Solutions to End-of-Chapter Questions

Chapter 1: About Science

1. An experiment.

2. Experiments are not very good at proving ideas right. They can be very useful, however, for proving ideas wrong.

3. Scientific research usually begins with the asking of a very broad question.

4. Powerful lasers.

5. There are 60 carbon atoms in the original buckyball identified by Kroto, Smalley, and Curl. Interestingly, they also discovered larger and smaller buckyballs, but C-60 was the most stable.

6. The research team led by Don Huffman of the University of Arizona and Wolfgang Kratschmer of the Max Planck Institute in Germany.

7. Technology is the application of knowledge of the natural world (usually gained through science) to practical purposes.

8.. The greatest obstacle to solving today’s problems lies more with social inertia than with a lack of technology.

9. No, medical X rays are used because the benefits of their diagnostic powers are judged to be greater than the risks of causing cancer.

10. Yes, when competent observers agree that it should.

11. A hypothesis.

12. A scientific theory.

13. Chemistry is often called the central science because it touches all of the sciences.

14. Basic research leads to a greater understanding of how the natural world works. Applied research focuses on developing applications of knowledge gained through basic research.

15. Members of the American Chemistry Council have pledged to manufacture their products without causing environmental damage.

16. The two major unit systems are the United States Customary System and the Système International.

17. A prefix is used in the metric system to designate a unit that is larger or smaller than a particular base unit by one or more powers of 10.

18. A milligram is equal to one thousandth of a gram.

19. As noted by Lavoisier, air has mass, which means that it also has weight. The weight of this air pushes against us in all directions. The force of this push at sea level is about 14 pounds for every square inch. So how does the card hold up the water in the bottle? Answer: It doesn’t. The downward push from the weight of the water in the bottle is less than a pound. The upward (and sideways) push against the outer side of the card from the weight of the air, however, is about 14 pounds. The air wins! Although invisible, air is real stuff. Because of this, birds and airplanes are able to fly. When turned sideways, the water flows out of the cup.

20. As you hold up the can, the water flows out through the hole because of gravity, which is a force that pulls things downward. When you release the can, gravity continues to do the same thing—it pulls the water downward, only this time it pulls the can down with it too. Because the can and the water are falling together, there is no reason for the water to flow out of the can.

For your further consideration: Does the same hold true when the hole is made not at the bottom of the can, but along the lower side? Try it and see.

21. A large risk/benefit ratio, such as 100, can be indicated as follows:

RISK/benefit = 100

This is a risky activity that you might choose to avoid. A small risk benefit ratio, such as 0.01, can be indicated as follows:

risk/BENEFIT = 0.01

This activity offers much benefit for only little risk and so may be worthwhile. Regarding the purchase of a lottery ticket, the chances of losing a small amount of money (the risk) far exceeds the chances of gaining a large amount of money (the benefit). The risk/benefit ratio, therefore, is quite large. However, if you ignore the probabilities, as many people do, then the risk benefit ratio appears deceptively small.

22. (25 ~~years~~)(12 ~~months~~/1 year) = 300 months

(25 ~~years~~)(365 days/1 ~~year~~) = 9,125 days

Or in a single equation form:

(25 ~~years~~)(12 ~~months~~/1 ~~year~~)(25 ~~years~~)(365 ~~days~~/1 ~~year~~) = 9,125 days

23. (2000 ~~years~~)(365 ~~days~~/1 ~~year~~)(24 ~~hours~~/1 ~~day~~)(60 ~~min~~/1 ~~hour~~)(60 sec/1 ~~min~~) = 63,072,000,000 seconds

24. b < c < a (The hypothesis may not be testable, which may make it less believable than a scientific hypothesis. The scientific hypothesis, however, may have yet to be tested, which would make it less believable than the scientific theory.)

25. a < c < b (Traveling by plane is generally much safer than traveling by car, especially over long distances. A teenager driving and talking on a cell phone is very dangerous.)

26. b < a < c (This assumes the quality of the generic medicine is equal to that of the brand name medicine and also that the herbal remedy does little to alleviate the sickness aside from a placebo effect.)

