

AP Chemistry Midterm Study Guide Problems

The following problems can be found in the supplementary study guide for your text book. Answers are available in the back of the study guide to check your work. This assignment will be graded on completeness and effort. Please show all work NEATLY, circle final answer with units and significant figures where applicable.

Chapter 1

Skim chapter 1 look at the sample exercises and work

Do the following exercise problems starting on pg 14

36,55,61,62

Chapter 2

Skim chapter 2 look at the sample exercises and work

Skim chapter 2

Do the following exercise problems starting on pg 39

4, 10(a-c),12 16,20-23,27,30,43

Chapter 3

Skim chapter 3 look at the sample exercises and work

Skim chapter 3

Do the following exercise problems on pg problems starting on pg 70

2,11,14,18,20,25,27,34,35,42-44,57,60,64,69

Chapter 4

Skim chapter 4 look at the sample exercises and work

Skim chapter 4

Do the following exercise problems starting on pg 107

1,4,6,8,10a,14,20,25,26,29,43,50,51,53*,73,84

* Id LEO and GER we will do half rxns as class.

Chapter 5 Gas Laws

Skim chapter 5 look at the sample exercises and work

Do the following exercise problems starting on pg 139

10-14even,15,25,29,31,45,41,47

Chapter 7 Quantum Numbers and Periodicity and PES

See webpage for PES materials

Skim chapter 7 look at the sample exercises and work

Do the following exercise problems starting on pg 182

4,23,29 (a-c), 30,34 (a), 36,46,49,52,55 (also review how to write an electron configuration and orbital diagram)

Chapter 6 Thermo

Skim chapter 6 look at the sample exercises and work

Do the following exercise problems starting on pg 160

1,3,15,18,19,21a-c,29

Chapter 16 ΔG , ΔS , ΔH

Skim chapter 16 look at the sample exercises and work

Do the following exercise problems starting on pg 399

4,9,10,20,37-38

Chapter 17 Electrochemistry

Skim chapter 17 look at the sample exercises and work

Do the following exercise problems starting on pg 420

5,10,13,18,20,26,36,44

Chapter 22 Organic

Skim chapter 22 look at the sample exercises and work

Do the following exercise problems starting on pg 500

1,2,6,10-12, 14,16,19,29-33,39,40,43,49,51,55

$$\text{Displacement of water} = \underset{\substack{\text{water} \\ + \\ \text{metal}}}{56.85 \text{ mL}} - \underset{\substack{\text{original} \\ \text{volume} \\ \text{of water}}}{31.47 \text{ mL}} = 25.38 \text{ mL}$$

$$\text{Density of the metal} = \frac{287.8 \text{ g}}{25.38 \text{ mL}} = 11.34 \text{ g/mL}$$

According to Table 1.5 in your textbook this metal is lead.

Problems 30-35 and 61-63 at the end of this study chapter cover material from this section.

1.9 Classification of Matter

This study section will help guide you through some of the terms and techniques that are discussed in this section of your textbook.

Terms you should be able to define:

1. Matter
 - a. solid
 - b. liquid
 - c. gas
2. Mixtures
 - a. homogeneous (solution)
 - b. heterogeneous
3. Physical and Chemical Changes
4. Compounds and Elements

You should be able to describe the following separation techniques:

1. Distillation
2. Filtration
3. Chromatography

Problems 36-37 and 64-66 at the end of this study chapter cover material from this section.

Exercises

1. In a simulated boxing match done on a computer several years ago, Joe Louis (champion in the 1940s) defeated Muhammad Ali (champion in the 1960s) in 15 rounds. The computer simulation took into account the fighters' height, weight, styles, punching power, and speed. Was the simulation realistic? What other variables would have to be included to make the simulation more valid?
2. If your chemistry teacher said she knew that the Earth is flat, and challenged you to prove, using scientific tests, that she was wrong, what tests might you perform?
3. List the fundamental units that you would combine to get the following derived units (you may need to look up the meaning of some of the terms):

a. velocity	d. specific heat
b. acceleration	e. density
c. volume	f. pressure

4. Put the following prefixes in order, from smallest to largest: femto, tera, mega, deci, kilo, atto, exa.
5. Put the following prefixes in order, from smallest to largest: giga, hecto, micro, peta, milli, nano, pico.
6. Three students weighed the same sample of copper shot five times. Their results were as follows:

<u>weighing</u>	<u>Student #1</u>	<u>Student #2</u>	<u>Student #3</u>
1	17.516 g	15.414 g	13.893 g
2	17.888 g	16.413 g	13.726 g
3	19.107 g	14.408 g	13.994 g
4	21.456 g	15.637 g	13.810 g
5	19.983 g	15.210 g	13.476 g

- a. Calculate the mean (average) mass of the sample, as determined by each student.
- b. The average deviation (a.d.) is a measure of precision. It is calculated by the formula:

$$\text{a.d.} = \frac{\sum_{i=1}^n |x_i - \bar{x}|}{n}$$

That means that you take each of the values in a data set (5 total values), subtract the mean, and take the absolute value. Add up all 5 absolute values and divide the total by 5. That number is your a.d. Calculate the average deviation for each of the students' data.

