Ch 11 (5th ed)

KEY TERMS

absolute temperature scale: The temperature scale with its zero point at absolute zero and degrees equal to those on the Celsius scale. Also called the Kelvin temperature scale.

atom: The smallest unit of an element that has the chemical and physical properties of that element.

atomic mass: The mass of an atom in atomic mass units.

atomic mass unit: One-twelfth of the mass of a carbon atom. Equal to 1.66×10^{-27} kilogram.

Avogadro's number: 6.02×10^{23} molecules, the number of molecules in 1 mole of any substance.

Celsius temperature scale: The temperature scale with the values of 0°C and 100°C for the temperatures of freezing and boiling water, respectively.

compound: A combination of chemical elements that forms a substance with its own properties.

element: Any chemical species that cannot be broken up into other chemical species.

Fahrenheit temperature scale: The temperature scale with the values of 32°F and 212°F for the temperatures of freezing and boiling water, respectively. Its degree is five-ninths of that on the Celsius or Kelvin scales.

ideal gas: An enormous number of very tiny particles separated by relatively large distances. The particles have no internal structure, are indestructible, and do not interact with each other except when they collide; all collisions are elastic.

ideal gas law: $PV = nRT$, where P is the pressure, V is the volume, T is the absolute temperature, n is the number of moles, and R is the gas constant.

Kelvin temperature scale: The temperature scale with its zero point at absolute zero and a degree equal to that on the Celsius scale. Also called the absolute temperature scale.

law of definite proportions: When two or more elements combine to form a compound, the ratios of the masses of the combining elements have fixed values.

macroscopic: The bulk properties of a substance, such as mass, size, pressure, and temperature.

microscopic: Properties not visible to the naked eye, such as atomic speeds or the masses and sizes of atoms.

mole: The amount of a substance that has a mass in grams numerically equal to the mass of its molecules in atomic mass units.

molecule: A combination of two or more atoms.

pressure: The force per unit area of surface. Measured in newtons per square meter, or pascals.

CONCEPTUAL QUESTIONS

1. The two essential elements of a good model are insight and predictive power. Many ancient cultures explained natural phenomena in terms of the actions of their gods. Did these models fail primarily because of lack of insight or lack of predictive power?
2. The two essential elements of a good model are insight and predictive power. Choose a model with which you are familiar and point out how it meets these two criteria.
3. A friend has created a model of how a candy vending machine works. His theory says that a little blue person (LBP) lives inside each vending machine. This person takes your coins and gives you candy in return. Although this LBP theory may not seem reasonable to you, can you suggest ways of disproving it without opening the machine?
4. For most of human history, we believed that Earth was stationary and the Sun and planets orbit Earth (the geocentric model). Beginning about 500 years ago, a second model emerged in which Earth orbits the Sun (the heliocentric model). When we read in the paper that the Sun rose at 6:40 this morning, which of these two models is being used?
5. Your friend notices that a brown can of diet cola floats whereas a green can of lemon–lime soda and a can of orange soda both sink. He postulates a model in which only nonbrown cans of soda sink. To prove his model, he tries a brown can of diet root beer and finds that it floats as expected. Has he proven that his model is correct? In general, can a model ever be proven true?
6. Following the experiments described in Question 5, your friend tries a brown can of nondiet root beer and finds that it sinks. He rightfully discards his original model and proposes an alternative. What would this new model be? Has it been proven correct?
7. Alchemists held a model in which matter was continuous. Atomists showed the fallacy of this model and replaced it with a model in which all objects are made of small, discrete particles. In your day-to-day living, which model do you appeal to more often? Is the most complete model always the most useful?
8. What role did the alchemist play in the development of an atomistic world view?

9. Which of the following are not elements: hydrogen, salt, nitrogen, granite, sodium, chlorine, water?

10. Would you expect carbon monoxide to be an element or a compound? Why?

11. When the element mercury is heated in air, a red powder is formed. Careful measurement shows that the mass of the resulting powder is greater than the mass of the original mercury. Is this powder an element or a compound? How do you account for this additional mass?

12. How were scientists first able to demonstrate that water is a compound?

13. What are the basic differences between mixtures and compounds?

14. Do water and salt form a compound or a mixture?

15. The atomic mass of ammonia is 17 atomic mass units. What is the atomic mass of nitrogen if a molecule of ammonia consists of one atom of nitrogen and three atoms of hydrogen?

16. The atomic mass of iron oxide (rust) is 160 atomic mass units. What is the atomic mass of iron if a molecule of iron oxide consists of two atoms of iron and three atoms of oxygen?

