Chapter 2

Summary of Terms

Absolute Zero The lowest possible temperature, which is the temperature at which the atoms of a substance have no kinetic energy: 0 K = -273.15°C = -459.7°F.

Alchemy A medieval endeavor concerned with turning other metals to gold.

Atoms Extremely small fundamental units of matter.

Avogadro's Law A gas law that describes the direct relationship between the volume of a gas and the number of gas particles it contains at constant pressure and temperature. The greater the number of particles, the greater the volume.

Boiling Evaporation in which bubbles form beneath the liquid surface.

Boyle's Law A gas law that describes the indirect relationship between the pressure of a gas sample and its volume at constant temperature. The smaller the volume, the greater the pressure.

Charles' Law A gas law that describes the direct relationship between the volume of a gas sample and its temperature at constant pressure. The greater the temperature, the greater the volume.

Condensation The transformation of a gas to a liquid.

Density The amount of mass contained in a sample divided by the volume of the sample.

Deposition The process of a material transforming from a gas directly to a sold without passing through the liquid phase.

Energy The capacity to do work.

Evaporation The transformation of a liquid to a gas.

Freezing The transformation of a liquid to a solid.

Gas Matter that has neither a definite volume nor a definite shape, always filling any space available to it.

Heat The energy that flows from one object to another because of a temperature difference between the two.

Ideal Gas Law A gas law that summarizes the pressure, volume, temperature, and number of particles of a gas within a single equation often expressed as PV = nRT, where P is presure, V is volume, n is number of molecules, R is the gas constant and T is temperature given in kelvins.

Kinetic energy Energy due to motion.

Kinetic Molecular Theory A theory that explains the properties of solids, liquids, and gases by proposing that they consist of rapidly moving tiny particles, either atoms or molecules or both.

Liquid Matter that has a definite volume but no definite shape, assuming the shape of its container.

Mass The quantitative measure of how much matter an object contains.

Melting The transformation of a solid to a liquid.

Molecule An extremely small fundamental structure built of atoms.

Potential energy Stored energy.

Solid Matter that has a definite volume and a definite shape

Sublimation The process of a material transforming from a solid directly to a gas without passing through the liquid phase.

Submicroscopic The realm of atoms and molecules, where objects are smaller than can be detected by optical microscopes.

Temperature How warm or cold an object is relative to some standard. Also, a measure of the average kinetic energy per molecule of a substance, measured in degrees Celsius, degrees Fahrenheit, or kelvins.

Thermometer An instrument used to measure temperature.

Volume The amount of space an object occupies.

Weight The gravitational force of attraction between two bodies (where one body is usually the Earth).

Review 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?

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?

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 and Heat

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?

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?

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?

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. A SCUBA tank is filled with 79.7% oxygen and 20.3% helium to a total pressure of 11.3 atm.What are the partial pressures of the oxygen and the helium?

Solutions (Odd-Numbered)

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.

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.

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

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.

11. The energy due to position is potential energy.aa

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

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

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.

21. The volume increases as the temperature increases.

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

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

$$(130 \text{ lb}) \times (1 \text{ kg}/2.205 \text{ lbs}) = 59 \text{ kg}$$

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

$$\text{density} = \text{mass/volume} = 52.3 \text{ grams}/4.16 \text{ mL} = 12.6 \text{ g/mL}$$

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 lbs/sq inch)(32.0 sq inches) = 1120 lbs

Weight upon all four tires (weight of car)

1120 pounds × 4 = 4480 pounds

33. P_{Oxygen} = (11.3 atm)(0.797) = 9.01 atm

P_{Helium} = (11.3 atm)(0.203) = 2.29 atm

Solutions to Chapter 2 Calculation Corners

Manipulating Algebraic Equations

1. 0.5 grams per milliliter
2. 400 grams
3. 100 milliliters

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:

$$P_1V_1 = P_2V_2$$
$$(1 \text{ atm})(5.00 \text{ L}) = (P_2)(3.38 \text{ L})$$
$$P_2 = (1.00 \text{ atm})(5.00 \text{ L})/3.38 \text{ L})$$
$$P_2 = 1.48 \text{ atm}$$

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:

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

$$(419 \text{ L})/(298 \text{ K}) = V_2/(323 \text{ K})$$
$$V_2 = (419 \text{ L})(323 \text{ K})/(298 \text{ K})$$
$$V_2 = 454 \text{ L}$$

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.

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

$$(401{,}000 \text{ L})/(298 \text{ K}) = V_2/(398 \text{ K})$$
$$V_2 = (401{,}000 \text{ L})(398 \text{ K})/(298 \text{ K})$$
$$V_2 = 536{,}000 \text{ L}$$

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

5. The density of air is 1.18 grams per liter. In other words, 1.18 grams equals 1 liter. As per the Calculation Corner of Chapter 1, you should be able to recognize this as a conversion factor. Put this together with the conversion factor of 1000 grams equals 1 kilogram and we can convert from liters to grams to kilograms in a single equation:

(135,000 L of air)(1.18 grams of air/L of air)(1 kilogram/1000 grams) = 159 kg