- c. If the true mass of copper shot is 15.384 g, which of the students was most accurate? Which was most precise? What could be the possible sources of error in the determinations?
7. A student weighed 15 pennies on a balance and recorded the following masses:

3.078	3.055	3.060	3.066	3.102
2.107	3.121	2.518	3.052	2.476
2.546	3.050	3.073	3.080	3.128

- a. Calculate the mean mass.
- b. What might cause the difference in weights?
8. Define the following terms:

a. accuracy	c. random error
b. precision	d. systematic error

9. How many significant figures are there in each of the following values?
- | | |
|---------------------------|--------------------|
| a. 6.07×10^{-15} | d. 8×10^8 |
| b. 0.003840 | e. 463.8052 |
| c. 17.00 | |
10. How many significant figures are there in each of the following values?
- | | | |
|------------|--------------|---------------------------|
| a. 1406.20 | c. 1600.0 | e. 1.250×10^{-3} |
| b. 0.0007 | d. 0.0261140 | |
11. Which value has more significant figures, 7.63×10^{-11} or 0.00076?
12. Use exponential notation to express the number 37,100,000 with:
- | | |
|-----------------|-------------------|
| a. one sig fig | c. three sig figs |
| b. two sig figs | d. six sig figs |
13. Perform the indicated calculations on the following measured values, giving the final answer with the correct number of significant figures.
- | |
|--|
| a. $16.81 + 3.2257$ |
| b. 324.6×815.991 |
| c. $(3.8 \times 10^{-12} + 4 \times 10^{-13}) / (4 \times 10^{12} + 6.3 \times 10^{13})$ |
| d. $3.14159 \times 68 / (5.18 \times 10^{-11} - 6 \times 10^{-4})$ |
14. Perform the indicated calculations on the following measured values, giving the final answer with the correct number of significant figures.
- | | |
|--------------------------|---|
| a. $2.85 + 3.4621 + 1.3$ | d. $27 / 4.148$ |
| b. $7.442 - 7.429$ | e. $[(3.901 - 3.887) / 3.901] \times 100.0$ |
| c. 1.65×14 | f. $6.404 \times 2.91 \times (18.7 - 17.1)$ |
15. Using the conversion factors in the inside back cover of your textbook, convert 3.5 quarts to:
- | | |
|---------------------|--|
| a. liters (L) | c. microliters (μL) |
| b. milliliters (mL) | d. cubic centimeters (cm^3) |
16. Using the conversion factors in the inside back cover of your textbook, convert 4.2 yards to:
- | | |
|----------------|----------------|
| a. meters | c. micrometers |
| b. centimeters | d. kilometers |
17. If you put 8 gallons of gas in your car and it cost you a total of \$9.20, what is the cost of gas per liter?
18. A runner can run a 5.0 kilometer race in a time of 21 minutes and 22 seconds.
- | |
|--|
| a. What is the runner's speed in miles per hour? |
| b. How long, on the average, did it take for the runner to run one mile? |
19. A student made the 27.0 kilometer drive to school in 16 minutes.
- | |
|--|
| a. How many miles did the student drive? |
| b. If the speed limit is 55 mph, was the student speeding? How fast was the student driving? |
20. A radio station broadcasts at a frequency of 107.9 megahertz (MHz), (cycles per second).
- | |
|--|
| a. How many seconds per cycle are there in 107.9 MHz? |
| b. What is the broadcast frequency in gigahertz (GHz)? |

21. A 5 lb bag of flour costs \$0.89. What is the cost of flour per kilogram?
22. A "joule", like a calorie, is a unit of energy. There are 4.184 joules per calorie. How many joules of energy are available in one ounce of Frosted Flakes, which has 120,000 calories? (Note: a "food calorie" (called a Calorie, with a capital "C") = 1000 energy calories.)
23. If you have to eat 20 tablespoonfuls of cereal to eat the entire ounce of dry Frosted Flakes (discussed in the previous problem) and there are 3 teaspoon measures in one tablespoon, how many food calories of Frosted Flakes are in each teaspoonful?
24. During a recent baseball game, a pitcher threw a fastball that had a velocity of 93.7 mph.
- Calculate the velocity in meters/second.
 - Calculate how long it took this pitch to travel from the mound to home plate (60 ft 6 in).
25. Which of the following is greater:
- 35 kg or 3500 g?
 - 6×10^4 mL or 6×10^3 L?
26. If a student weighs 185 lb, what is his mass in μg ?
27. Which is the higher temperature, 42°C or 92°F ?
28. Perform the following temperature conversions:
- $300. \text{K}$ to $^\circ\text{F}$
 - $300.^\circ\text{F}$ to K
 - $-40.^\circ\text{F}$ to $^\circ\text{C}$
 - $-100.^\circ\text{C}$ to K
 - 1555K to $^\circ\text{C}$
 - 0.0K to $^\circ\text{F}$
29. Perform the following temperature conversions:
- 16°C to $^\circ\text{F}$
 - 305K to $^\circ\text{F}$
 - 0.0°F to $^\circ\text{C}$
 - 150°F to K
 - -45°C to K
 - 920K to $^\circ\text{C}$
30. A sample of motor oil with a mass of 440 g occupies 500 mL. What is the density of the motor oil?
31. A worker at the United States Mint wants to know if a batch of 100 pennies was minted before 1982 (100% copper) or after 1982 (3% copper and 97% zinc). Assuming that both groups of pennies had the same dimensions, would she get her answer by weighing the coins? Explain.
32. The density of an object is 1.63 g/mL . Its volume is 0.27 L. What is the mass of the object?
33. An object weighing 4.0 lbs occupies 1700 mL. What is the density of the object in g/mL ?
34. The density of the Earth is about 3.5 g/cm^3 . If the Earth has a radius of 7000 miles, what is its mass? (volume = $[4\pi r^3/3]$)
35. Which of the following is less:
- 8.7 g/mL or $6.1 \mu\text{g}/\mu\text{L}$?
 - $4 \times 10^{-2} \text{ kg/cm}^3$ or $4 \times 10^{-1} \text{ mg/cm}^3$?
36. Define the following:
- mixture
 - pure substance
 - homogeneous
 - heterogeneous
37. List five physical methods of separating mixtures.