17. Silver has an atomic mass of 108. Which, if either, contains more atoms: 1 gram of silver or 1 gram of hydrogen?

18. Silver has an atomic mass of 108. Which, if either, contains more atoms: 1 mole of silver or 1 mole of hydrogen?

19. How does the number of molecules in 1 liter of oxygen compare with the number of molecules in 1 liter of carbon dioxide if they are both at the same temperature and pressure?

20. Oxygen molecules contain two oxygen atoms, and carbon dioxide molecules contain one atom of carbon and two atoms of oxygen. How does the total number of atoms in 1 liter of oxygen compare with the total number of atoms in 1 liter of carbon dioxide if they are both at the same temperature and pressure?

21. The atomic mass of sulfur is 32 atomic mass units. How many grams of sulfur are needed to have an Avogadro's number of sulfur atoms?

22. How many grams of water are needed to have an Avogadro's number of water molecules?

23. What is the most important single assumption in the ideal gas model?

24. The ideal gas model accounts very well for the behavior of gases at standard temperature and pressure. Would the ideal gas model begin to fail for very large pressures or for very small pressures? Explain your answer.

25. A cube and a spherical ball are made of the same material and have the same mass. Which exerts the larger pressure on the floor?

26. You can apply enough force to the head of a pushpin to push it into a plaster wall with your thumb. However, it is not a good idea to try to do this with a needle. Use the concept of pressure to explain the difference between these two situations.


George Semple

27. If you screw the cap of an empty plastic drinking bottle on tightly while walking in the mountains, why are the sides of the bottle caved in when you return to the valley?

28. Your right rear tire has to support a weight of 3000 newtons. Normally, the contact area of your tire with the road is 200 square centimeters. If the pressure in your tire is suddenly reduced from 32 pounds per square inch to 16 pounds per square inch, what must be the new contact area to support the car?

29. Use the microscopic model of a gas to explain why the pressure in a tire increases as you add more air.

30. As you drive your car down the road, the friction of the rubber with the road causes the air inside the tire to increase in temperature, resulting in an increase in pressure. Use the microscopic model of a gas to explain why the pressure increases.

31. If the average speed of a perfume molecule is 500 meters per second, why does it take several minutes before you smell the perfume from a bottle opened across the room?

32. What happens to the average speed of the molecules of a gas as it is heated?

33. Why does an alcohol-in-glass thermometer have a bulb at the bottom?

34. It is possible to cut the very top off of an alcohol-in-glass thermometer without any of the alcohol spilling out. However, it will no longer function as a good thermometer. Why not?

35. What conditions must be imposed before the boiling point of water can be used as a fixed temperature?

36. Why is body temperature not a good fixed temperature for establishing a temperature scale?

37. Two students are sick in bed with 2-degree fevers. One has a temperature of 39.0°C; the other, 100.6°F. Which student has the higher fever?

38. Is a sauna at a temperature of 190°F hotter or colder than one at 85°C?

39. Where should you set your new Celsius thermostat so that your hot tub stays at a comfortable 102°F?

Jeff Greenberg/Visuals Unlimited

40. You move to Canada and find that the thermostat in your home is in Celsius degrees. You normally like your house about 72°F. To what should you set your new thermostat?

41. What is the freezing point of water on the Kelvin scale?

42. Nitrogen boils at 77 K. At what Celsius temperature does it boil?

43. What microscopic property of an ideal gas doubles when the absolute temperature is doubled?

44. What temperature change would be needed to double the average speed of the molecules in an ideal gas?

45. Air is a mixture of several gases, primarily nitrogen and oxygen. Would the average kinetic energy for the nitrogen molecules be greater than, equal to, or less than the average kinetic energy for the oxygen molecules?

46. Consider a mixture of helium and neon gases. The atomic masses of helium and neon are 4 atomic mass units and 20 atomic mass units, respectively. Is the average speed of a helium atom greater than, equal to, or less than the average speed of a neon atom? (*Hint:* Both gases are at the same temperature.)

47. If you heat a gas in a container with a fixed volume, the pressure increases. Use the ideal gas model to explain this.

48. If the volume of an ideal gas is held constant, what happens to the pressure if the absolut+e temperature is cut in half?

49. What macroscopic property of an ideal gas doubles when the absolute temperature is doubled while the pressure remains constant?

50. If you put a sealed plastic bottle partially filled with hot tea in the refrigerator, the sides of the bottle will cave in as the tea cools. Why?

51. What happens to the temperature of an ideal gas if you reduce its volume to one-fourth while holding the pressure constant?

52. Why does the pressure inside the tires increase after a car has been driven?

53. Use the microscopic gas model to explain why the pressure of a gas rises as the volume is reduced while the temperature remains constant.

