also wrong. There should be a third lone electron pair on the nitrogen. It also looks like the solution is missing an illustration. Most likely, the next illustration should have a double bond between the C and N, and two lone pairs still on the N. Then, the illustration that is currently the last one should be under the text that it is currently above.
17. On pages 191-195 and 201-204, the text discusses identifying polar bonds with an arrow that indicates where the charge goes. In the second edition, the bonds became the arrows. In the new edition, the arrow is added in addition to the bonds. This is done in many chemistry books, so that's not the problem. The problem is that when the arrow is added in that way in other chemistry texts, it is drawn far from the bonds and usually stretches from the center of one atom to the center of the other atom. That way, it is clear the arrow is not a part of the bonds. In this book, the arrow looks like it is a bond. As a result, single bonds look like double bonds, and double bonds look like triple bonds. That's pretty confusing.
18. On page 196, Experiment 5.2, the student is asked to hypothesize about "the solubility of polar and nonpolar covalent compounds in this experiment." However, the student doesn't know that vegetable oil (which is part of the experiment) is nonpolar.
19. In the practice problems for Module 5 (p. 206), #3 uses the term "aqueous," which has not been introduced yet. It will be introduced on page 223 of the text. This is because the new edition has a different order for certain topics. In the second edition, the term was introduced before the student reached this question. In this edition, it is not introduced until after the student reaches this question.
20. On page 207, the text says, "We also learned about what molecules look like, how they are shaped, and their tendencies (periodic properties)." The text did not discuss periodic properties of *molecules*. It discussed periodic properties of *elements*.
21. On page 209, Experiment 6.1 begins. It is very hard to find toilet bowl cleaner that doesn't cling to the bowl anymore, and that's really what needs to be used here. A clinging bowl cleaner will work, but will make the egg really hard to see. This is an example of an experiment that *should* have been updated in a new edition, but it wasn't. Also, the experiment asks the students to make an hypothesis about whether chemical changes and physical changes can be reversed, but the text gave them the answer before the experiment!
22. On page 214, OYO 6.2 asks whether cubes of frozen alcohol will float or sink in liquid alcohol. The answer has to do with density, but density isn't discussed until three pages later. This is once again due to the fact that topics were rearranged between the editions.
23. On page 214, George Stokes is introduced as someone who "laid foundations in the field of fluids." There is no "field of fluids." Perhaps the text meant, "study of fluids." However, that wouldn't be accurate, either, as Stokes made important contributions to the field of *fluid dynamics*. The text should really say something like, "laid foundations for the study of how fluids move." Also, he is introduced when the text is talking about solids and liquids, but a fluid can be a liquid or a gas.
24. On page 215, Figure 6.2 is introduced this way: "Whether we are talking about the solid phase, liquid phase, or gas phase, the molecules that make up matter are in some kind of

random motion. Figure 6.2 illustrates this concept." The problem is that the figure doesn't illustrate any motion at all! The captions mention the motion, but it is not illustrated in the figure. In the second edition, the motion was illustrated.

25. On page 216, Experiment 6.3 asks the students to make a hypothesis about molecules moving faster at higher temperatures. Once again, the students have already been told that molecules move faster at higher temperatures.
26. On page 229, the student has just learned to determine whether or not an equation is balanced. In OYO 6.8, the student is asked to determine whether or not an equation is balanced. The equation includes chemical formulae with parentheses in them. Unfortunately, the student is not taught how to deal with such formulae in balancing equations. The solution to the problem gives no mention of how to do it. It just plows through the problem without indicating how to deal with the parentheses. To compound the error, that solution is wrong! It says there are 18 + 9 = 27 O's on the reactants side, when in fact, if you use the parentheses correctly, there are 18 + 12 = 30 O's on the reactants side. In the practice problems, another such equation is given. Once again, there is no explanation of how to use chemical formulae with parentheses in a balancing a chemical equation. Then, *two modules later*, Example 8.1 has an equation that uses chemical formulae with parentheses, and there is a long explanation as to how to use the parentheses when balancing the equation. It also tells the student that he has to get used to such notation, because he will see it again. Students will have to read Example 8.1 *before* doing OYO problem 6.8 and the practice problems for Module #6 so as to understand the process.
27. Starting at the end of page 249, the text states, "There are many combustion reactions in chemistry that don't release heat or light." I can't say for sure that there are no such reactions, but none come to mind. Since combustion occurs spontaneously because the products are lower in energy than the reactants, how is the heat of combustion released if not in heat or light? Sound is an alternate way energy can be released, but I don't know of any reaction that releases *all* of its energy as sound! Later on, the text gives the example of rusting for a combustion reaction that doesn't "release heat and light in the form of flame." That's true, but it still releases heat. Perhaps that's what the text meant to say on page 249 – there are combustion reactions that don't produce heat and light *in the form of a flame*.
28. Near the top of page 250, the text says, "As long as oxygen gas is a reactant, the reaction can be classified as a combustion reaction." That is not anywhere close to true. Consider the formation reaction of $CaCO_3$ ($2Ca + 2C + 3O_2 \rightarrow 2CaCO_3$) It has oxygen as a reactant, but it is not a combustion reaction in any sense of the word.
29. On page 255, a biography of William Prout is given. The book says, "These whole numbers would be integer multiples of the smallest atom, which he called protyle but we now know as the hydrogen atom." That's not correct. Lavoisier named hydrogen gas six years before Prout's birth (Ebbe Almqvist, *History of Industrial Gases*, Kluwer Academic/Plenum 2003, p. 21). Prout knew the name for hydrogen. He said that hydrogen is composed a single fundamental particle, and he called *that fundamental particle* the protyle. It is where we get the name "proton."
30. On page 274, #10 is written too vaguely. It simply asks how an equation can be interpreted. The answers it wants are in terms of atoms and moles. However, there are lots of ways the equation can be interpreted, including in terms of dozens or couples. Any collective noun would work. You can also interpret it as both a combustion reaction and an oxidation/reduction reaction.