27. The explanations given by science are testable explanations of the natural world.

28. The idea of the Earth revolving around the Sun is the simplest explanation of what we observe. It helps to explain the seasons. It also helps to explain why we see different constellations of stars at different times of the year. We can chart the progress of other planets around the Sun and infer that perhaps we are like them and thus also revolve around the Sun. From these and other observations, we conclude that the Earth revolves around the Sun. Alternatively, we can trust others to make these observations and reach these conclusions for us. But do we trust their observations and conclusions? If these can be verified repeatedly by many different people working in many different laboratories, then the answer is "Yes, most likely."

29. The older, well-seasoned scientist tends to spend more time pondering broad questions and communicating with others. The younger, less-seasoned scientist tends to spend more time on the tedious detailed work, which includes a lot of time in the library learning about what has been published and in the laboratory working late at night trying to perform successful experiments.

30. The performing of experiments is typically, but not necessarily, the most involved and time-consuming, as well as money-consuming, activity.

31. A scientist can develop a hypothesis at any time no matter what she may be doing. She could be cooking at a barbeque when suddenly the idea pops into her head. Again, for emphasis, there is no one prescribed path to follow in order to hold to the scientific method.

32. Because of the great potential for error in a procedure, an experiment can only be considered valid if other scientists can reproduce it.

33. It is a sign of strength for a scientist to change his or her view when faced with evidence inconsistent with that view. Holding to hypotheses and theories that are either not testable or have been shown to be wrong is contrary to the spirit of science.

34. Any false claims are eventually uncovered. Scientists, therefore, stand to gain most from reporting their results truthfully.

35. Kroto, Curl, and Smalley were the initial discovers of this molecule and for this they received the Nobel Prize. Huffman and Kratschmer's work merely helped to confirm this discovery.

36. Technologies whose risks and benefits differ for different people tend to be hotly debated. An example would include the placement of a large, obtrusive, and noisy wind energy turbine within a neighbor's backyard—the neighbor gets the benefit of cheap electricity while you gain an eyesore. Also, should people be allowed to use cell phones while driving? While the cell phone user gains the benefit of a convenient phone call, others share the risk of a potential traffic accident.

37. During the 1950s nuclear arms race, there was great fear that "the other side" with its different ideological views would attack. The benefit of the nuclear bombs was their ability to deter either side from being eager to use them. The very real risk was obscured of placing a lot of radioactivity into the atmosphere. This radiation made its way into the food chain. The supply of milk, for example, was soon found to be tainted with radioactive strontium. Of course, hindsight is 20/20. It's easy for us to look back on this history and shake our heads. At the time, coming out of the tragedy of World War II, however, the perspective was quite different. Actual risk and our perceptions of that risk are difficult to gauge.

38. The urge to protect oneself or one's immediate family and friends is strong. Thus, the perception of risk gets amplified when that risk is striking close to home. A greater focus on the benefits should help to offset the skewed perceived risk. Sadly, as in the case of vaccinations, this focus is often not realized until after the many children who didn't receive the vaccine become sick. Also helpful would be to foster a trust between the developers of a technology (the vaccination) and the users of that technology (the general public).

39. Vaccinations prevent sickness and this is their benefit. While not sick, however, people tend to move on with their lives often taking their good health for granted. In such a case, the benefit of the vaccination becomes invisible and thus difficult to perceive. A vaccination program, however, must continue until the disease has been totally eradicated across the entire population. This is especially true in our modern society where people travel between different parts of the world so frequently.

40. A hypothesis must be testable, at least in principle, in order to be deemed scientific. The tests may suggest that the hypothesis is correct or incorrect. Either way, so long as some definitive tests can be designed, then the hypothesis is scientific: a, c, d, f

41. Science is unable to answer non-testable questions, such as those that are philosophical or religious in nature. Science can, however, generate ideas that have philosophical or religious implications.

