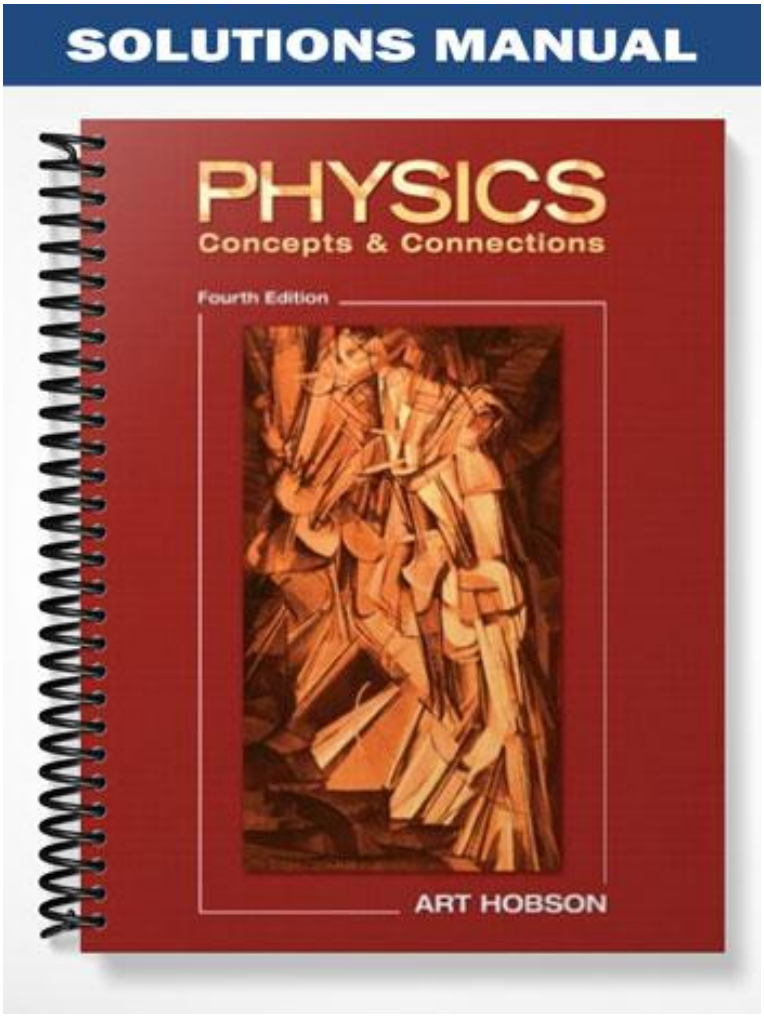
SOLUTIONS MANUAL



CHAPTER 2

review questions

THE GREEK ATOM

1. What macroscopic evidence is there for atoms?
2. What light-based microscope evidence is there for atoms?
3. What experiment did the ancient Greek atomists imagine doing, and what did they believe the result would be?
4. An experiment such as the Greeks (previous question) imagined was actually carried out recently. Describe it.
5. Which is bigger, an atom or the wavelength of light? A little bigger or a lot?

ATOMS AND MOLECULES

6. From the microscopic point of view, what is the difference between an element and a compound?
7. From a macroscopic point of view, what is the difference between an element and a compound?
8. What is the difference between an atom and a molecule?
9. Why is the periodic table arranged in the way that it is?
10. If you chemically decompose water, will you get anything like water? What will you get?

THE ATOM'S EXPLANATORY POWER

11. Describe the microscopic process by which perfume gives off an odor that you can smell some distance away.
12. How do solids, liquids, and gases differ macroscopically? Microscopically?
13. Which is easiest to compress: solids, liquids, or gases? Why?
14. Is a perfect vacuum ever attained on Earth, over a volume as large as 1 cubic centimeter? Elsewhere?
15. What is the microscopic difference between hot water and cold water?

ATOMIC MATERIALISM AND ATOMIC MODELS

16. Name several things that people ordinarily regard as real but that, according to atomic materialism, are not real.
17. Describe the philosophy of materialism.
18. Give arguments for the materialist philosophy.
19. Give arguments against the materialist philosophy.
20. Name three different models of the atom. Describe two of them.

CHEMISTRY AND LIFE

21. What is meant by a *chemical reaction?*
22. Name three different chemical reactions.
23. Is air a single substance (a single compound)? Describe its chemical composition.
24. Describe an experiment involving burning that supports the notion of conservation of matter.
25. In what types of experiments is the conservation of matter correct to a very good approximation?
26. Describe the following reactions: burning, respiration, and photosynthesis.

conceptual exercises

THE GREEK ATOM

1. Is the atomic theory known, for certain, to be true?
2. Carbon atoms are about 25% lighter than oxygen atoms (the ratio of their weights is 3 to 4). What is the weight ratio of the carbon and oxygen that go into the formation of carbon monoxide? Answer the same question for carbon dioxide.
3. A carbon atom is 12 times heavier than a hydrogen atom. If methane (CH_4) is chemically decomposed, what will be the ratio of the weights of the resulting carbon and hydrogen?
4. A carbon atom is 12 times heavier than a hydrogen atom, and an oxygen atom is 16 times heavier than a hydrogen atom. If glucose $(C_6H_{12}O_6)$ is chemically decomposed, what will be the ratio of the weights of the resulting elements?