54. If you hold the temperature of an ideal gas constant, what happens to its volume when you triple its pressure?

55. The water in a canvas water bag placed in front of your car when driving across the desert stays cooler than the surrounding air. Explain this in terms of the average kinetic energies of the water molecules that leave and stay behind.

Gerald F. Wheeler

56. How does an alcohol rub cool your body?

57. Why might hikers get hypothermia during wet weather even when the temperature is above freezing?

58. The temperature of boiling water does not increase even if the heat is turned on high. Use the microscopic model to explain this.

EXERCISES

1. If 1 g of hydrogen combines completely with 8 g of oxygen to form water, how many grams of hydrogen does it take to combine completely with 24 g of oxygen?

2. In ammonia, 14 g of nitrogen combines completely with 3 g of hydrogen. How many grams of hydrogen does it take to combine completely with 56 g of nitrogen?

3. Given that 1 g of hydrogen combines completely with 8 g of oxygen to form water, how many grams of water can you make with 8 g of hydrogen and 32 g of oxygen?

4. Given that 12 g of carbon combines completely with 16 g of oxygen to form carbon monoxide, how many grams of carbon monoxide can be made from 36 g of carbon and 80 g of oxygen?

5. A ham sandwich consists of one slice of ham (10 g) and two slices of bread (25 g each). You have 1 kg of ham and 1 kg of bread. You make as many sandwiches as you can. How many sandwiches did you make? What is the mass of the sandwiches? Which ingredient is left over? What is the mass of the ingredient that is left over?

6. One mole of water molecules consists of 1 mole of oxygen (16 g) and 2 moles of hydrogen (1 g each). You combine 1 kg of oxygen with 1 kg of hydrogen to make water. How many moles of water did you make? What is the mass of the water? What is the mass of the element that is left over?

7. Given that the carbon atom has a mass of 12 amu, how many carbon atoms are there in a diamond with a mass of 1 g?

8. Given that the sulfur molecule has a mass of 32 amu, how many sulfur molecules are in 1 g of sulfur?

9. One liter of water has a mass of 1 kg, and the mass of a water molecule is 18 amu. How many molecules of water are there in 1 L of water?

10. One liter of oxygen has a mass of 1.4 g, and the oxygen molecule has a mass of 32 amu. How many oxygen molecules are there in 1 L of oxygen?

***11.** One liter of nitrogen combines with 3 L of hydrogen to form 2 L of ammonia. If the molecules of nitrogen and hydrogen have two atoms each, how many atoms of hydrogen and nitrogen are there in one molecule of ammonia?

***12.** One liter of oxygen combines with 1 L of hydrogen to form 1 L of hydrogen peroxide. Given that the molecules of hydrogen and oxygen contain two atoms each, how many atoms are there in one molecule of hydrogen peroxide?

13. About how many atoms would it take to deposit a single layer on a surface with an area of 1 cm^2?

***14.** About how many atoms would you expect to be in a g of milk? State clearly any assumptions you have to ma

15. You exert a force of 30 N on the head of a thumbtack. T head of the thumbtack has a radius of 5 mm. What is pressure on your thumb?

16. The pressure in each of your car tires is 2.5×10^5 Pa. T mass of your car is 1600 kg. Assuming that each of y tires bears one-quarter of the total load, what is the c tact area of each tire with the road?

17. What happens to the volume of 1 L of an ideal gas wh the pressure is tripled while the temperature is held fix

18. An ideal gas at 27°C is contained in a piston that ensu that its pressure will always be constant. Raising the te perature of the gas causes it to expand. At what tempe ture will the gas take up twice its original volume?

***19.** A helium bottle with a pressure of 100 atm has a volu of 3 L. How many balloons can the bottle fill if each b loon has a volume of 1 L and a pressure of 1.25 atm?

***20.** When the temperature of an automobile tire is 20°C, t pressure in the tire reads 32 psi on a tire gauge. (T gauge measures the difference between the pressures inside and outside the tire.) What is the pressure when t tire heats up to 40°C while driving? You may assume th the volume of the tire remains the same and that atm spheric pressure is a steady 14 psi.

***21.** A volume of 150 cm^3 of an ideal gas has an initial temp ature of 20°C and an initial pressure of 1 atm. What is t final pressure if the volume is reduced to 50 cm^3 and t temperature is raised to 40°C?

***22.** An ideal gas has the following initial conditions: V_i = 500 cm^3, P_i = 3 atm, and T_i = 100°C. What is its final te perature if the pressure is reduced to 1 atm and the v ume expands to 1000 cm^3?

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