42. If all the material that makes a tree comes from the surrounding soil, then one would expect the mass of that surrounding soil to get smaller as the tree grows larger. For an experiment, therefore, you could grow a tree within a pot adding only water to keep the growing tree alive. The dry mass of the soil before the tree grows is then compared to the dry mass of the soil after the tree has grown, as well as to the mass of the tree itself. The results will show that the dry mass before and after has not changed sufficiently to account for the much greater mass of the tree. Interestingly, through photosynthesis, the bulk of a tree's mass comes from the absorption atmospheric carbon dioxide and water vapor plus water also coming up from the roots. This explains why large trees are not generally found growing within sunken depressions.

43. A scientific theory that *can* be modified to account for new experimental evidence is a theory that is stronger than it was prior to that modification. However, if such modifications to a scientific theory are not possible, then that theory is taken to be wrong and is scrapped.

44. You exhale carbon dioxide, some of which is absorbed by trees and transformed (via photosynthesis) into wood, which is used to make paper.

45. Physics is the most fundamental science as it lays the foundation for chemistry, which is the study of the physics of the atom. Chemistry, in turn, lays the foundation for the most complex science, which is biology.

46. Biology is the study of life. A living organism is an example of the most complicated chemical system in the universe. In learning biology, you need to have a solid understanding of the many chemicals that are used to create life. One important topic is DNA, – which holds the genetic code for a living organism, which consumes and generates all sorts of biomolecules, such as carbohydrates, lipids, and proteins. Learn your chemistry first before the biology. Then you will be much better equipped to understand the supremely complicated details of biology.

47. For the United States, the major advantage of using the United States Customary system is that this system is already in use and familiar to everyone. Instituting a different measurement system would involve considerable disruption in many areas of life, including science, commerce, and industry.

48. The number of zeros in the decimal equivalent is equal to the numeral given in the superscript of the exponential form. For example, there are two zeros in 100, which can be expressed as 10^2. Note also that there are zero zeros in 1, which has the exponential form 10^0. 49. Making observations is an activity that occurs on a continual basis, even during the course of other activities. Remember, we humans are very good at observing. We do it all the time.

50. Many medicines are flushed down drains or toilets directly or after already having passed through the human body and into the urine. These drugs then end up in downstream water supplies. By the time they reach the downstream consumer their concentration is at a relatively low level. But this level is easily measured. Perhaps of greatest concern is the effect these low doses might have over the long term. Drinking a single glass of drug tainted water might not have a noticeable effect. But what if this water is consumed by an individual over his or her lifetime? Once released into the environment, these drug molecules are difficult to remove because they are so dilute. A solution would be a media campaign to discourage people from flushing pharmaceuticals. But would the cost of such a campaign be worth it? First, scientists might assess the degree to which harm is being caused. But is there enough preliminary evidence to support such a research endeavor? Might the money be better spent on other more immediately pressing environmental issues, such as the global climate? Where we place our money for research can be a very difficult decision.

Chapter 2: Particles of Matter

1. It would take you 31,800 years to count to a trillion. Do this 125 million times and you would have counted to about the number of atoms there are in a single grain of sand.

2. A biological cell is microscopic, which means it is best viewed through a microscope.

3. The term atom was derived from the Greek phrase *a tomos*, which means “not cut” or “that which is indivisible.”

4. Antoine Lavoisier

5. Mendeleev predicted the existence of elements that had not yet been discovered.

6. Mass is a measure of inertia. Inertia is the resistance an object has to a change in motion.

7. Weight can change from one location to the next because it is dependent on gravity.

8. Mass is the measure of how much matter an object contains. Volume is the amount of space that the material occupies.

9. Density is the ratio between the mass of a substance and its volume. As the mass of the substance increases, so does its volume. The ratio of the mass to volume, which is its density, remains the same.

10. The volume of a loaf of bread gets smaller as the loaf is squeezed. Its massremains the same. As the mass of the loaf gets compressed into a smaller volume, the overall density of the loaf then increases. Air is getting squeezed out of the loaf. The density of the solid foodstuff used to make the bread remains about the same.