31. On page 277, a biography of Charles Stine is given. It has nothing to do with the topic at hand. However, it does have a Christian quote by him, which is why it is included. The bio says he "produced a more stable explosive than dynamite." This is not true. What he did was use sodium sulfite as a purifying agent in the production of TNT, and that produced a more stable form *of* dynamite.
32. On page 317, a bio of van Helmont is given. At least he relates to the topic at hand, since he did a lot with acid/base chemistry. However, the text says, "he found that salts neutralize acids." That's not true. He found that the vast majority of salts don't affect acids at all. However, one specific group, known as *alkali salts*, does neutralize acids. The text also says that this explains "why the stomach contains an acid for digestion but the bowels contain bases that neutralize digestive juices." This is also wrong. First, van Helmont only *postulated* that stomach acid must be neutralized. He suggested the gall bladder produced something that did that, but he was wrong. Second, the bowels *do not* contain bases. The pancreas secretes a single base (the bicarbonate ion) to neutralize the stomach acid.
33. On page 327, a "quick" way of balancing acid/base reactions is given. This method generally works, but when the acid is diprotic and the base has three OH^- ions (or the acid is triprotic and the base has two OH^- ions), it doesn't. This should be mentioned, because in OYO 9.4c, the latter kind of situation is given. The solution doesn't mention that the "quick" way for balancing won't work. Instead, it just gives the balanced equation.
34. On pp. 353-354, the text uses the phrase "purely covalent," which is not defined. This is because the second edition used that term, but the third edition changed it to "nonpolar covalent" in previous modules. That's fine; however, they didn't change the term here, so the student is faced with a term he or she has no knowledge of.
35. On page 357, the hypothesis instruction is very vague. "The solution will cool when it is put in the freezer" would be consistent with the instructions, but it is not the kind of hypothesis that has any merit. Also, the hypothesis that is really desired (that solubility decreases with decreasing temperature for solid solutes) has already been given away by Figure 10.6, which really appears too early. It should be put after the experiment, not before.
36. On the top of page 368, the student is asked to remember that the freezing point of water is 0.00 C and a thoroughly-mixed solution of ice water is at 0.00 C. However, because the third edition rearranged the topics, that hasn't been covered yet. It won't be covered for two more modules in this text. Most students will have a hard time believing the statement that a thoroughly-mixed solution of ice water is always at 0.00 C, because they think the amount of ice determines the temperature. That's why there is an experiment to help them understand it. In this edition, that experiment and explanation is two modules after this statement has been made.
37. On page 376, the solution for 10.5 is in need of serious revision. You could consider this a typographical error, but it makes the solution so confusing that I consider it a problem. The numbers in the problem were change from the second edition, but not all of the solution was changed. So, the first two equations in the solution are correct for this edition. However, the next equation is for the solution to the second-edition problem, so it is incorrect for this edition. The last equation of the solution is incorrect, regardless of which edition's numbers you use. It has the wrong denominator in the second fraction. It has "2 moles NaOH", but using the second-edition numbers, it should be "6.5 moles NaOH." Using third-edition numbers, it should be "8.10 moles NaOH." Nevertheless, the answer is correct. So the

proper numbers were used to get the answer, but they were not used in the last two equations.