ATOMS AND MOLECULES

5. How many atoms are in a molecule of H_2SO_4 (sulfuric acid)?
6. How many atoms are in the alcohol molecule C_2H_5OH?
7. Which of these is a pure compound, which is an element, and which is neither: helium gas, carbon dioxide, polluted water, $C_6H_{12}O_6$, gold, steam?
8. Which of these is a pure compound, which is an element, and which is neither: pure water, oxygen gas, liquid mercury, H_2SO_4, U, air?
9. Suppose you obtained the smallest single particle of each of the following substances. In which cases would this

particle be a molecule made of more than one atom, and in which cases would it be a single unattached atom: pure water, oxygen gas in the form found in Earth's atmosphere, H_2SO_4, U, He, carbon dioxide, H_2, H?

10. Helium is an inert gas, meaning that it does not readily enter into chemical reactions with other substances. List five other substances that you would expect to also be inert gases.
11. Chlorine has a strong tendency to combine with a single hydrogen atom to form HCl. Look in the periodic table and list at least three other elements that you would expect to combine with hydrogen the way that chlorine does.
12. Consider a pure chemical substance A. Suppose that it can be chemically decomposed into two other pure substances B and C. Can we then conclude that B and C *must* be elements? That B and C *must* be chemical compounds? That A must be a chemical compound?
13. What is the chemical formula for methane (carbon and four hydrogens)?
14. What is the chemical formula for sulfur dioxide?
15. What is the chemical formula for carbon tetrachloride (*tetra* means "four")?
16. On the simplifying assumption that oxygen and carbon atoms have the same weight, how many tons of carbon dioxide gas are formed when 1 ton of coal burns (coal is nearly pure carbon)?
17. Referring to the preceding problem: In a typical large coal-fed electrical generating plant, a ton of coal is burned every 10 seconds. About how many tons of carbon dioxide enter the atmosphere every hour from such a plant?

THE ATOM'S EXPLANATORY POWER

18. Why can't you observe Brownian motion in easily visible objects such as floating bits of paper?
19. What is the chemical formula for the odor of violets (see Figure 2.6)?
20. A dog follows an escaped convict's trail by putting its nose to the ground. Explain this from a microscopic point of view.
21. If air is put into a sealed container that is then compressed (reduced in volume), what do you predict will happen to the air pressure on the container walls? Explain this from a microscopic point of view.
22. If air is put into a sealed container and warmed, what do you predict will happen to the air pressure on the container walls? Explain this from a microscopic point of view.
23. If a balloon is partially filled with air (so that it isn't fully expanded), sealed, and then warmed, what do you predict will happen to the balloon? Explain this from a microscopic point of view. What if the balloon is cooled

instead?

24. Why is it so difficult to remove the lid from a vacuum-sealed jar?
25. Suppose that you observe in Brownian motion tiny pollen grains floating in still air enclosed in a glass bottle. What would happen if you increased the amount of air? What would happen if you warmed the air?
26. Why does the air pressure in a tire increase as you add air? Why does the air pressure in a tire increase as you warm the tire?
27. Suggest an experiment that would show that air has weight.
28. What if, in addition to its random molecular motion, all the air molecules in some volume of air had an overall collective motion, all of them moving, say, eastward. Could this collective motion be observed macroscopically? What would we call it?

METRIC DISTANCES AND POWERS OF 10

29. Write as ordinary numbers: 10^{9}; 10^{-6}; 3.6×10^{13}; 5.9×10^{-8}.
30. Write in powers of 10 notation: 3 trillion; five-thousandths; 730,000,000,000,000; 0.000 000 000 082.
31. The distance to the moon is 384,000 km. Express this using powers of 10. How far is this in meters? In millimeters?
32. Our Milky Way galaxy contains perhaps 400 billion stars. Suppose that 0.05% (i.e., 0.000 5) of these stars have planetary systems containing at least one Earthlike planet (one that could conceivably support Earthlike life). Express these two numbers using powers of 10, and then multiply them together to find how many Earthlike planets there are in our galaxy. Express this number in words (thousands or millions, etc.).
33. The universe is a million trillion seconds old. Write this number in ordinary (not powers of 10) notation.

THE SMALLNESS OF ATOMS

34. Put these in order from lightest to heaviest: water molecule, oxygen atom, raindrop, hydrogen atom, glucose molecule, electron, DNA molecule.
35. Put these in order from lightest to heaviest: H_2 molecule, methane molecule, fine dust particle, hemoglobin molecule, proton, glucose molecule.
36. How old are a baby's atoms? Are they older than an old person's atoms? What about a baby's DNA molecules?
37. **Making estimates.** One sheet of paper is about 0.1 mm thick. An atom is about 10^{-10} m across. About how

many atoms thick is one sheet of paper?

38. **Making estimates.** The average weight, per atom, of the atoms in your body is about 10^{-26} kg (2×10^{-26} pounds). About how many atoms are there in your body?

39. **Making estimates.** The smallest dust particle visible to the unaided eye measures about 0.05 mm across. About how many *atoms* across is this? In other words, if we line up atoms side by side, about how many would it take to make a line of atoms 0.05 mm long?

40. **Making estimates.** Referring to the preceding exercise: Assume the small dust particle is shaped like a cube. About how many atoms does it contain?

CHEMISTRY AND LIFE

41. What is the chemical reaction formula for burning hydrogen gas in air? What substance is created by this reaction?

42. For safety, gas-filled balloons are filled with helium instead of hydrogen. What does this tell you about the behavior of helium in the atmosphere?

43. Gasoline is a hydrocarbon fuel. What are the main compounds created when gasoline burns in a car engine?

44. NO_X (nitrogen oxide and nitrogen dioxide) is one pollutant from automobiles. What elements must combine to form NO_X?

45. Referring to the preceding exercise: Gasoline contains neither oxygen nor nitrogen. So where must these elements come from when NO_X is formed in car engines?

46. Are there any molecules in your body that you could claim are “your” molecules, unique to your body and unlike any other molecules in the universe?