Chapter 2: Review Questions

Solutions to odd numbered questions at the end of this document

Basic Questions

2.1 The Submicroscopic World Is Super-Small

1. It would take you 31,800 years to count to a trillion. About how many times would you have to do this to have counted all atoms there are in a single grain of sand?

2. Is a biological cell macroscopic, microscopic, or submicroscopic?

2.2 Discovering the Atom

3. The term "atom" was derived from what Greek phrase?

4. What 18th century chemist discovered the law of mass conservation?

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5. What did Mendeleev predict based upon his newly created periodic table?

2.3 Mass Is How Much and Volume Is How Spacious

6. What is inertia, and how is it related to mass?

7. Which can change from one location to another: mass or weight?

8. What is the difference between an object's mass and its volume?

2.4 Density Is the Ratio of Mass to Volume

9. The units of density are a ratio of what two quantities?

10. What happens to the volume of a loaf of bread that is squeezed? The mass? The density?

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2.5 Energy Is the Mover of Matter

11. What do we call the energy an object has because of its position?

12. What do we call the energy an object has because of its motion?

13. Which represents more energy: a joule or a calorie?

2.6 Temperature Is a Measure of How Hot—Heat It Is Not

14. In which is the average speed of the molecules less: in cold coffee or in hot coffee?

15. Which temperature scale has its zero point as the point of zero atomic and molecular motion?

16. Is it natural for heat to travel from a cold object to a warmer object?

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2.7 The Phase of a Material Depends on the Motion of Its Particles

17. How does the arrangement of particles in a gas differ from the arrangements in liquids and solids?

18. Which requires the removal of thermal energy: melting or freezing?

19. What is it called when evaporation takes place beneath the surface of a liquid?

2.8 Gas Laws Describe the Behavior of Gases

20. What happens to the pressure inside a tire as more air molecules are pumped into the tire?

21. What happens to the volume of a gas as its temperature is increased? (Assume constant pressure and number of particles.)

22. At what temperature do gases theoretically cease to occupy any volume?

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23. What happens to the volume of a gas as more gas particles are added to it? (Assume constant pressure and temperature.)

24. Why do real gases not obey the ideal gas law perfectly?

Quantitative Questions

25. What is the mass in kilograms of a 130-pound human standing on Earth?

26. Gravity on the Moon is only one-sixth as strong as gravity on the Earth. What is the mass of a 10-kilogram object on the moon, and what is its mass on the Earth?
27. Some one wants to sell you a piece of gold and says it is nearly pure. Before buying the piece, you measure its mass to be 52.3 grams and find that it displaces 4.16 mL of water. Calculate its density and consult Table 2.1 to assess its purity.

28. What volume of water would a 52.3 gram sample of pure gold displace?

29. How many joules are there in a candy bar containing 230,000 calories?

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30. How many milliliters of dirt are there in a hole that has a volume of 5 liters? How many milliliters of air?

31. You measure the pressure of the four tires of your car each to be 35.0 pounds per square inch (psi). You then roll your car forward so that each tire is upon a sheet of paper. You outline the surface area of contact between each tire and the paper, which you later measure to be 32.0 square inches. What is the weight of your car?

32. A perfectly elastic balloon holding 1.0 liters of helium at 298K is warmed to 348K. What is the new volume of the helium-filled balloon?

33. Rank the following in order of increasing volume:

a. Bacterium b. Virus c. Water Molecule

34. Rank the following in order of increasing temperature:

a. 100 K b. 100 °C c. 100 °F

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35. Rank the following in order of increasing molecular kinetic energy:

a. Cupful of boiling water at 100°C.

b. Swimming pool full of boiling water at 100°C

c. A cup of ice at -10°C on the top floor of a skyscraper.

36. Rank the following in order of increasing *average* molecular kinetic energy:

a. Cupful of boiling water at 100°C.

b. Swimming pool full of boiling water at 100°C

c. A cup of ice at -10°C on the top floor of a skyscraper.