38. On page 385, Figure 11.2 is wrong. It shows a mass exerting pressure on a piston, and the pressure is supposed to get larger in each section of the figure, leading to a smaller volume for the gas inside the piston. However, the representation of the mass is the same for each section of the figure. That means the pressure is the same for each section. Thus, the volume should be the same as well, but it is not. For the figure to be accurate, the mass should be larger as the volume gets smaller. This is the way the figure is discussed in the text, which mentions the mass getting larger, even though it does not in the figure. This error becomes more important because on page 388, the discussion specifically mentions the size of the mass in another figure (Figure 11.4) and says for that figure, "…the pressure is constant because the size of the mass on the top of the piston is the same."
39. On page 386, Figure 11.3 is titled, "Volume Affects Pressure." However, there is nothing in the figure that indicates this. It is simply a picture of two gas tanks. There are pressure gauges on the tanks, but you can't read them. Also, it is not clear which tank has more volume. The one on the left is shorter than the one on the right, but it is also wider. There is no discussion of the figure in the text.
40. On page 387, a bio of Robert Boyle is given. It does relate to the topic at hand, so that's good. However, it says he demonstrated the existence of a vacuum, which is not true. Torricelli did that. Boyle repeated Torricelli's experiments after learning about them and then eventually had a vacuum pump made based on a report about Otto von Guericke's famous Magdeburg hemispheres experiment. This brings up another error. The text says that Boyle invented an ingenious vacuum pump. However, the pump was not his design. His assistant, Robert Hooke did the work. There is still another error in the bio. The text says he wrote *The Wisdom of God as Manifested in the Works of Creation*. That's not his book. That's John Ray's book, and it is very important, because John Ray was one of the great "parson naturalists" from this time period. Unlike Boyle, Ray thought that working as a paid minister gave his scientific writing greater impact.
41. On page 390, the text discusses extrapolation. It then says, "Whether you realize it or not, you use the process of extrapolation all of the time." The second edition gives an example, so the students actually see how they extrapolate in real life. This edition just ends the discussion with that statement – no example.
42. On page 391, the combined gas law is given as $\frac{P_1V_1}{P_1T_1}=\frac{P_2V_2}{P_2T_2}$. That is wrong! It should be $\frac{P_1V_1}{T_1}=\frac{P_2V_2}{T_2}$. While this is just a typographical error, it ends up causing confusion, because the student doesn't see the correct form of the equation until the example problems that start using it. Those examples don't appear until after a full page of discussion about the nature of the equation!
43. On page 403, Experiment 11.1 has the student measure the value for the ideal gas constant. This is a common high school experiment, but it won't work with the lab kit that comes with this course. According to the introduction to the text, the kit has two 50.0-mL graduated cylinders, but the instructions tell them to release 80-90 mL of gas. They can't measure that with the cylinders in the kit. If the introduction is wrong, and they have at least a 100.0-mL graduated cylinder, the lab still won't work, because they have to measure the mass of the gas released. At room temperature and standard atmospheric pressure, 90 mL of butane has

a mass of about 0.2 grams. The scale they have is a normal food scale which, at best, has a precision of 2 grams. There is simply no way they can measure that mass, so they can't do this experiment. The sample calculations provided in the Solutions and Tests Guide (pp. 204-205) actually show this, as they use a mass of 0.3 grams.

44. On page 414, near the top, the text says, "The mole fractions don't add up to exactly 1 because of significant figures." However, in this problem, they do add up to exactly 1.
45. On page 421, a bio of James Joule is given. This is good, because it actually relates to the topic being discussed. However, the text says, "James Prescott Joule (1818 – 1889) was an English scientist whose work in the study of heat of was not accepted until Lord Kelvin asked to work with him. Why was his work not accepted? It was due to his social class as a son of a common man who was a brewer." This is incorrect. Kelvin did not start working with Joule until 1852. However, in 1849, Joule read a paper to the Royal Society, and *Michael Faraday* was his sponsor. In 1850 (a full two years before he started working with Kelvin), he was elected to the Royal Society, which means he was considered an important voice in science by then. It is true that Kelvin was an enthusiastic supporter (and was probably the first to push for him to be heard), but it was Faraday who actually gave Joule the gravitas to present his paper to the Royal Society, and this was all before Joule started working with Kelvin. (N.C. Datta, *The Story of Chemistry*, Universities Press 2005, pp.228-229) Also, it wasn't the fact that he was a brewer's son that initially caused the Royal Society to dismiss him (the Royal Society would have had no idea who his father was). It was where he lived. When discussing why the Royal Society panned his first paper, Joule said, "I could imagine those gentlemen in London sitting round a table and saying to each other, 'What good can come out of a town where they dine in the middle of the day?'" (D. S. Cardwell, *James Joule: A Biography*, Manchester University Press 1989, p. 41)
46. On page 433, the text says, "Is there an instrument that will allow us to measure specific heat? Unfortunately, there is no such instrument!" This is not true. There are instruments designed to measure specific heat. They use the "light flash method," which has been around since 1961. Here is an example: http://thermophysical.tainstruments.com/instruments/flash-diffusivity-systems/
47. On page 471, Figure 13.3 is entitled "Entropy," and it shows two pictures. On the left is a nicely-arranged vegetable market, and on the right is a street with boxes and trash strewn everywhere. There are no captions, so the student has no idea what they are supposed to represent. The left picture is a low entropy situation, while the right picture is a high entropy situation. The text should indicate that somewhere, but it does not. Instead, the discussion in the text revolves around a vase that is broken, which has nothing to do with the figure.
48. On pages 485-486, there are problems with the graphs presented as answers to OYO 13.8. First, reaction A is supposed to be hard to start. This means it must have a large hump in its energy diagram to represent a large activation energy. It is also very hot, so the products must be much lower in energy than the reactants. Reaction B is supposed to be easy to start, so its hump should be smaller than the hump in the graph for A. Also, it only gets slightly warm, so the products should be lower in energy than the reactants, but not by much. In the answers, the *same graph* is given for both! Reaction C is supposed to get slightly cold, so it is an endothermic reaction. However, the graph given as the answer is for an *exothermic* reaction. Reaction D is supposed to be easy to start, but its answer has a hump even higher than the hump in the graph for A, which means it is *harder* to start than reaction A. In

addition, the difference in energy between the products and reactants should be small, but it is about as large as the difference for Reaction A. Finally, the graph for reaction D is very blurry.