Multiple Choice Questions

38. Which of the following is the correct order of steps to establish a theory?
- Conducting experimental work, collecting observations, making a hypothesis, establishing a theory.
 - Establishing a theory, conducting experimental work, collecting observations, making a hypothesis.
 - Making a hypothesis, collecting observations, establishing a theory, conducting experimental work.
 - Collecting observations, making a hypothesis, conducting experimental work, establishing a theory.
39. Which of the following statements is not an observation?
- There are two hydrogen atoms and an oxygen atom in a water molecule.
 - The Earth is the third planet of our solar system.
 - The Universe might have begun with a Big Bang explosion which took place approximately 15 billion years ago.
 - In a total absence of water, plants cannot survive.
40. Which one of the following is not one of the seven basic SI units?
- Mass
 - Volume
 - Time
 - Mole
41. The basic unit for amount of substance is:
- Mole
 - Liter
 - Kilogram
 - Gram
42. A picometer is
- Greater than a micrometer
 - Equal to a micrometer
 - Less than a micrometer
 - Twice as large as a micrometer
43. Which of the following units would best describe the distance between two asteroids that are 8 deca hecto kilo miles apart?
- Gigamile
 - Teramile
 - Macromile
 - Megamile
44. The number of zeroes preceding and following the decimal point for the following two prefixes, femto and exa, are
- 18 and 18
 - 14 and 18
 - 15 and 18
 - 15 and 19
45. Which of the following cannot be an exact number
- Three eggs
 - 12 mL of water measured in a 20-mL cylinder
 - 12 roses
 - 2400 air flights
46. Which of the following is the estimated error for 12.3008 g of sugar?
- ± 0.001
 - ± 0.0001
 - ± 0.0008
 - ± 0.00001
47. Which number has the greatest uncertainty?
- 1.02 ± 0.01
 - 4.60 ± 0.01
 - 100.0 ± 10.00
 - 1.00 ± 0
48. Round 20.589958 to 4, 3, and 2 significant figures, respectively
- 20.59, 20.5, 20
 - 20.58, 20.5, 20
 - 20.60, 20.6, 21
 - 20.59, 20.6, 21
49. The solution to $(22.41 + 0.464) \times 999/18.465$ is
- 1237.32
 - 1.24×10^3
 - 1.2×10^4
 - 1237