11. The energy due to position is potential energy.

12. Kinetic energy is the energy of motion.

13. One calorie is 4.184 times greater than one joule.

14. The molecules in a hot cup of coffee are moving faster than in a cold cup.

15. The Kelvin scale places zero at the point of zero atomic and molecular motion.

16. Heat always travels from the warmer object to the cooler object.

17. The particles in a gas have so much energy that they overcome their attractions to each other and expand to fill all of the space available. In a liquid the particles move around one another. In a solid, the particles are fixed in a three-dimensional arrangement.

18. Freezing requires the removal of thermal energy.

19. When evaporation occurs beneath the surface of a liquid it is called boiling.

20. The pressure increases as more air is pumped into the tire.

21. The volume increases as the temperature increases.

22. Gases reach a theoretical minimum volume at absolute zero, which is –273.15°C on the Celsius scale and 0 K on the Kelvin scale.

23. The volume of a gas increases as more particles are added to it.

24. Real gases deviate from the ideal gas law because their particles are not infinitely small and because these particles may be attracted or repelled by one another.

25. No question asked.

26. The dye should become dispersed uniformly within the hot water first. At a higher the temperature, the average kinetic energy of the molecules is higher. Because the molecules within the hot water are moving faster, the effect on the dye of the Kool-aid crystals is quicker. Furthermore, the hot water will tend to have more convection currents that will also help to distribute the dye throughout the water.

27. No question asked.

28. To represent the liquid phase, simply shake the balloon very gently so that the beads still remain together but tumble over one another. To represent the solid phase, gently vibrate the balloon. Notice that in both these cases you are adding energy to the balloon. Holding the balloon still would represent absolute zero.

29. The volume of water that gets displaced by a submerged object only depends on the volume of the submerged object.

30. Mulitply by the conversion factor to arrive at the answer:

$$130 \text{ lb} \quad \frac{1 \text{ kg}}{2.205 \text{ lbs}} = 59.0 \text{ kg}$$

31. The mass does not change with gravity, so the mass is the same on the earth and the moon.32. Divide the mass by volume to arrive at the density:

$$\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{52.3 \text{ grams}}{4.16 \text{ mL}}$$ = 12.6 g/mLFrom Table 2.1, we see that this is substantially less than the accepted density of pure gold, which is 19.3 g/mL. This evidence indicates that the piece they were trying to sell you was not pure gold.

33. From Table 1.4, the density of gold is 19.3 g/mL. Use the following formula to find the volume of the sample: $V = \frac{M}{D} = \frac{\mathbf{52.3g}}{\mathbf{19.3\ g/mL}} = 2.71 \text{ mL}$

34. Multiply by the conversion factor to arrive at the answer:

230,000 calories 4.184 joule/1 calorie = 960,000 joules

35. There are zero mL of dirt in the hole, but

$$5 \text{ L} \quad \frac{1000 \text{ mL}}{1 \text{ L}} = 5000 \text{ mL of air.}$$

36. Multiply the pressure of each tire by its surface area of contact to find the weight placed downward on each tire. Since there are four tires, multiply by four to arrive at the total weight of your car.

Weight upon each tire

(35.0 pounds/square inch)(32.0 square inches) = 1120 pounds

Weight upon all four tires (weight of car)

1120 pounds × 4 = 4480 pounds

37. Plug the following values into Charles's Law and solve for the new volume: V_1 = 1.0 liters; T_1 = 298K; T_2 = 348K.

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{(1.0 \text{ liters})}{(298\text{K})} = \frac{V_2}{(348\text{K})}$$

$$\frac{(348\text{K})(1.0 \text{ liters})}{(298\text{K})} = V_2$$

$$1.168 \text{ liters} = V_2$$

Round to the appropriate number of significant figures (See Appendix B)

$$1.2 \text{ liters} = V_2$$

38. c < b < a

39. a < c < b

40. c < a < b

41. c < a = b

42. c < b < a

43. a < b < c

44. The 50 mL plus 50 mL do not add up to 100 mL because within the mix, many of the smaller BB's are able to fit within the pockets of space that were empty within the 50 mL of large BB's.

