SECTION F– ANSWERS FOR END-OF-CHAPTER QUESTIONS

CHAPTER 1: THE AIR WE BREATHE

Emphasizing Essentials

1. $\frac{1\text{ L}}{1\text{ breath}} \times \frac{15\text{ breaths}}{1\text{ minute}} \times \frac{60\text{ minutes}}{1\text{ hour}} \times \frac{8\text{ hours}}{1\text{ working day}} = 7200\text{ L}$

2. $\frac{78\text{ L nitrogen}}{100\text{ L air}} \times 500\text{ L air} = 390\text{ L nitrogen}$

3. $\frac{0.25\text{ L carbon dioxide}}{5.0\text{ L air}} \times 100 = 5\%$ carbon dioxide by volume
Note this is considerably higher than the 0.03% by volume commonly found in dry air.

4. Examples of particulate matter found in air may include dust, soot, dirt, droplets of liquid, bacteria, and viruses. The difference between $PM_{2.5}$ and PM_{10} is due to size. The $PM_{2.5}$ particles are smaller (fine particles averaging less than 2.5 μm in diameter). The PM_{10} particles have an average diameter of less than 10μm. The smaller $PM_{2.5}$ particles are more damaging to human health

5. **a.** Ranked in order of abundance in the troposphere: $N_2 > O_2 > Ar > CO_2 > CO > Rn$
b. It is most convenient to express the concentrations of CO_2 and CO in terms of ppm. Using percent is more reasonable for N_2, O_2 and Ar. The concentration of Rn is best described in terms of ppb.
c. Among these gases, the EPA has set permissible levels for CO.
d. Yes, Rn is radon, a Group 8A noble gas.

6. **a.** $9000\text{ ppm} \times \frac{100\text{ parts per hundred}}{1{,}000{,}000\text{ ppm}} = 0.9\text{ parts per hundred or } 0.9\%$

b. $0.04\text{ parts per hundred} \times \frac{1{,}000{,}000\text{ parts per million}}{100\text{ parts per hundred}} = 400\text{ parts per million}$

c. $50{,}000\text{ ppm} \times \frac{100\text{ parts per hundred}}{1{,}000{,}000\text{ ppm}} = 5\text{ parts per hundred or } 5\%$

7. Oxygen reacts with the metabolic byproducts of foods during the process of human metabolism to produce carbon dioxide and water. This has the effect of *decreasing* the percentage of oxygen in exhaled air, but *increasing* the percentage of carbon dioxide.

8.

Air going into car engine	Air going out of tailpipe
N_2, O_2, Ar, CO_2, water vapor	N_2, O_2, CO_2, CO, water vapor, VOCs

The amount of CO_2 and water vapor coming out of a tailpipe will increase with respect to the amount going in.

9. **a.** 1.5×10^{3} m **b.** 9.58×10^{-11} m
c. 7.5×10^{-6} m **d.** 1.5×10^{5} mg

10. **a.** 85,000 g **b.** 10,000,000 gallons
c. 0.0050 % **d.** 0.00001 g

11. **a.** 7.2×10^7 cigarettes **b.** 1.5×10^4 °C
c. 3×10^{-9} g **d.** 2.2×10^{-4} g

12. The troposphere ends at approximately 15 km. Consult Figure 1.10 to find these values.

Altitude (km)	0	5	10	15	20
Pressure (atm)	1	0.50	0.25	0.16	0.12

Going from 0 to 5 km, the pressure drops by 50% from 1 atm to 0.50 atm. Then going from 5 to 10 km, the pressure also drops by about 50% from 0.50 to 0.25%. The relationship no longer holds true going from 10 km to 15 km because the pressure only drops from 0.25 atm to 0.16 atm, not to the 0.12 atm which would represent a 50% drop. The relationship is not valid throughout the entire troposphere, only to about 10 km.

13. **a**. Group 1A and Group 7A

b. 1A: hydrogen, lithium, sodium, potassium, rubidium, cesium, francium

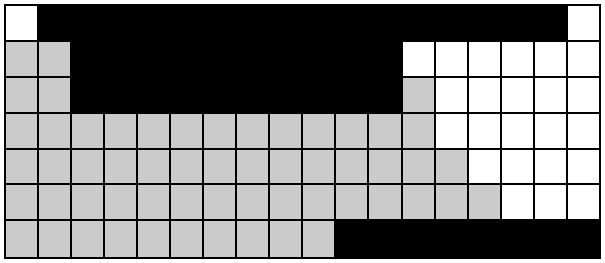
7A: fluorine, chlorine, bromine, iodine, and astatine

c. 1A: These are all reactive nonmetals.