50. The solution to $9.99/22.41 \times (18.465 + 0.464)$ is
 A. 8.44 B. 8 C. 8.4 D. 8.438
51. Assume mass and weight to be equivalent, i.e. $28.4 \text{ g} = 1.00 \text{ oz}$. Calculate the weight of the earth in lbs if its mass is $3.7 \times 10^{24} \text{ kg}$.
 A. $8.1 \times 10^{24} \text{ lbs}$ B. $8.3 \times 10^{38} \text{ lbs}$ C. $4.0 \times 10^{20} \text{ lbs}$ D. $1.7 \times 10^{69} \text{ lbs}$
52. What are the dimensions, in metric units, for a linebacker who is 6' 4.0" and weighs 245 lbs?
 A. 193 cm and 6,900 g C. 0.193 m and 100 kg
 B. 1.93 m and 111 kg D. 1.11 m and 193 kg
53. A rectangular tile, 15 by 18 inches, can be converted into square meters by which one of the following conversion setups?
 A. $(15\text{in} \times 18\text{in}) (2.54\text{cm}/1\text{in}) (1\text{m}/100\text{cm})$ C. $(15\text{in} \times 18\text{in}) (2.54\text{cm}/1\text{in})^2 (1\text{m}/100\text{cm})^2$
 B. $(15\text{in} \times 18\text{in}) (2.54\text{cm}/1\text{in})^2 (1\text{m}/100\text{cm})$ D. $(15\text{in} \times 18\text{in}) (2.54\text{cm}/1\text{in}) (1\text{m}/100\text{cm})^2$
54. A parsec is an astronomical unit of distance. 1 parsec = 3.26 light years (or the distance traveled by light in one year). Light speed = 186,000 miles per second. An object travels 9.6 parsecs. Calculate this distance in cm.
 A. $2.0 \times 10^{13} \text{ cm}$ B. $3.0 \times 10^{19} \text{ cm}$ C. $9.6 \times 10^8 \text{ cm}$ D. $3.7 \times 10^{15} \text{ cm}$
55. How many cubic feet are there in a cube whose edge is 6.0×10^{21} miles in length?
 A. 2.2×10^{63} B. 3.2×10^{76} C. 1.0×10^{27} D. 3.6×10^{42}
56. Ultra-deka light is ten times the speed of light (speed of light = 186,000 miles per second). How many feet will a space vessel travel at ultra-deka light in 10 seconds?
 A. 9.8×10^{10} B. 6.7×10^7 C. 1.9×10^9 D. 3.9×10^9
57. 8 quarts = 1 peck, and 4 pecks = 1 bushel. How many quarts are there in half megabushel?
 A. 1.6×10^7 B. 1.3×10^4 C. 4.0×10^6 D. 6.5×10^7
58. At what temperature does $^{\circ}\text{C} = 0.5 (^{\circ}\text{F})$?
 A. $^{\circ}\text{C} = 60$ and $^{\circ}\text{F} = 120$ C. $^{\circ}\text{C} = 45$ and $^{\circ}\text{F} = 90$
 B. $^{\circ}\text{C} = 160$ and $^{\circ}\text{F} = 320$ D. $^{\circ}\text{C} = 0$ and $^{\circ}\text{F} = 0$
59. The average daytime temperatures on Earth and Jupiter are 72°F and 313 K , respectively. Calculate the difference in temperature, in $^{\circ}\text{C}$, between these two planets.
 A. 18°C B. 32°C C. 20°C D. 193°C
60. A column of liquid is found to expand linearly on heating 5.25 cm for a 10°F rise in temperature. If the initial temperature of the liquid is 98.6°F , what will the final temperature be in $^{\circ}\text{C}$, if the liquid has expanded by 18.5 cm?
 A. 37.0°C B. 72.2°C C. 19.6°C D. 56.6°C
61. Calculate the density, in kg/L, of a block of wood 2.5 feet by 18 inches by 1 yard that weighs 646 lbs.
 A. 0.92 kg/L B. 9.2 kg/L C. 1.1 kg/L D. 4.9 kg/L

62. The specific gravity of benzene is 0.865 and the density of water is 0.996 g/cm^3 at 25°C . Specific gravity is defined as the ratio of the density of some material to the density of some standard material, such as water. Calculate the density of benzene at 25°C .
- A. 0.865 g/cm^3 B. 0.862 g/cm^3 C. 1.000 g/cm^3 D. 0.996 g/cm^3
63. If the volume occupied by an electron equals that occupied by a proton, what is the ratio of densities of proton to electron? You can consult your textbook to find the mass of the electron and that of the proton.
- A. 1840:1 B. 1:1000 C. 1000:1 D. 1.00:1.00
64. Which of the following is a pure substance?
- A. An egg B. Sea water C. Bronze D. Copper
65. Which of the following is a homogeneous mixture?
- A. An egg B. Copper C. Oil and vinegar D. An unused piece of photocopy paper
66. One of the following techniques is the least desirable for separating sand and water
- A. Freezing B. Decanting C. Evaporation D. Extraction

Exercises

1. In an exothermic (heat producing) reaction, chlorine reacts with 2.0200 g of hydrogen to form 72.926 g of hydrogen chloride gas. How many grams of chlorine reacted with hydrogen?
2. Sulfur and oxygen can react to form both sulfur dioxide and sulfur trioxide. In sulfur dioxide, there are 32.06 g of sulfur and 32.00 g of oxygen. In sulfur trioxide, 32.06 g of sulfur are combined with 48.00 g of oxygen.
 - a. What is the ratio of the weights of oxygen that combine with 32.06 g of sulfur?
 - b. How do these data illustrate the law of multiple proportions?
3. By experiment it has been found that 2.18 g of zinc metal combines with oxygen to yield 2.71 g of zinc oxide. How many grams of oxygen reacted with zinc metal?
4. A sample of H_2SO_4 contains 2.02 g of hydrogen, 32.07 g of sulfur, and 64 g of oxygen. How many grams of sulfur and grams of oxygen are present in a second sample of H_2SO_4 containing 7.27 g of hydrogen?
5. Describe what part of Dalton's Atomic Theory each chemical statement relates to.
 - a. $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$
 - b. There are 3.01×10^{23} atoms in 20.04 g of calcium.
 - c. Lead does not change to chromium when it forms lead hydroxide.
6. Identify each of the following elements:

a. ${}_{40}^{91}\text{X}$	d. ${}_{36}^{85}\text{X}$
b. ${}_{47}^{108}\text{X}$	e. ${}_{23}^{51}\text{X}$
c. ${}_{16}^{33}\text{X}$	f. ${}_{55}^{133}\text{X}$
7. Identify each of the following elements:

a. ${}_{43}^{98}\text{X}$	d. ${}_{6}^{14}\text{X}$
b. ${}_{75}^{186}\text{X}$	e. ${}_{19}^{40}\text{X}$
c. ${}_{33}^{75}\text{X}$	f. ${}_{54}^{131}\text{X}$
8. How many protons and neutrons are in each of the following elements?

a. ${}^{89}\text{Y}$	d. ${}^{238}\text{U}$
b. ${}^{73}\text{Ge}$	e. ${}^{35}\text{Cl}^-$
c. ${}^{24}\text{Mg}^{2+}$	f. ${}^{65}\text{Zn}$
9. How many protons and neutrons are in each of the following elements?