49. On page 492, the text gives some questions and then says, "These are some of the questions we'll find answers to in this module." However, one of the questions is, "Will a chemical reaction need something to start it?" That question is not answered in this module. It was answered in the previous module.
50. On page 498, the text says that the problem with using the equation $R = \frac{\Delta\,[\text{product}]}{\Delta t}$ is that the equation is "…good only for the time that was in the denominator." There are two problems with that statement. First, the denominator doesn't have a specific time. It has a *change in time*. To make the statement correct, it should read, "good only as an average over the time interval for which Δt was calculated." Second (and more importantly), the equation they then present for calculating rate: $R = k[A]^x[B]^y$ *is also good only for the time at which the concentrations are measured.* At the very next instant in time, the concentrations will change, so the rate will change as well. So this equation has no superiority over the first equation when it comes to how it changes with time!
51. On page 514, Figure 14.4 tries to illustrate how a catalyst changes activation energy (the hump on a reaction's energy diagram). It shows two energy diagrams, one with no catalyst, and one with a catalyst. There are at least three problems with the figure. First, because the artist wanted to do the illustration in 3-D (even though the student hasn't seen any 3-D versions of those diagrams), you can't really tell which diagram has the lower hump. The hump on the one with the catalyst needs to be visibly lower to indicate what the catalyst does. That can't be determined by looking at the figure. Second, the diagrams are backwards. Reactants are supposed to be on the left, and products are supposed to be on the right. In this figure, products are on the left, and reactants are on the right. Finally, the discussion that follows (which comes from the second edition) says the catalyst provides a "shortcut" for the reactants. However, there is no "shortcut" in the figure. Why the discrepancy? Because the figure in the second edition shows a single energy diagram and then shows the catalyst allowing the reactants to "tunnel" through the activation energy hump instead of going over it. That's the shortcut. However, the new edition's figure doesn't use the "tunnel," so there is no shortcut.
52. On pages 550-551, the pH discussion and its accompanying figure (Figure 15.4) have at least five problems. First, the text says the pH scale goes from 0 to 14. There is no mention anywhere in the text about negative pH. However, the figure has the pH scale going from -5 to 14. Second, a pH lower than -1.8 is not really possible, at least not the way pH is discussed in the text. That's because the pH scale as discussed in the text is defined as $pH = -\log[H_3O^+]$. Water has a density of about 1,000 g/liter. That means the concentration of pure water is about 56 M. If you could turn all the H_2O's in a sample of pure water into H_3O^+ (which is impossible), the pH would be -1.7. That's the lowest pH can really be, at least the pH scale that deals with H^+ and OH^-, which is how the text discusses it. Third, there is a reason that every chemistry book of which I am aware has the pH scale going from 0 to 14: You can't measure negative pH with standard lab equipment. Current pH probes suffer from "acid error," which causes them to read low pH's too high. In the end, a standard pH probe cannot read a negative pH. Fourth, if you are going to talk about pH's that go beyond the standard values of 0 – 14, why wouldn't you talk about pH's above 14? After all, a saturated solution of NaOH has a pH of about 15. Why wouldn't you include

that as well? Fifth, the figure has "SUPERACIDS" at the negative side of the pH scale and "SUPERBASES" at the side that ends at 14. However, superacids and superbases are not properly judged on the pH scale. They are judged with the Hammett acidity function. This is because superacids and superbases cannot be used in aqueous solutions, which is what the pH scale as discussed in the text is based on.

53. On page 550, the text reads, "Having a scale of 0 to 14 is a lot easier to work with than a range of actual concentration of 1 to 10^{-14} (100 to 10^{-14})." There are no units, but there should be; they should be Molarity. Also, there is no way to tell what they mean by the parenthetical statement. How does 1 to 10^{-14} relate to 100 to 10^{-14}?
54. On page 562, OYO 16.1c asks for the oxidation number of P in the molecule P_2O_5. However, the only way the student has been taught to determine that is if the oxidation number of the other atom in the molecule is given. The student is not given the oxidation number of O, so at this point in the module, he or she has no way to answer this question. In the second edition, OYO 16.1c asked for the oxidation number of N in NO_3^-, and then told the student "(In this compound, O's oxidation number is -2.)" This edition should include the same statement in OYO 16.1c.
55. On page 577, Experiment 16.2 (a new experiment for this edition) requires an LED. However, it isn't a part of the kit (at least not the kit described in the introduction). Parents should be at least told where to get an LED. Better yet, it should be part of the kit. In addition, the experiment uses pennies and nails, but the illustration that goes with the experiment does not have pennies and nails. It has copper and zinc strips.
56. There are several problems with the index. For example, "purely covalent molecule" refers you to pp. 347-349, where the term is not used. The entry for "corrosion" sends you to pp.581-582, but the term is used only on p. 582. In addition, there are lots of entries that should be in the index but aren't. For example, none of the scientists whose bios appear in the text are in the index. The term "nonpolar" is not found in the index, even though it is the new term this edition uses for "purely covalent."