7A: These are all reactive nonmetals.

14.

a.



b. iron, Fe; magnesium, Mg; aluminum, Al; sodium, Na; potassium, K; silver, Ag.
c. Answers will vary.

15. **a.** compound **b.** compound **c.** mixture
d. element **e.** mixture **f**. element

16. **a.** potassium oxide **b.** aluminum chloride
c. sodium iodide **d.** magnesium bromide

17. **a.** N_2O **b.** O_3 **c**. NaF **d.** CCl_4

18. **a.** One atom of the element carbon, two atoms of the element hydrogen, and one atom of the element oxygen are combined to form one molecule of formaldehyde, CH_2O.

b. Two atoms of the element hydrogen are combined with two atoms of the element oxygen to form one molecule of hydrogen peroxide, H_2O_2.

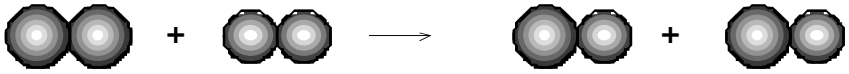
c. One atom of the element carbon, three atoms of the element hydrogen, and one atom of the element bromine are combined to form one molecule of methyl bromide, CH_3Br.

19. **a.** $N_{2(g)} + O_{2(g)} \rightarrow 2\ NO_{(g)}$

b. $O_{3(g)} \rightarrow O_{2(g)} + O_{(g)}$

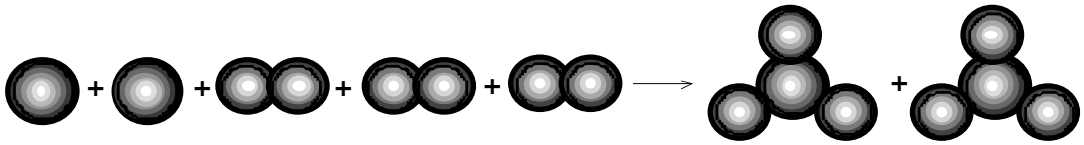
c. $2\ S_{(s)} + 3\ O_{2(g)} \rightarrow 2\ SO_{3(g)}$

20. a.



b.

c.



21. a. $C_2H_4(g) + O_2(g) \rightarrow 2\ C(s) + 2\ H_2O(g)$

b. $C_2H_4(g) + 2\ O_2(g) \rightarrow 2\ CO(g) + 2\ H_2O(g)$

c. $C_2H_4(g) + 3\ O_2(g) \rightarrow 2\ CO_2(g) + 2\ H_2O(g)$

22. The balanced equations show that complete combustion requires the highest ratio of oxygen to ethylene. If limited oxygen is present, carbon monoxide and water are formed. Carbon monoxide is a toxic gas that is responsible for the deaths of several people each winter, usually from inadequately ventilated stoves or space heaters. If very limited oxygen is available, then solid carbon, such as soot or lampblack, is formed. Note that water is a product of all three equations describing the combustion of ethylene.

23. a. C = 6, H = 16, O = 14 on each side of the equation.

b. C = 16, H = 36, O = 50 on each side of the equation.

24. a. platinum = Pt, palladium = Pd, rhodium = Rh

b. All three metals are in Group 8B on the periodic table. Platinum is directly under palladium, and rhodium is just to the left of palladium.

c. These metals are solids at the temperature of the exhaust gases, so they must have relatively high melting points. Also, they do not undergo permanent chemical change when catalyzing the reaction of CO to CO_2 in the exhaust stream.

25. 6 m x 5 m x 3 m = 90 m^3; 40 ppm means 40 mg of formaldehyde for every m^3 of air.

$$\frac{40\text{ mg formaldehyde}}{1\text{ m}^3} \times 90\text{ m}^3 = 3600\text{ mg formaldehyde, which is } 3.6 \times 10^3\text{ mg}$$

Concentrating on Concepts

26. Air is often described as “invisible” if only colorless gases are present. If the air contains condensed water vapor, airborne particulate matter, or gases that have a distinct color, then it can be “seen”.