a. ${}^{227}\text{Ac}$	d. ${}^{251}\text{Cf}$
b. ${}^{70}\text{Ga}$	e. ${}^{239}\text{Pu}$
c. ${}^{11}\text{B}$	f. ${}^{64}\text{Cu}$
10. How many protons, neutrons, and electrons are in each of the following ions?

a. ${}^{56}\text{Fe}^{3+}$	d. ${}^{31}\text{P}^{3-}$
b. ${}^{40}\text{Ca}^{2+}$	e. ${}^{127}\text{I}^-$
c. ${}^{19}\text{F}^-$	f. ${}^{127}\text{I}^{7+}$

11. How many protons, neutrons, and electrons are in each of the following?

- | | | |
|------------------------|---------------------------|--------------------------|
| a. $^{195}\text{Pt}^+$ | d. $^{16}\text{O}^{2-}$ | g. ^{184}W |
| b. ^{93}Nb | e. $^{122}\text{Sb}^{2+}$ | h. $^{133}\text{Cs}^+$ |
| c. $^{40}\text{Ar}^-$ | f. $^{56}\text{Fe}^{2+}$ | i. $^{28}\text{Si}^{3-}$ |

12. Fill in the missing information in the following table:

Symbol	Protons	Neutrons	Electrons	Charge
$^{80}_{35}\text{Br}^-$	_____	_____	_____	_____
____ $^{5+}$	35	45	_____	+5
137 ____	56	_____	54	_____
$^{108}_{47}\text{Ag}^+$	_____	_____	_____	_____
____ $^{5+}$	_____	_____	_____	_____
____Co____	_____	32	_____	+2

13. Fill in the missing information in the following table:

Symbol	Protons	Neutrons	Electrons	Charge
____	13	_____	10	_____
$^{88}_{38}$ ____	_____	_____	_____	+1
____ $^{2+}$	30	35	_____	_____
35 ____	_____	18	18	_____
____Te $^{2-}$	_____	76	_____	_____
85 Rb____	_____	_____	_____	+1

14. Name the family to which each of the following elements belongs:

- | | | |
|-------|-------|-------|
| a. Fe | c. Ar | e. Rb |
| b. Cl | d. Sr | f. Nd |

15. Are the following elements metals or nonmetals?

- | | | |
|-------|-------|-------|
| a. Mg | d. Br | g. Co |
| b. Si | e. O | h. Mo |
| c. Ge | f. Bi | i. Xe |

16. Name the family to which each of the following elements belongs:
- | | | |
|-------|-------|-------|
| a. Es | d. Yb | f. Fr |
| b. I | e. Kr | g. Ca |
| c. Au | | |
17. Given the position in the periodic table, what is the most likely oxidation state that each element will have when forming an ion?
- | | | |
|-------|-------|-------|
| a. Cs | c. Br | e. Al |
| b. N | d. K | f. S |
18. Would you expect the following atoms to gain or lose electrons when forming an ion? If so, how many would be gained or lost?
- | | | |
|-------|------|-------|
| a. Be | d. O | f. Li |
| b. Cl | e. F | g. P |
| c. Al | | |
19. An element combines with 2 atoms of chlorine to form an ionic compound. The element has 20 neutrons in its most abundant form. Write the formula of the compound.
20. Predict the formula and state the name of a compound likely to be formed from the following pairs of elements:
- | | |
|------------------------|------------------------|
| a. sodium and fluorine | b. aluminum and oxygen |
|------------------------|------------------------|
21. Predict the formula and state the name of the compound likely to be formed from the following substances:
- | | |
|------------------------------|------------------------------|
| a. calcium and phosphate ion | b. potassium and nitrate ion |
|------------------------------|------------------------------|
22. Name each of the following compounds:
- | | | |
|----------------------------|---------------------------------------|--------------------------------------|
| a. PbI_2 | e. CsCl | i. $\text{K}_2\text{Cr}_2\text{O}_7$ |
| b. NH_4Cl | f. OsO_4 | j. Na_2SO_4 |
| c. Fe_2O_3 | g. $\text{Cr}(\text{OH})_3$ | k. KH_2PO_4 |
| d. LiH | h. $\text{NaC}_2\text{H}_3\text{O}_2$ | |
23. Name each of the following compounds:
- | | | |
|----------------------------|--------------------|-------------------------------|
| a. MgSO_4 | d. KMnO_4 | g. $\text{Fe}(\text{IO}_4)_3$ |
| b. N_2O_3 | e. NiO | h. SO_3 |
| c. Ce_2O_3 | f. BaSO_4 | i. KClO_4 |
24. Name each of the following compounds:
- | | | |
|-------------------|------------------------------|---------------------------|
| a. NI_3 | c. CO | e. N_2O_4 |
| b. PCl_5 | d. P_4O_{10} | f. NH_3 |
25. Name each of the following compounds:
- | | | |
|---------------------------|--------------------|--------------------|
| a. P_4O_6 | d. AgNO_3 | f. AgCl |
| b. KOH | e. BF_3 | g. KHCO_3 |
| c. N_2 | | |
26. Name each of the following compounds:
- | | | |
|-------------------|--------------------|----------------------------|
| a. HIO_3 | d. HCN | f. K_2SO_3 |
| b. HBr | e. NaNO_2 | g. NaHSO_3 |
| c. HNO_2 | | |