Solutions Manual

1. On page 34, the answer to problem 2 should be the Law of Definite proportions. The Law of Multiple Proportions says that when two elements combine to form different compounds, the ratio of masses of the second element that react with a fixed mass of the first element is a simple, whole number ratio. The Law of Definite proportions says that if the proportions are different, the elements form a different compound. The latter is what the question asks.
2. On page 50, the answer to 8 should be "True." The question is, "True or False: All atoms have an equal number of protons and electrons." The solution says "False. All atoms *do not* have an equal number of protons and electrons. Atoms with charge will have a different number of electrons than protons." However, atoms with charge are not called atoms. They are called *ions*. Also, the second centered, blue statement on page 90 of the student text says, "All atoms have an equal number of electrons and protons."
3. On page 51, the answer to 12 should be "none of the above." The question asks what Rutherford's experiment proved. First, experiments can't prove anything. Second, the solution says the answer is "protons existed as part of the atom." However, Rutherford's experiment didn't show that. The fact that protons existed in the atom was already well known before his experiment. The experiment showed that the protons were not evenly

spread out, as was assumed in the Plum Pudding Model. Instead, they are concentrated at a single point in the atom.

4. On page 51, the answer to 16 should be "not enough information." The question asks, "Which light has the greatest amplitude? The possible answers are (a) Blue (b) Yellow (c) They are both the same. (d) Not enough information to answer this question." The solution says the answer is (c), but without being told about the brightness, there is no way to know about the relative amplitude. A dim yellow light has a lower amplitude than a bright blue light.
5. On page 93, #15 (also the pullout test for Module 5), the question uses the term "aqueous," which has not been introduced yet. This is because they changed the order of certain topics for this edition. In the second edition, the term was introduced before the students reached this question.
6. On page 109, #6 (also the pullout test for Module 6), the question asks about photosynthesis, which hasn't been discussed yet. Nevertheless, the student needs to know that it is a chemical change. This could be partially alleviated with an explanation of what photosynthesis is in the solution (p. 111), but unfortunately, the "explanation" is simply, "Photosynthesis is a chemical change."
7. On page 112, the answer for #17 is wrong. The properly balanced equation is:
   $2C_9H_{20}O + 27O_2 \rightarrow 18CO_2 + 20H_2O$
   The bigger problem is that the technique needed to balance the equation (using fractions and then multiplying through by the lowest common denominator) isn't taught until the next module!
8. On page 116, the answer for #3 is wrong, as well as parts of the solution. In the third equation down should not have a "2" in front of C_8H_{18}. It should also not be there in the next equation (the fourth equation down). It *should* be there in the next equation (the fifth equation down), but it isn't!
9. On page 145, #9 (also the pullout test for Module 8), the problem should state that H_2S and O_2 are in excess. Otherwise, there is no guarantee that the given amount represents the limiting reactant.
10. On page 181, #3 is wrong. The question asks about the solvent, but the answer discusses the solute. The answer should be "It does matter what the solvent is. The same solute will dissolve differently in different solvents."
11. On page 192, #9 (also the pullout test for Module 10), the problem is not fair. The student hasn't been taught how temperature affects the solubility of a solute that dissolves endothermically.
12. On pages 204-205, the sample calculations for Experiment 11.1 are given. The students can't do this experiment with the equipment they have, but if they got a scale with the necessary precision, the sample calculation is wrong because it doesn't take into account the vapor pressure of water, which was the focus of pages 396-399 in the student text! The student needs to find the vapor pressure of water at the temperature of the experiment and subtract it from the atmospheric pressure. This is done in the sample calculations for Experiment 11.2.
13. On page 204, the answer to #10 is wrong. The third equation should us 97.1 moles, so the answer should be 4.1×10^3 L.
14. On page 212, #4 (also the pullout test for Module 11), there are two valid answers, but the test only allows for one. The question asks, "Which of the following describes Charles's

Law?" The first answer, "a. T/V = constant" expresses Charles's Law. After all, Charles's Law is V/T = constant. If V/T is constant, then T/V is also constant. The other valid answer is the one given in the solution: "b. As long as pressure is constant, temperature and volume are linearly proportional to each other."