45. The 50 mL plus 50 mL do not add up to 100 mL because within the mix, many of the smaller water molecules are able to fit within the pockets of space that were empty within the 50 mL of larger ethanol molecules. This is analogous to the previous question involving the BB's and is yet another example where the existence of molecules helps to explain observed phenomena.

46. As described in Section 2.8, Avogadro's Law tells us that the volume of a gas increases as the number of gas particles increases. Conversely, volume decreases when the number of particles also decrease. As the water level rose inside the jar, the volume of air in the jar was decreasing. This suggests that the number of gas particles in the jar was also decreasing. Remarkably, Lavoisier hypothesized that the gas was being absorbed by the tin as it decomposed. In other words, the tin was reacting with oxygen and formed a tin oxide. This was a clue that helped lead Lavoisier to propose the Law of Mass Conservation.

47. That atoms can neither be created nor destroyed in a chemical reaction helps to explain why the mass of all the reacting materials equals the mass of all the products formed.

48. There are 8 atoms before the reaction but 9 atoms afterwards. This is a violation of the conservation of mass principle, which states that atoms are neither created nor destroyed in a chemical reaction. Furthermore, the atoms that exist before a reaction are the very same atoms that exist after the reaction. If the atoms are the same, then, graphically speaking, it would make sense to make them the same color.

49. The atoms of the gasoline transform into the atoms of the exhaust fumes, which escape into the atmosphere. The atoms literally go into the gas tank and then out the exhaust pipe. The atoms are conserved, but the gasoline isn't.

50. Yes, an object can have mass without having weight. This may occur deep in space where a floating object (with mass) would be "weightless". In order to have weight, however, the object must have mass. So, an object cannot have weight without having mass. are two different quantities. Mass is a measure of how much "stuff" is present in an object. Weight is a measure of the gravitational attraction between two masses—typically, we refer to examples where one of the objects is a planet or a moon.

51. Yes, a 2 kg iron brick has twice the mass as a 1 kg iron brick. While on the same planet, it also has twice the weight as well as twice the volume.

52. This question requires you to be able to distinguish between mass and volume. Imagine a container that holds exactly 1 liter when filled to the brim. Fill this container with 20°C water and then warm this water up to 80°C. As the water warms, it expands, which means some will be lost as it flows over the brim. In other words, there is less water in a liter at 80°C than there is in a liter of water at 20°C. A liter of water at 80°C, therefore, weighs less than a liter of water at 20°C.

53. The air inside the car has more inertia than the helium in the helium balloon. As the car starts forward, the greater inertia of the air causes it to pitch backwards, much like the girl's head. As this air holds to the back of the car, the lighter helium balloon moves forward. A similar effect can be seen when sliding a bottle of water on its side across a table. As you accelerate the bottle forward, the water inside the bottle has an inertia that holds it back. Any bubble of air within the bottle thus runs forward in the direction that the bottle was pushed.

54. Density is the ratio of a material's mass to volume. As the mass stays the same and the volume decreases, the density of the material increases.

55. Box A represents the greatest density because it has the greatest number of particles packed within the given volume. Because the particles of this box are packed close together and because they are randomly oriented, this box is representative of the liquid phase. Box C is representative of the gaseous phase, which occurs for a material at higher temperatures. This box, therefore, represents the highest temperature. For most materials, the solid phase is more dense than the liquid phase. For the material represented here, however, the liquid phase is seen to be more dense than the solid phase. As is explored further in Chapter 8, this is exactly the case for water where the solid phase (ice) is less dense than the liquid phase (liquid water).

56. Air expands upon being heated, which results in a decrease in density. Interestingly, warm air rises because it is less dense than its surroundings.

57. Density is mass divided by volume. If the mass of empty space is zero, then the density of that empty space is also zero.

58. Kinetic energy is more evident to us because it typically involves some form of motion. An object possessing potential energy, by contrast, may be motionless.

59. The kinetic energy of a pendulum bob is maximum where it moves fastest, at the lowest point; potential energy is maximum at the uppermost points.