27. Name each of the following compounds:

- | | | |
|-------------------------------|-----------------------------|-----------------------------|
| a. UF_6 | d. SF_6 | f. SnCl_2 |
| b. $\text{Cu}(\text{NO}_3)_2$ | e. $\text{Mg}(\text{OH})_2$ | g. Na_2CO_3 |
| c. H_3PO_4 | | |

28. Write formulas for each of the following compounds:

- | | | |
|----------------------------|----------------------|-------------------|
| a. sodium cyanide | d. lead (II) nitrate | g. sodium bromate |
| b. tin (II) fluoride | e. iron (III) oxide | |
| c. sodium hydrogen sulfate | f. calcium phosphate | |

29. Write formulas for each of the following compounds:

- | | | |
|-----------------------|-----------------------------|---------------------|
| a. sodium sulfate | d. potassium hypochlorite | g. magnesium oxide |
| b. manganese dioxide | e. lithium aluminum hydride | h. copper (I) oxide |
| c. potassium chlorate | f. barium chloride | |

30. Write formulas for each of the following compounds:

- | | | |
|-------------------------|---------------------------|---------------------------------|
| a. potassium carbonate | g. rubidium nitrate | l. sulfurous acid |
| b. magnesium hydroxide | h. potassium chlorate | m. potassium hydrogen phosphate |
| c. dinitrogen tetroxide | i. carbon tetrachloride | n. ammonium acetate |
| d. hypoiodous acid | j. sodium iodate | o. ammonium dichromate |
| e. iron (III) chloride | k. potassium permanganate | p. hydrobromic acid |
| f. tin (IV) oxide | | |

31. Give the names of the following acids:

- | | | |
|----------------------------|-------------------|----------------------------|
| a. H_2SO_3 | c. HBr | e. H_3PO_4 |
| b. HI | d. HNO_2 | f. HCl |

32. Give formulas for the following acids:

- | | | |
|----------------------|---------------------|-----------------------|
| a. nitric acid | c. sulfuric acid | e. hydrosulfuric acid |
| b. hydrofluoric acid | d. hydrocyanic acid | f. acetic acid |

33. Give the alternate or common name for each of the following compounds or cations:

- | | |
|---|-----------------------------------|
| a. sodium hydrogen carbonate (NaHCO_3) | d. iron (II) [Fe^{2+}] |
| b. dinitrogen monoxide (N_2O) | e. tin (IV) [Sn^{4+}] |
| c. nitrogen monoxide (NO) | f. lead (II) [Pb^{2+}] |

34. Where in a group will you probably find atoms having the largest atomic radius? Explain.

Multiple Choice Questions

35. The mass of an apple, orange, grape and banana are 800, 750, 72 and 650 g, respectively. Determine the combined mass of 10 apples, 6 oranges, 20 grapes and 5 bananas.
- A. 17190 g B. 8595 g C. 2272 g D. 95200 g

36. A pound cake consists of 1.0 lb of butter, 1.25 lb of flour, 1.0 lb of sugar, 6 eggs (1.25 lb in mass) and 0.5 lb of milk. After the cake has baked and cooled, it weighs 5.25 lbs. Which of the following statements is true?
- The Law of Mass conservation has been violated by a gain in 0.25 lbs
 - The Law of Mass conservation is conserved since 0.25 lbs of gas were produced during baking
 - The Law of Mass conservation has been violated by a gain in 12.0 oz
 - The Law of Mass conservation has been violated by a gain in 8.0 oz
37. The oxides of CO and CO₂ must have the following carbon-to-oxygen mass ratio
- 12:16, 12:32
 - 12:12, 12:16
 - 12:8, 12:4
 - 12:12, 12:24
38. When silicone and oxygen combine to form silicon dioxide, silicon and oxygen
- Fuse together to yield a new atom
 - Retain their identities
 - Duplicate their mass
 - Some atoms retain their individual identities, and some do not
39. Every atom contains
- As many neutrons as electrons
 - As many protons as neutrons
 - As many nuclei as neutrons
 - As many electrons as protons
40. The atomic number represents
- The number of nuclei in that atom
 - The number of protons in that atom
 - The number of neutrons in that atom
 - The number of electrons in that atom
41. Which of the following elements has $Z = 68$ and $A = 167$?
- Erbium
 - Californium
 - Calcium
 - Dysprosium
42. The atomic number and atomic mass, respectively, for vanadium, are:
- 23, 51
 - 51, 23
 - 46, 102
 - 46, 51
43. Atom A has 30 protons, 32 neutrons and 30 electrons. Atom B has 30 protons, 28 neutrons, and 30 electrons. Atoms A and B are
- Isotopes
 - Isobars
 - Isomers
 - Isoneutrons
44. How many electrons and protons, respectively, are there in Ra^{2+} ?
- 88, 88
 - 86, 88
 - 224, 226
 - 228, 224
45. How many total protons are found in two molecules of $\text{C}_{20}\text{H}_{30}\text{O}$?
- 102
 - 316
 - 302
 - 600
46. What is the charge of an ion with 29 protons and 28 neutrons?
- 0
 - +1
 - +2
 - Unknown
47. What is the charge of an ion with 38 electrons, 38 neutrons and 35 protons?
- 0
 - +3
 - 3
 - 5
48. How many electrons does an ion with mass number 210, with 125 neutrons, and a charge of -2 have?
- 85
 - 83
 - 87
 - 89