15. On page 212, #5 (also the pullout test for Module 11), the student is asked, "What does -273.15 ℃ represent?" He is supposed to choose "all of the above," but the last one on the list is "d. The temperature at which all atoms stop moving." The student hasn't been told anything about the motion of atoms at absolute zero, so he or she has no way to know whether or not this is related to -273.15 ℃.
16. On page 213, #7 (also the pullout test for Module 11), the solutions says the answer is "none of the above." That's not correct. The question asks, "Which of the following are properties of an ideal gas. One of the answers, "c. The molecules are always exchanging energy with one another when they collide," is correct. Every collision is elastic, which just means the *total* energy doesn't change. However, the individual energies of each molecule in the collision do change. Thus, the molecules do exchange energy with one another.
17. On page 236, #9 (also the pullout test for Module 12), the question asks which statement is *not* true about calorimetry. The answer the text wants is, "c. The temperature change of the water and the object will be equal." However, there are two other answers that are not true. The answer, "b. An object of known temperature is dropped into the calorimeter" is not true in all cases, because you can measure initial temperature with a calorimeter. If you do that, the temperature is not known. Also, sometimes you don't drop an object in a calorimeter. Sometimes, you run an reaction in it to measure the heat absorbed or released in the reaction. In addition, "d. The heat absorbed by the water is equal to the heat released by the object" is not correct, because the calorimeter also absorbs heat.
18. On page 238, the student is told, "Styrofoam is a good insulator because it has a <u>high</u> heat capacity." This is not true. It is a good insulator because it is a poor conductor of heat. Water has a high heat capacity, but it is not a good insulator.
19. On pp. 242-243, #7 (also the pullout test for quarter 3), the question asks which statement is not true for an ideal gas. The answer the text wants is "e. The temperature must be at 273 K for a gas to behave ideally. However, the answer, "d. The pressure must be at or lower than 760 torr for a gas to behave ideally" is also not true. This is just a rule of thumb. A gas that behaves ideally at 760 torr will also behave ideally at 770 torr, but answer (d) doesn't allow for that.
20. On page 259, the answers are both incorrect. For ΔH, the text says, "ΔH = 1200 kJ – 200 kJ = 1000 kJ," when it should be "ΔH = 200 kJ – 1200 kJ = -1000 kJ." For activation energy, the text says it should be the energy of the intermediate state minus the energy of the reactants (which is correct), but then it uses the energy of the intermediate state and subtracts the energy of the products. Thus, while it says the activation energy is "1500 – 200 = 1300 kJ," it should be "1500 kJ – 1200 kJ = 300 kJ."
21. On page 290, the solution to #9 is wrong. The question gives three solutions and their pH's and asks which is made from the acid with the lowest ionization constant. The answer says, "All of these solutions are acids, so we are really just asking which acid is the weakest acid…" However, the third solution in the problem has a pH of 11. It is not an acid. It is a base. This leads to the wrong answer. The proper answer is solution B, since it has the highest *acidic* pH.

<u>Odd things that don't make sense</u>:

Student Text

1. On page 35, the idea that people once thought maggots came from rotting meat is discussed. In that discussion, nothing is mentioned to indicate that this is wrong. In fact, experiments are discussed to indicate it seems correct. The student has to read the next section, which is in a different font size and color, to learn that the idea is wrong. Why wouldn't the text state that this is wrong in the section the student is currently reading?
2. On page 44, the text says, "Adam was permitted to name things created by God. We continue to exercise that honor in science." What does this mean? Who else would "exercise that honor"? Animals? Plants? Does this happen only in science? This is just a strained attempt to add more Christian material to a course that is already explicitly Christian.
3. On pp.162-163, the design of the ozone layer is discussed. The text of the chapter ends this way, "We must have ozone to protect us from the sun's ultraviolet rays, but we cannot breathe too much of it, or it will kill us. Seems like a contradiction, doesn't it. It would be, except the *Designer* of our planet is smarter than we are." That's it. That's the end. To see why it isn't a contradiction, you have to read the "science and creation" section, which is on the *previous* page in a different font and color. Why? The text in that section flows naturally from the text that ended the module. Why not just end the module with it rather than making it a separate section on the *previous* page?
4. On page 212, Experiment 6.2 has been changed from the previous edition. This change makes sense, since it can be hard to find a rectangular metal can, which is what the second edition required. However, they changed it to condensing steam in a milk jug. While the experiment does illustrate the concept, it is really wimpy. Apologia has a better one on their course website, where coke cans collapse almost instantly. Why wouldn't the text use that one? It gives a more dramatic effect.
5. On page 247, at the end of Example 7.1, the text says, "Notice the list of atoms for the reactants side and products side. This is a trick you can use to help you balance equations. It helps you make sure you have the same number of atoms of each type on both sides of the equation." But this is nothing new. In fact, *every* solution so far has been done with a list like that. Why is this not at the end of the first example that uses the method (Example 6.3)?
6. On pp. pp. 252-253, the book talks about incomplete combustion. In the second edition, the discussion of incomplete combustion numbered the chemical equations so they could be referred to easily. The new edition doesn't do that, so the equations are referred to as the "carbon monoxide product equation" and the "carbon product reaction." This is awkward, and some students won't understand it is a reference to the chemical equations that were previously shown. Why wouldn't the text use numbers for the equations? The text uses them in other modules.
7. Page 365 is a good example of why the "On Your Own" format is bad. They have the question squeezed into a ½-page box, forcing the chemical equation to take up three lines. This makes it very unreadable. The OYO problems should take up the entire width of the page, as they sometimes do in this edition (p. 332, for example). That way, they are not easily skipped and can be easily read.