60. Kinetic energy is a maximum as soon as the ball leaves the hand or as it hits the ground. Potential energy is a maximum when the ball has reached its zenith.

61. Yes, a car burns more gasoline when its lights are on. Lights and other electric devices are run off the battery, which "runs down" the battery. The energy used to recharge the battery ultimately comes from the chemical potential energy from the gasoline.

62. The swimming pool has much more energy even though it is at a cooler temperature. Consider the electric utility bill after heating each of these to their respective temperatures.

63. Heat never flows of itself from a lower temperature substance into a higher temperature substance.

64. Temperature is a measure of the average kinetic energy of the atoms and molecules of a material. Heat is thermal energy that flows from one object to another because of a temperature difference. Heat always flows from the higher temperature object to the lower temperature object.

65. The glass will contract when cold and expand when warmed. Fill the inner glass with cold water while running hot water over the outer glass to help separate the two.

66. At cruising speed (faster than the speed of sound), air friction against the jet raises its temperature dramatically, resulting in this significant thermal expansion.

67. The warmth from the house causes the wood frame of the attic to expand, while the cool of the night causes the frame to contract. As parts of the wood expand and other parts contract the result is a creaking noise.

68. At 25°C there is a certain amount of thermal energy available to all the submicroscopic particles of a material. If the attractions between the particles are not strong enough, the particles may separate from each other to form a gaseous phase. If the attractions are strong, however, the particles may be held together in the solid phase. We can assume, therefore, that the attractions among the submicroscopic particles of a material in its solid phase at 25°C are stronger than they are within a material that is a gas at this temperature.

69. (b) The trail lines behind each circle in this diagram are meant to indicate that the particles are moving faster. Diagram (a) shows the particles congregated to one side of the box. This is an unlikely scenario because the motion of gaseous particles are randomly oriented. Diagram (a) may have been misinterpreted to mean that the gas was hotter, thus the hot air rises. The trail lines in this diagram do not indicate any faster motion.

Diagram (c) shows fatter gas particles. Upon the addition of heat, gas particles don't grow any fatter. Instead, they move faster, which is to say that they have a greater average kinetic energy.

70. In the middle box you should have drawn all the particles aligned with each other as is seen in the left side of the first box. This would indicate the solid phase. In the box on the right, you should have drawn all the particles in random places as is seen in the right side of the first box. This represents the liquid phase. If each one of these particles represented a water molecule, the first box on the left would be indicative of ice melting, which occurs at 0°C.

71. At the cold temperatures of your kitchen freezer, water molecules in the vapor phase are moving relatively slowly, which makes it easier for them to stick to inner surfaces within the freezer or to other water molecules.

72. It is warmer behind the ear. This allows the perfume to evaporate faster providing for a more intense scent.

73. Gas meters measure the volume of gas that passes through them. As the gas warms it gains in volume and causes greater measurement readings in the meter. The gas company benefits.

74. At a depth of around 10 meters the pressure has been doubled. According to Boyles law, the volume of air inside of the glass will be halved, which means that the water level will have risen to about the halfway mark.

75 Airplane windows are small because the pressure difference between the inside and outside surfaces result in large net forces that are directly proportional to the window's surface area. Larger windows would have to be proportionately thicker to withstand the greater net force—windows on underwater research vessels are similarly small.

76. Strictly speaking, you do not suck the drink up into the straw. You instead reduce the pressure in the straw, which allows the weight of the atmosphere to press the liquid up into the straw.

77. The surface of the liquid inside the bottle is sealed off from the atmosphere which can no longer help to push the beverage through the straw up into your mouth.

78. The bubbles of boiling water expand to larger volumes as they rise to the surface. The reason for this is because as they rise, the water pressure become less. According to Boyle's Law, this means that the volume increases.

79. The rubber balloon will expand until it eventually pops. The material of the balloon will fall back to Earth while the helium will continue on its way into outer space.

80. The pressure within an airplane flying at high altitudes is less. This causes the gases within the package to expand to a larger volume.