27. Answers will vary depending on the answer calculated in 1.1 Consider This and the size of the classroom. For most students, the volume of air inhaled in a day will be on the order of 10^4 L or 10^7 cm^3. Classrooms will hold a much greater volume of air. If the length, width, and height measurements are estimated in meters, and then converted to cm, the calculated volume of air in the room will be in cm^3. This will facilitate the comparison with liters of air inhaled in a day, which can easily be changed to mL or cm^3.

28. These are a few possible examples of changes that would take place if the concentration of oxygen in the atmosphere were halved.

1. Iron and steel would rust more slowly, prolonging the useful life of many objects made from these materials.
2. Anything burning would last for a longer time, such as the charcoal in your grill, a log in your fireplace, or the gasoline in your car's engine.
3. We would have to breathe at approximately twice the present rate since we would get less oxygen per breath.

29. CO is termed the "silent killer" because your senses cannot detect this colorless and odorless gas. The same term cannot be applied to either O_3 or SO_2. Each has a distinctive odor that can be detected at concentrations below the level of toxicity.

30. **a.** Many students will represent these data with a bar graph and others will use some form of pictograph or even a traditional graph. Communication of the information will be helped with good labeling and with an informative title for the visual representation.

b. The air quality in Philadelphia, PA does not to show a regular trend through the 1992-1999 time period, although since 1993 it has been consistently better than it was in 1993. The air quality in Phoenix, AZ since 1992 has been consistently better than that in Philadelphia, with the worst year on record since 1992 coming in 1995.
c. There is very little predictive value in these graphs; the trends are not regular enough. For example, the actual readings in 1993 were 16 days for Phoenix and 51 days for Philadelphia, neither of which could be predicted from the graphs.

31. Reporting the absolute difference, 0.01 ppm, does not sound very significant and minimizes the amount by which the standard is exceeded, at least in the eyes of the general public. Unless the standard is reported as well, there is no way to compare the magnitude of the difference to the magnitude of the standard. Calculating the percentage by comparing the difference (0.01 ppm) to the standard (0.12 ppm) gives 8%, which may give the general public a better understanding of the relative amount by which the standard has been exceeded.

32. **a.** The order of increasing length is 5.0×10^{-3} m, 1 m, and 3.0×10^{2} m.
b. If 1 meter is 1 year, then 3.0×10^{2} m is equivalent to 300 years. 5.0×10^{-3} m is equivalent to 0.0050 years. This is about 1.8 days.

33. Air quality data is gathered by state and local offices and may not be available on a timely basis to television stations or to newspapers. The Environmental Protection Agency has links to state websites that post air quality data, but only 14 states and the District of Columbia are included at the time this is being written. Television stations have ready access to weather information collected by the National Weather Service or by their own Doppler Radar System, and may even use this as an advertising point to attract viewers. It may also be that viewers and readers are far more interested in weather information than they are in air quality data, at least until it begins to affect their daily activities.

34. Perception of risk depends not only on the actual risk, but involves highly individual decisions. These are some factors that may be brought to bear on the rankings.
• Roller blading: Will not be high risk for many students, particularly if protective gear is worn
• Eating raw cookie dough: could be risky depending on if raw eggs are an ingredient (risk of Salmonella poisoning)
• Driving on the expressway: Level of risk is highly dependent on the area in which one drives
• Breathing second hand smoke: Long term risks of developing lung cancer, heart disease
• Not wearing a bike helmet: Some risk of brain damage
• Eating beef: Will not be considered a risk for some, but is considered a risk by vegetarians
• Taking aspirin: Many will not consider this a risk, but overuse of aspirin can lead to bleeding ulcers or other unwanted effects
• Drinking tap water: Not considered a high risk in most areas. The book and film *A Civil Action* might affect opinions for some students.

35. Figure 1.10 shows that atmospheric pressure *decreases* with *increasing* altitude. However, this is not a straight-line relationship. Humans can adjust to the somewhat reduced atmospheric pressure observed in Denver; approximately 0.8 atm. Pressure falls more steeply at higher altitudes and at 30,000 ft, the pressure is only about 0.3 atm. Humans can not adjust to this very low atmospheric pressure.

36. Sample **a.** represents a compound because two different atoms are joined.

Sample **b.** represents a mixture because two different types of atoms are shown.

Sample **c**. represents a mixture because both elements and a compound are shown.

Sample **d.** represents an element because all of the atoms are the same.