8. On page 383, Pascal is mentioned, along with some of his accomplishments and his Christian faith. Why wouldn't this be a "salt and light" section? It actually relates to the discussion at hand.
9. On page 448, the text says, "You've learned, however, that energy is neither created nor destroyed. It only changes form. It's a fascinating fact about creation. 'Is there anything of which one can say, 'Look! This is something new?' It was here already, long ago; it was here before our time.' (Ecclesiastes 1:10. NIV)." The problem is, this doesn't relate to energy conservation in the least. The context of the chapter in Ecclesiastes is about repetition. The verse right before, for example, says, "What has been will be again, what has been done will be done again; there is nothing new under the sun." Energy conservation isn't about repetition. It is about a constant amount of energy in the universe. Also, energy conservation does not forbid energy changing form, which can produce new things.
10. On page 491, there is a cartoon from the second edition. However, it looks like this is the only one. The second edition had several cartoons. Why keep this one and not the others?
11. The final bio (page 582) is on William Phillips, who is not associated in any way with the topic being discussed. In fact, he isn't even a chemist. He is a physicist. However, he has some quotes about being a scientist and a Christian, which is why he is included. If you are going to include someone here, why not Michael Faraday? He was a committed Christian, has a lot of good quotes about Christianity, and is at least associated with electrochemistry, the topic of this module. If you want a modern scientist, why not a famous chemist, like Henry F. Schaefer III, who has done research in electrochemistry? Once again, he has a lot of good quotes about being a Christian and being a scientist, and at least he's a chemist who has done electrochemistry.

<u>Typographical Errors</u>:

Student Text

1. On page 10, the decimal "0.151 meter" is missing the zero.
2. On page 55, the line that starts "Amount of sodium used" and the next line are in a different font from the other text.
3. On page 56, the "5.9 g leftover chlorine" should be "5.0 g leftover chlorine"
4. On page 97, they are describing alpha particles passing through atoms. They say, "The closer it passes to the protons, its path will bend." It should read, "The closer it passes to the protons, the more its path will bend."
5. On page 155, the first set of text is centered. It should not be, in order to be consistent with the way all the other examples are formatted.
6. On page 156, on the third illustration down, the arrow showing how the red electron moves from one O to in between the two O's is missing.
7. Page 211, "condensing" should be in boldface type. There are many examples throughout the text where words that should be remembered are in blue but not boldfaced, while other words that should be remembered are both blue and boldface.
8. On page 249, the last section begins with, "The final type of reaction we want to discuss is called combustion reactions." The sentence should be, "The final type of reaction we want to discuss is called a combustion reaction."

9. On page 270, the solution to 7.3, it starts with the formation reaction for $KHCO_3$, which is not a part of problem 7.3. It gets on the right track with the next equation, though.
10. On page 272, #7.7, the equation ends with 1.1 moles Sc. It should be 1.11 moles Sc.
11. On page 275, #9, the word "molecules" should be replaced by "atoms"
12. On page 290, Example 8.6, the spacing is very tight in most of the explanation. It is quite different from other examples. This happens from time to time throughout the text.
13. On pages 293 and 294, we find an example of a common inconsistency in the text. For the first question in Example 8.7, the chemical equation is in boldface type, like the rest of the question. For the second question, the equation is not in boldface type. Throughout the text, sometimes the equation that is a part of an example question is bolded, sometimes it is not.
14. On page 325, the second equation needs a "+" between K^+ and H_2O.
15. On page 329 in Example 9.3, the second question ("What reaction occurs between $H_2Cr_2O_7$ and water?) need to be large and bold, like the first question.
16. On page 333, the spacing in Example 9.5 is too tight.
17. On page 344, the second equation in the solution to part (c) should have an equal sign where there is a minus sign.
18. On page 345, the third equation should have "10.0 L HNO_3" instead of "1 L HNO_3"
19. On page 350, there is an arrow that should be pointing from "sodium ions" to the red balls. Instead, it is pointing from nothing to the bottom of a green ball.
20. On page 371, the last equation should have "0.31 m", not "0.031 m"
21. On page 372, the text talks about the "myth" that adding salt to water makes it boil more quickly. This is not necessarily a myth. It depends on how the situation is constructed. The specific heat of saltwater is lower than the specific heat of water. Thus, if I have equal masses of pure water and saltwater, the saltwater will come to a boil more quickly, even though it has a higher boiling point, because it has a lower specific heat. The specific heat effect is more important, so the saltwater reaches its boiling point first. However, if I take equal masses of water and THEN add salt to one, the saltwater will come to a boil more slowly, because it has a higher boiling point and there is more mass to heat up.
22. On page 378, the solution to 10.8 ends with the wrong number of significant figures. Because you only know freezing point to the tenths place, the answer can only go to the tenths place, so it should be 9.3 °C.
23. On page 379, the solution to 10.10, there are too many significant figures in the mass of the solvent. The problem gives only two, so the mass should be 2.0 kg. This limits the molality and boiling point elevation to two significant figures.
24. On page 388, there is a thin, gray line on the right and bottom of the graph. It goes through the top of the x-axis labels.
25. On page 393, the answer to the fifth equation has its units (m^3) as a superscript. It should not be superscripted.
26. On page 398, the spacing in Example 11.2 is too tight.
27. On page 402, in the fourth equation, "P_2" should be "P_T".
28. On page 410, Equation 11.10 should have "X" capitalized.
29. On page 424, "experimental scatter" should be blue and in boldface type.
30. On page 435, the spacing in Example 12.2 is too tight.
31. On pages 436-437, the spacing in Example 12.3 is too tight.
32. On page 447, #5, the mass should be 3.40×10^2 grams.
33. On page 478, Equation 13.7 should start $\Delta G°$, not ΔGo.