Exercises

- An element "E" is present as ^{10}E with a mass value of 10.01 amu, and as ^{11}E with a mass value of 11.01 amu. The natural abundances of ^{10}E and ^{11}E are 19.78% and 80.22% respectively. What is the average atomic mass of the element? What is the element?
- Naturally occurring sulfur consists of four isotopes, ^{32}S (95.0%), ^{33}S (0.76%), ^{34}S (4.22%), and ^{36}S (0.014%). Using these data, calculate the atomic weight of naturally occurring sulfur. The masses of the isotopes are given in the table below.

<u>Isotope</u>	<u>Atomic mass (amu)</u>
^{32}S	31.97
^{33}S	32.97
^{34}S	33.97
^{36}S	35.97

- An unknown sample of mystery element "T" is injected into the mass spectrometer. According to the mass spectrum, 7.42% of the element is present as ^6T and 92.58% is present as ^7T . The mass value for ^6T is 6.02 amu and 7.02 amu for ^7T . Calculate the average atomic mass and identify the mystery element.
- A noble gas consists of three isotopes of masses 19.99 amu, 20.99 amu, and 21.99 amu. The relative abundance of these isotopes is 90.92%, 0.257%, and 8.82% respectively. What is the average atomic mass of this noble gas? What noble gas is this?
- Chlorine has two stable isotopes. The mass of one isotope is 34.97 amu. Its relative abundance is 75.53%. What is the mass of the other stable isotope?
- Complete the following table of isotopic information for the element neon (Ne).

<u>Isotope</u>	<u>Mass (amu)</u>	<u>Abundance</u>
^{20}Ne	19.99	_____
^{21}Ne	20.99	0.257%
^{22}Ne	21.99	_____

- Silicon has three stable isotopes in nature as shown in the table below. Fill in the missing information.

<u>Isotope</u>	<u>Mass (amu)</u>	<u>Abundance</u>
^{28}Si	27.98	_____
^{29}Si	_____	4.70%
^{32}Si	29.97	3.09%

- Gallium has two stable isotopes of masses 68.93 amu (^{69}Ga) and 70.92 amu (^{71}Ga). What are the relative abundances of the two isotopes?
- Magnesium exists as three isotopes in nature. One isotope (^{25}Mg) has a mass of 24.99 amu and a relative abundance of 10.13%. The other two isotopes have masses of 23.99 amu (^{24}Mg) and 25.98 amu (^{26}Mg). What are their relative abundances? (atomic mass Mg = 24.305 amu)
- An element "X" has 5 major isotopes, listed along with their abundances, below. What is the element? Does the atomic mass that you calculate based on these data agree with that listed in your periodic table?

<u>Isotope</u>	<u>% Natural Abundance</u>	<u>Atomic Mass</u>
^{46}X	8.0%	45.95269
^{47}X	7.3%	46.951764
^{48}X	73.8%	47.947947
^{49}X	5.5%	48.947841
^{50}X	5.4%	49.944792

11. How many moles are in a sample of 300 atoms of nitrogen? How many grams?
12. How many atoms of gold does it take to make 1 gram of gold?
13. If you buy 38.9 moles of M&M's[®], how many M&M's[®] do you have? (1 mole of M&M's[®] = 6.022×10^{23} M&M's[®])
14. A sample of sulfur has a mass of 5.37 g. How many moles are in the sample? How many atoms?
15. Give the number of moles of each element present in 1.0 mole of each of the following substances:
 - a. Hg_2I_2
 - b. LiH
 - c. PbCO_3
 - d. $\text{Ba}_3(\text{AsO}_4)_2$
 - e. $\text{RbOH} \cdot 2\text{H}_2\text{O}$
 - f. H_2SiF_6
16. How many grams of zinc are in 1.16×10^{22} atoms of zinc?
17. How many amu are in 3.68 moles of iron?
18. Calculate the molar masses of each of the following:
 - a. Cu_2SO_4
 - b. NH_4OH
 - c. $\text{C}_{10}\text{H}_{16}\text{O}$
 - d. $\text{Zr}(\text{SeO}_3)_2$
 - e. $\text{Ca}_2\text{Fe}(\text{CN})_6 \cdot 12\text{H}_2\text{O}$
 - f. $\text{Cr}_4(\text{P}_2\text{O}_7)_3$
19. Calculate the molar mass of
 - a. $\text{Zn}(\text{CN})_4$
 - b. $\text{Cu}(\text{NH}_3)_4 \cdot 8\text{H}_2\text{O}$
20. What is the mass of 4.28×10^{22} molecules of water?
21. What is the mass of 4.89×10^{23} atoms of the element "X" described in problem # 10?
22. How many milligrams of Br_2 are in 4.8×10^{20} molecules of Br_2 ?
23. How many sodium ions are present in each of the following:
 - a. 2 moles of sodium phosphate
 - b. 5.8 grams of sodium chloride
 - c. a mixture containing 14.2 grams of sodium sulfate and 2.9 grams of sodium chloride?
24. How many potassium ions are present in each of the following:
 - a. 3 moles of potassium chloride
 - b. 6.2 grams of potassium nitrate
 - c. a mixture containing 12.6 grams of potassium phosphate and 5.4 grams of potassium chloride?
25. What is the weight in grams of
 - a. 0.4 moles of CH_4
 - b. 11 moles of $(\text{SO}_4)^{2-}$
 - c. 5 moles of $\text{Mg}(\text{OH})_2$?
26. Determine the molar mass of $\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$.
27. How many moles of cadmium bromide (CdBr_2) are in a 39.25 g sample?
28. A sample of calcium chloride (CaCl_2) has a mass of 23.8 g. How many moles of calcium chloride is this?