37. **a.** Yes, the masses of reactants and products are the same. The Law of Conservation of Mass is obeyed.

b. No, the number of molecules of reactants and products are not the same. There are four molecules of reactants represented, but only two molecules of products.

c. Yes, the numbers of each type of atom present as reactants and products are the same. The Law of Conservation of Mass is obeyed. There is the same number of atoms of each element represented on both sides of the equation.

38. **a.** Jogging outdoors, as opposed to sitting outdoors, increases your exposure to air pollutants because you will be breathing harder and exchanging more air during your exercise.

b. See answer to question 42; also consider information in Table 1.10.

39. While there is not a direct proportion in the strict mathematical sense, there has been a general downward trend in annual variation in lead concentrations in human blood since 1976. Although this appears to start with the banning of lead in gasoline in 1976, the graph does not provide any information from before 1976, making a firm conclusion impossible.

40. **a.** Beijing has some serious air-pollution problems, particularly with respect to SO_2 and particulate matter (See Table 1.9). The reduced visibility caused by airborne particulate matter helps to establish the motivation for going to an "oxygen bar" for a breath of invigorating fresh air.

b. Considering the levels of particulate shown in Table 1.9, the most likely markets to consider appear to be Bangkok, Thailand, Cairo, Egypt, Jakarta, Indonesia, Cairo (Egypt), and Mexico City, Mexico.

41. One possible solution is to suggest that only one vehicle permit per household be issued, which would encourage more carpooling, or even working at home. Another would be to suggest development of a system of peripheral parking lots to allow better access to centralized bus and other mass transit systems, decreasing the number of vehicles in the congested city centers. Any suggestion offered must be aimed at decreasing the number of miles driven by automobiles during peak rush hours if it is to be effective in improving air quality.

42. Formaldehyde can be released from cigarette smoke and from synthetic materials such as foam insulation, and from the adhesives used in dying and gluing carpet pads, carpets, and laminated building materials. The air indoors is often not well circulated, leading to an accumulation of formaldehyde and other pollutants. Efforts to make homes air tight, leading to greater energy efficiency, have led in some cases to making problems of indoor air pollution worse, rather than better.

Exploring Extensions

43. The volume percentage concentration means that the volume of the oxygen molecules accounts for 21% of the total volume. The mass percent means that the mass of the oxygen molecule accounts for 23% of the

total mass. The other major component of the atmosphere is nitrogen gas, so oxygen gas molecules must be slightly heavier than nitrogen gas molecules.

44.  Visit the *Chemistry in Context* website at http://www.mhhe.com/cic, or directly enter the EPA website through http://www.epa.gov. Then find the Green Chemistry website can be at http://www.epa.gov/greenchemistry. The Presidential Green Chemistry Challenge was established by President Clinton to promote pollution prevention and industrial ecology in partnership with the chemical industry. The program originated in 1995. The most recent winners at this time are the 2004 winners, but the website will give up-to-date information. The summaries should reflect individual understanding of the Green Chemistry advance, not just the words used on the website.

45.  A web search for Nitrox® will lead to the information that these mixtures are enriched in oxygen, compared with the usual atmospheric composition; the percentage oxygen is enriched to over 30%. Divers use Nitrox because it allows longer and deeper dives. Because Nitrox is enriched in oxygen, it has a reduced nitrogen composition. This is desirable because at greater depths, nitrogen dissolves to a greater extent than does oxygen in the bloodstream. Then, as the diver returns to the surface, bubbles of nitrogen gas are released from the blood stream. This can cause a painful condition known as the "bends" and may lead to death in extreme cases.

46. **a.** The trends in the Pollutant Standards Index rating are not identical in any of the cases. Since 1992 Denver has had a very small number of days when it did not meet acceptable air-quality standards. Compared to Houston, Boston had a relatively small number of noncompliance days, but the trend in the number of those days is unclear. Houston shows a relatively large number of unacceptable air-quality days with no obvious decline occurring.

b.  Many factors could be researched, including climate statistics, weather patterns, population growth, changes in industry, and development of rapid transit. Be careful not to place too much dependence on these statistics as indications of definite trends that can be used for prediction.

47. The term nanotechnology means the ability to assemble atoms in exactly the structure desired. Being able to manipulate individual atoms, typically with diameters measure in nanometers, will make it possible to assemble new machines the size of molecules, making lighter, stronger, smarter, cheaper, cleaner, and more precise products.