81. To increase the pressure within the cabin of the airplane from 0.743 atm to 1.00 atm would require adding more air molecules into the cabin. This is an application of the Ideal Gas Law. These added air molecules have weight, which makes the plane heavier. As any pilot knows, the heavier the plane, the more fuel that must be consumed to fly at a given speed. The choice, therefore, is to increase the cabin pressure and slow down or decrease the cabin pressure and speed up. A cabin pressure corresponding to around 8000 feet is the happy medium, though it does explain, in part, why flying can be a stress to the body.

82. As you move your breath into your mouth with closed lips your cheeks puff outwards because of the greater number of air molecules now in your mouth. This is an application of Avogadro's gas law, which states that volume increases with a greater number of particles.

83. The concept that matter is made of molecules came about only after the asking of many questions about the behavior of matter. If no or only few questions are asked, then the conclusion that matter is made of molecules is not likely to be reached. How you might lead others, or yourself even, to accept the idea of molecules is to see how well this idea helps to answer questions and explain observations.

For example, is cinnamon scented air a single material or a mixture of two materials? If it is two materials, should it not be heavier than the same volume of fresh air? (It is) Can this air be made fresh by passing it through a filter of activated charcoal? (It can) Does the charcoal now smell like cinnamon? (It does) Does the cinnamon smell of the charcoal increase or decrease as it is warmed? (It increases, but eventually tapers off). Does the charcoal lose or gain weight as the cinnamon smell tapers off? (It loses weight). Might the charcoal be losing weight as tiny particles (molecules) of cinnamon evaporate from its surface. (That would make sense.) Notice that through this process you need never say that molecules exist because someone told you they do. Instead, we come to conclude that molecules exist because they offer the best explanation for what we observe.

84. Before you quickly patched the hole, the pressure inside your suit would decrease as it contains fewer air molecules—the Ideal Gas Law. As the internal pressure decreases, you might expect the volume also to decrease, as per Boyle's Law. Keep in mind, however, that there are no air molecules in the vacuum of space to push the suit inward. Even though air molecules are escaping from the suit, the number of them in the suit remains greater than the number of them just outside the suit. Thus, there would be no appreciable change in volume of the suit, especially if the suit is fairly rigid. The escaped air molecules would fall downward to join the other air molecules in the atmosphere, . because of the force of gravity.

85. The scale falls because gravity pulls it downward. An orbiting space craft also falls, but the spacecraft is moving sideways so fast (17,500 mph) that it falls *around* the Earth rather than into it. There would be no parking possible for a space shuttle alongside the observation deck. Interestingly, astronauts within the orbiting shuttle are as weightless as you are when you jump off a high dive. The only difference is that they're moving sideways superfast, which they can only do above the air-drag of the atmosphere. Understanding the rules of nature helps us to appreciate nature.

86. You probably should not spend too much time of showing the politicians your analysis of the data. If your credentials are good and you are respected among your peers, then the politicians will likely trust your assessments. Politicians will be much more interested in the impact such climate change will have on the general public, especially in terms of the economy. Your time would be well spent focusing on potential solutions to the problem. Even better if your solutions offered new jobs for the politician's constituents. John Ashton also said, "The more effort scientists put into how their message might be heard, how it might be manipulated and made mischief, the better. If we want to successfully respond to climate change we have to form it as part of the solution to the economic crisis."

Chapter 3: Elements of Chemistry

1. Nothing. During a physical change, the chemical identity of a substance remains the same.

2. During a chemical reaction there is a change in the way atoms are bonded together.

3. An observed change may be physical or chemical because both involve changes in appearance.

4. An element consists of only one type of atom.

5. Atom is used to refer to submicroscopic particles in a sample and element is used for microscopic and macroscopic samples.

6. The periodic table has 7 periods and 18 groups.

7. Across any period, the properties of elements gradually change.

8. These subsets of the sixth and seventh periods are placed beneath the main body of the periodic table so that the periodic table conveniently fits on a piece of paper.

9. An element has only one type of atom. A compound has combinations of different types of atoms.

10. The chemical formula tells us the ratio in which atoms come together to form one unit of a particular substance.