37. Rank the following in order of increasing force of attraction between its submicroscopic particles:

a. Sugar b. Water c. Air

38. Rank the following in order of increasing temperature: A billion billion molecules of a gas at 1 atmosphere of pressure in a

a. 10 liter container. b. 5 liter container. c. 1 liter container.

Challenging Questions

2.1 The Submicroscopic World Is Super-Small

39. You take 50 mL of small BB's and combine them with 50 mL of large BB's and you get a total of 90 mL of BB's of mixed size. Explain.

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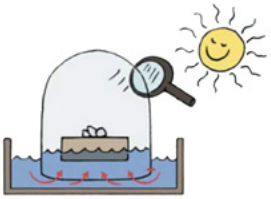
40. You take 50 mL of water and combine it with 50 mL of purified alcohol and you get a total of 98 mL of mixture. Explain.

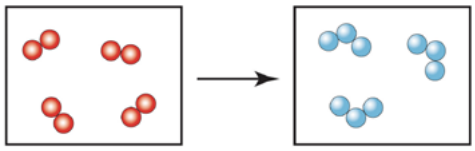
2.2 Discovering the Atom

41. In one of his experiments, Lavoisier used sunlight to heat a piece of tin on a floating block of wood covered by a glass jar. As the tin decomposed, the water level inside the jar rose. Explain this result using Avogadro's Law.



42. Which of Dalton's postulates accounts for Lavoisier's mass-conservation principle?

43. What is wrong with the following depiction of a chemical reaction?



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44. A friend argues that if mass were really conserved he would never need to refill his gas tank. What explanation do you offer your friend.

2.3 Mass Is How Much and Volume Is How Spacious

45. Can an object have mass without having weight? Can it have weight without having mass?
46. Does a 2-kilogram solid iron brick have twice as much mass as a 1-kilogram solid iron brick? Twice as much weight? Twice as much volume?

47. Which weighs more: a liter of water at 20°C or a liter of water at 80°C?

48. A little girl sits in a car at a traffic light holding a helium-filled balloon. The windows are closed and the car is relatively airtight. When the light turns green and the car accelerates forward, her head pitches backward but the balloon pitches forward. Explain why.

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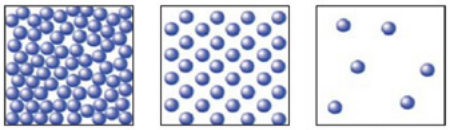
2.4 Density Is the Ratio of Mass to Volume

49. What happens to the density of a gas as the gas is compressed into a smaller volume?

50. The following three boxes represent the number of submicroscopic particles in a given volume of a particular substance at different temperatures. Which box represents the highest density? Which box represents the highest temperature? Why would this be a most unusual substance if box (a) represented the liquid phase and box (b) represented the solid phase?



51. What happens to the density of air as it is heated?

52. What is the density of empty space?

2.5 Energy Is the Mover of Matter

53. Which is more evident: potential or kinetic energy? Explain.

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54. At what point in its motion is the kinetic energy of a pendulum bob at a maximum? At what point is its potential energy at a maximum?

55. Consider a ball thrown straight up in the air. At what position is its kinetic energy at a maximum? Where is its gravitational potential energy at a maximum?

56. Does a car burn more gasoline when its lights are turned on? Defend your answer.

2.6 Temperature Is a Measure of How Hot—Heat It Is Not

57. Which has more total energy: a cup of boiling water at 100°C or a swimming pool of slightly cooler water at 90°C?

58. Under what circumstances does heat naturally travel from a cold substance to a warmer substance?

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59. Distinguish between temperature and heat.

60. An old remedy for separating two nested drinking glasses stuck together is to run water at one temperature into the inner glass and then run water at a different temperature over the surface of the outer glass. Which water should be hot and which cold?

61. A supersonic jet heats up considerably when traveling through the air at speeds greater than the speed of sound. As a result, the jet in flight is several centimeters longer than when it is on the ground. Offer an explanation for this length change from a submicroscopic perspective.

62. Creaking noises are often heard in the attic of old houses on cold nights. Give an explanation in terms of thermal expansion.