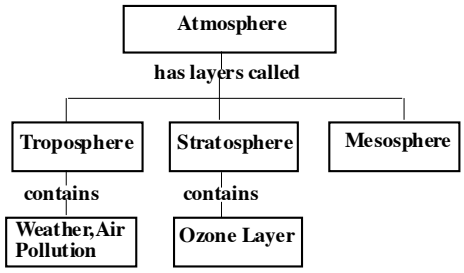
48. In addition to the rogue scientists in ``Prey," the Michael Crichton novel mentioned in this question, consider the following. In his 1986 book ``Engines of Creation," Palo Alto theorist K. Eric Drexler popularized the notion of building things atom by atom, using tiny, self-replicating machines. At the same time, he warned that these ``molecular assemblers" could multiply out of control, forming a gray goo that destroys life on the planet. In 1990, Sun Microsystems co-founder Bill Joy built on that notion with an essay in *Wired* magazine. He suggested that the world faces an unprecedented threat from a trio of technologies -- nanotechnology, biotechnology and robotics -- that have one thing in common: They are capable of producing things that make copies of themselves, and thus could evolve to become more powerful than humans.

In 2004, President Bush's science adviser, John Marburger noted the importance of focusing on the societal impact of nanotechnology. It is something the Office of Science and Technology Policy "is following closely," he said. Referencing the Nanotechnology Research and Development Act enacted in 2003, Marburger applauded its provisions related to societal concerns. He concluded that it is critical "to establish credible approaches to identifying and dealing with potential impacts of nanotechnology to preserve public credibility for this important emerging field." Research is underway at several institutions at the writing of this edition.

Helpful Web sites: http://www.ruf.rice.edu/~cben/ColvinTestimony040903.shtml

http://www.nsf.gov/home/crssprgm/nano/BroaderSocIssue.pdf
http://nanotech-now.com/2004-july-news.htm

49. The concept web shows that the three terms describe regions of the atmosphere. Figure 1.8 also shows the regions, but also gives their position relative to the surface of the earth and each other, which is an advantage. Figure 1.8 gives some indication of the reason why the troposphere is important to study of this chapter, and why the stratosphere will become important in the next chapter. The concept web could be reordered, and then expanded with other links to represent that information. Consider this expanded web.



50. **a.** This graph clearly indicates that exposure to greater and greater carbon monoxide concentrations for longer and longer periods of time becomes increasingly life-threatening.

b. Answers will vary. All paragraphs should indicate the serious health threat posed by the presence of carbon monoxide in the atmosphere. Additionally, students may wish to mention that this gas is colorless and odorless, making it impossible to detect without a detection kit. Furthermore, the initial symptoms of carbon monoxide poisoning are not unique, and those suffering from the associated headaches and nausea could easily presume the symptoms are due to the flu. Untreated, individuals will ultimately lapse into a coma, after which point they will be unable to call for assistance. For these reasons, a carbon monoxide detector could become a life-saving device.

51. **a.** It appears that the peak concentrations of both hydrocarbons and ozone occur during the daytime hours when human activity is at its greatest level. Hydrocarbon concentration peaks in the morning hours corresponding to high levels of automobile use.

b. One would expect that levels of NO would follow the same pattern as that for the hydrocarbons, increasing as human activity increases. NO forms as a result of VOCs reacting with hydroxyl radicals according to Equation 1.11. NO is a player in the formation of tropospheric ozone. While one cannot predict the levels of NO on this graph, it is reasonable to suggest that the peak level would occur at a time somewhere between the peak levels of hydrocarbons and ozone.

c. Health effects in this urban area might include respiratory ailments, reduced lung function and congestion. The ultimate formation of NO2 could lead to respiratory infections.

52. Answers will vary. The following EPA site allows searches based on location. It creates reports based on total chemical release or ones focused on industrial sites. It shows trends and data can be compiled for different years. http://www.epa.gov/triexplorer/chemical01.htm?year=2000

53. Essays will vary and this is an opportunity for the creative students to have some fun. See Section G, Consider This 1.3 for ideas that might be incorporated into the essays.

54. Answers will vary. Something to consider: mercury concentrations in air are usually low and of little direct concern. But when mercury enters water, biological processes transform it to a highly toxic form that builds up in fish and animals that eat fish. People are exposed to mercury primarily by eating fish.

55. **a.** $2\ NO_2 \rightleftharpoons N_2O_4$

b. There may be more moisture in the air on a warm summer day adding to the color.