34. On page 480, "Recognizing that the ΔGfo's" should be "Recognizing that the ΔG_f^o's"
35. On page 489, #5, "Na+ (aq)" should be "Na^+ (aq)"
36. On page 490, the mass in #4 should be 250.0 g to match the solution given in the Solutions and Tests guide.
37. On page 521, the "M" units for the second rate overlaps with the text on the next line.
38. On page 571, there are three illustrations. On the top one, the Cu^{2+} ions in the beaker on the left are labelled, but the "2+" is not a superscript in the label, as it should be. Also, the first illustration has an arrow labelled "water" pointing to the beaker on the right. However, at that point in the discussion, the beaker doesn't have water in it (the water is not in the illustration). That label should be moved down to the third illustration.
39. On page 575, two of the labels in the solution to the example are wrong. "Cu^{2+}" needs to be replaced with "Ag^+", and "Zn^{2+}" needs to be replaced with "Mg^{2+}".

Solutions Manual

1. On page 2, there should be a blank space between 9a and 9b.
2. On page 55, numbers 10 and 11, "potential" should be replaced with "energy." The second edition used the term "ionization potential," while this new edition uses "ionization energy." The term wasn't changed here.
3. There are several cases where a question has multiple-guess answers, but the solutions don't tell you the letters. They give the actual answers. An example is answer to #11 on page 75.
4. On page 84, #5 and #6, the illustrations are mixed up. The second illustration on the page should come after "6. To determine shapes, we must first drawn the Lewis structure:", not before it.
5. On page 86, part c, the arrows that show where the charge goes are now a part of the bonds. This is different from the others, where the arrow is drawn in addition to the bonds.
6. On page 112, #17, the first "O" is actually a zero (the answer is also wrong, as discussed in a previous section).
7. On page 116, #4, "An Sn atom" should read "An Ar atom"
8. On page 119, the cancelling bars on the second-to-last equation are strange – they jump down to the subscripts in the chemical formulae. This is the first time I noticed it, but it seems to be the way all of them are done.
9. On page 134, #2, the formula of tarnish is sometimes listed incorrectly as Ag_3S.
10. On page 168, #10, the volume should be 0.3451 L, not 0.345 L.
11. In general, the answer to a mathematical problem is put first, with the solution below. However, sometimes, it is not put first. Instead, it is put at the end of the solution. An example of the latter is #6 on page 185. Sometimes, it is put at *both* the beginning and the end, as happens in #7 of page 185.
12. On page 201, the sixth equation, the answer should be 0.044 moles SO_3. The overall answer to the problem is correct.
13. On page 224, the last line of #7 has the wrong answer. It should be 0.96, not 0.096. The initial answer given at the top of the problem is correct.
14. On page 225, the "J" in the units of the answer at the bottom of #8 goes into the line above.
15. On page 226, the unit "g" has a line through it in the answer at the bottom of #9 and at the top of #10. It should not have a line through it in either case.

16. On page 247, #9, the moles for O_2 should be 0.047, not 0.043. Also, the solution does not finish the problem. The mole fractions must be multiplied by the total pressure to get the partial pressures.
17. On page 251, #21, the answer to the second equation should have units “molal,” not “M.”
18. On page 254, #6, the ΔH for the second diagram (-30 kJ) is not given.
19. On page 257, the answer to #2 should be negative, not positive.
20. On page 258, #6, the second problem should be labelled “b”, not “c.”
21. On page 259, #9 starts with “(Add following, not in manuscript).” I assume that’s a note to the layout artist and shouldn’t be in there. There are also errors in the solution, as discussed in a previous section.
22. On page 266, #6 (also the pullout test for Module 13), “ΔHf” in answer (c) should be “ΔH_f”.
23. On page 270, the equation used in #13 should have “greater than” signs instead of equal signs.
24. On page 293, the numerator of the first equation in the solution for #5 should be “$[SO_3]^2$.”
25. On page 294, the first equation in #9 needs to have “H^+ (aq)” as the first product.
26. On page 294, the first equation in #10 needs to have “HPO_4^{2-} (aq)” as the first product.