2.7 The Phase of a Material Depends on the Motion of Its Particles

63. Which has stronger attractions among its submicroscopic particles: a solid at 25°C or a gas at 25°C? Explain.

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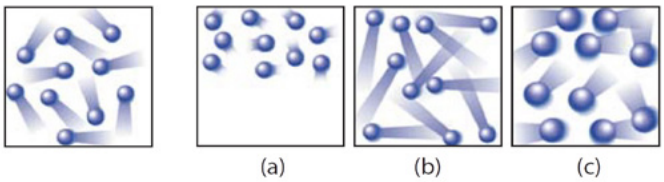
64. The leftmost diagram below shows the moving particles of a gas within a rigid container. Which of the three boxes on the right (a, b, or c) best represents this material upon the addition of heat?



65. The leftmost diagram below shows two phases of a single substance. In the middle box, draw what these particles would look like if heat were taken away. In the box on the right, show what they would look like if heat were added. If each particle represents a water molecule, what is the temperature of the box on the left?

66. Humidity is a measure of the amount of water vapor in the atmosphere. Why is humidity always very low inside your kitchen freezer?

67. Why is perfume typically applied behind the ear rather than on the ear?

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2.8 Gas Laws Describe the Behavior of Gases

68. Would you or the gas company gain by having gas warmed before it passed through your gas meter?

69. At a depth of about 10 meters the water pressure on you is equal to the pressure of 1 atmosphere. The total pressure on you is therefore 2 atmospheres—1 atm from the water and a 1 atm from the air above the water. When the glass shown below is pushed down to a depth of around 10 meters in depth, what will be the level of the water on the inside of the glass?

70. Why do you suppose that airplane windows are smaller than bus window?

71. When you suck through a soda straw into a drink, what causes the drink to rise into your mouth: the muscles of your lungs and cheeks or the weight of the atmosphere?

72. A soda straw fits snuggly through a cork that's wedged into a narrow-neck bottle containing a liquid beverage. You try to suck the beverage out of the bottle, but doing so is not possible for you. Why?

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73. What happens to the size of the bubbles of boiling water as they rise to the surface? Why? Which gas law applies?

74. A child's lost helium-filled rubber balloon rises higher and higher into the sky. What eventually happens to the balloon? What happens to the helium?

75. Use Boyle's Law to explain why a package of chips puffs up on board a high flying airplane.

76. An airliner cruises around 30,000 feet, but the cabin is kept at more comfortable pressure that corresponds to around 8000 feet, which is about 0.743 atmospheres. For most people, the cabin would be even more comfortable if it were kept at a pressure of 1.00 atmospheres. Why don't airlines pressurize their cabins to 1.00 atmospheres? Which gas law applies?

77. Close your lips and blow air into your mouth. What happens to your cheeks? Why? Which gas law applies?

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Discussion Questions

78. Your friend smells cinnamon coming from an inflated rubber balloon containing cinnamon extract. You tell him that the cinnamon molecules are passing through the micropores of the balloon. He accepts the idea that the balloon contains micropores but insists that he is simply smelling cinnamon flavored air. You explain that scientists have discovered that gases are made of molecules, but that's not good enough for him. He needs to see the evidence for himself. How might you lead him to accept the concept of molecules?

79. You're at the top of a 200 mile tall tower that extends above the atmosphere into outer space. Because there is no air that high you are wearing a pressurized spacesuit. If a hole were poked into your suit, the air molecules in your suit would escape. Before you quickly patch the hole, what would happen to the pressure inside your suit? What would happen to the volume of your suit? Would the escaped air molecules fall up or down or remain level? Which laws apply to each of these questions?

80. You're at the top of a 200 mile tall tower that extends above the atmosphere into outer space. On the observation deck you step onto a scale, which shows you to be a couple pounds lighter than you were at the bottom of the tower. But since you're in outer space, you wonder what would happen if you stepped off the observation deck. You instead hold the scale over the edge and then let go of it. What happens to the scale? Does it float or fall? Is there gravity in outer space? Would it be possible for the space shuttle to park along side this observation deck? Why is it important for us to know these sorts of things?

81. The British diplomat, physicist and environmentalist John Ashton in speaking to a group of scientists stated (paraphrased): "There has to be much better communication between the world of science and the world of politics. Consider the different meaning of the word 'uncertainty'. To scientists, it means uncertainty over the strength of a signal. To politicians it means 'go away and come back when you're certain.'" Pretend you are a scientist with strong but no 100 percent conclusive evidence in support of impending climate change. How might you best persuade politicians to take action?

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Solutions to Chapter 2 Review

Solution to Calculation Corner: Scuba Diving and Hot Air Balloons

1. The new volume of the scuba diver will be two times that of the original volume:

$V_2 = P_1 V_1/P_2$

$= (2.00 \text{ atm})(V_1)/(1 \text{ atm})$

$= 2.00 V_1$

2. Plug the following values into Boyles law and solve to the new pressure, P_2:

$P_1V_1 = P_2V_2$

(1 atm)(5.00 L) = (P_2)(3.38 L)

P_2 = (1.00 atm)(5.00 L)/3.38 L)

P_2 = 1.48 atm

3. Plug the following values in Charles's Law and solve for the new volume, V_2. Be sure to use the absolute temperatures given in kelvin:

=

(419 L)/(298 K) = V_2/(323 K)

V_2 = (419 L)(323 K)/(298 K)

V_2 = 454 L

4. Use Charles's Law to show that the new volume at the higher temperature would be 536,000 liters. The answer needs to have three significant figures, which is why 535,564 liters rounds up to 536,000 liters. Take the difference to find the volume of gas that escapes from the balloon.

=

(401,000 L)/(298 K) = V_2/(398 K)

V_2 = (401,000 L)(398 K)/(298 K)

V_2 = 536,000 L

Volume of air that escapes = V_2 — V_1 = 135,000 liters

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Solutions to Odd Numbered Review Questions

Basic Questions

2.1 The Submicroscopic World Is Super-Small

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.

2.2 Discovering the Atom

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

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

2.3 Mass Is How Much and Volume Is How Spacious

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

2.4 Density Is the Ratio of Mass to Volume

9. Density is the ratio between the mass of a substance and its volume. Note, that 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.

2.5 Energy Is the Mover of Matter

11. The energy due to position is potential energy.

13. A calorie is 4.184 times greater than a joule.

2.6 Temperature Is a Measure of How Hot—Heat It Is Not

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

2.7 The Phase of a Material Depends on the Motion of Its Particles

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 tumble loosely around one another. In a solid, the particles are fixed in a three-dimensional arrangement.

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

2.8 Gas Laws Describe the Behavior of Gases

21. The volume increases as the temperature increases.

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

Quantitative Questions

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

130 lb × = 59 kg

27. Divide the mass by volume to arrive at the density:

density = = = 12.6 g/mL

From 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 far from pure.

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

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

31. 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

33. c < b < a

35. c < a < b

37. c < b < a

Challenging Questions

2.1 The Submicroscopic World Is Super-Small

39. 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.

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2.2 Discovering the Atom

41. 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. This was a clue that helped lead Lavoisier to propose the Law of Mass Conservation.

43. 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.

2.3 Mass Is How Much and Volume Is How Spacious

45. 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. Because they 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.

47. 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.

2.4 Density Is the Ratio of Mass to Volume

49. 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.

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

2.5 Energy Is the Mover of Matter

53. 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.

55. Kinetic energy is a maximum as soon as the ball leaves the hand. Potential energy is a maximum when the ball has reached its zenith.

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2.6 Temperature Is a Measure of How Hot—Heat It Is Not

57. 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.

59. 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 in the direction of the higher temperature object to the lower temperature object.

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

2.7 The Phase of a Material Depends on the Motion of Its Particles

63. 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.

65. 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.

67. It's warmer behind the ear. This allows the perfume to evaporate faster providing for a more intense scent.

2.8 Gas Laws Describe the Behavior of Gases

69. 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.

71. 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.

73. 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.

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

77. 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.

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Discussion Questions

79. Before you quickly patched the hole, the pressure inside your suit would decrease as it contains fewer air molecules—Avogadro's 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. Why? Because of the force of gravity.

81. 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. All the 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."

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