29. If 0.172 moles of baking soda (NaHCO_3) were used to bake a chocolate cherry cake, how many grams of baking soda would the recipe call for?
30. How many moles are there in a sample of barium sulfate (BaSO_4) weighing 9.90×10^{-7} g?
31. How many grams are there in 0.36 moles of cobalt (III) acetate ($\text{Co}(\text{C}_2\text{H}_3\text{O}_2)_3$)? How many grams of cobalt are in this sample? How many atoms of cobalt?
32. How many milligrams of chlorine are there in a sample of 3.9×10^{19} molecules of chlorine gas (Cl_2)? How many atoms of chlorine?
33. Bauxite, the principle ore used in the production of aluminum cans, has a molecular formula of $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$.
- Determine the molar mass of bauxite.
 - How many grams of Al are in 0.58 moles of bauxite?
 - How many atoms of Al are in 0.58 moles of bauxite?
 - What is the mass in grams of 2.1×10^{24} formula units of bauxite?
34. Calculate the mass percent of Cl in each of the following compounds:
- ClF
 - HClO_2
 - CuCl_2
 - PuOCl
35. Calculate the mass percent of each element in $\text{C}_5\text{H}_{10}\text{O}$.
36. Calculate the mass percent of each element in potassium ferricyanide, $\text{K}_3\text{Fe}(\text{CN})_6$.
37. Calculate the mass percent of each element in barium sulfite (BaSO_3).
38. Calculate the mass percent of each element in natural lucite (KAlSi_2O_6).
39. Calculate the mass percent of silver in each of the following compounds:
- AgCl
 - AgCN
 - AgNO_3
40. Chlorophyll a is essential for photosynthesis. It contains 2.72% magnesium by mass. What is the molar mass of chlorophyll a assuming there is one atom of magnesium in every molecule of chlorophyll a?
41. Calculate the mass percent of each of the elements in Nicotine ($\text{C}_{10}\text{H}_{14}\text{N}_2$).
42. Which of the following formulas can be empirical?
- CH_4
 - CH_2
 - KMnO_4
 - N_2O_5
 - B_2H_6
 - NH_4Cl
 - Sb_2S_3
 - N_2O_4
 - CH_2O
43. Determine the empirical and molecular formulas of a compound that has a mass of 31.04 g/mole and contains the following percentages of elements by mass:
- $\text{C} = 38.66\%$, $\text{H} = 16.24\%$, $\text{N} = 45.10\%$
44. The analysis of a rocket fuel showed that it contained 87.4% nitrogen and 12.6% hydrogen by weight. Mass spectral analysis showed the fuel to have a molar mass of 32.05 grams. What are the empirical and molecular formulas of the fuel?

45. A compound is found, by mass spectral analysis, to contain the following percentages of elements by mass:

$$C = 49.67, \text{ Cl} = 48.92\%, \text{ H} = 1.39\%$$

The molar mass of the compound is 289.9 g/mole. Determine the empirical and molecular formula of the compound.

46. Vanillin, the pleasant smelling ingredient used to bake chocolate chip cookies, is often used in the production of vanilla extract. Vanillin has a mass of 152.08 g/mole and contains the following percentages of elements by mass:

$$C = 63.18\%, \text{ H} = 5.26\%, \text{ O} = 31.56\%$$

Determine the empirical and molecular formula of vanillin.

47. Determine the empirical formula of a compound that contains the following percentages of elements by mass:

$$\text{Mo} = 43.95\%, \text{ O} = 7.33\%, \text{ Cl} = 48.72\%$$

48. A molecule with a molecular weight of approximately 110 g/mole is analyzed. The results show that it contains 10.05% of carbon, 0.84% of hydrogen, and 89.10% of chloride. Calculate the molecular formula of this compound.

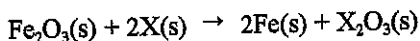
49. Using the data provided, calculate the empirical formulas for the compounds indicated:

- an oxide of nitrogen, a sample of which contains 6.35 g of nitrogen and 3.65 g of oxygen
- an oxide of copper, one gram of which contains 0.7989 g of copper
- an oxide of carbon that contains 42.84% carbon
- a compound of potassium, chloride, and oxygen, containing K = 31.97%, O = 39.34%
- a compound of hydrogen, carbon and nitrogen containing H = 3.70%, C = 44.44%, and N = 51.85%.

50. How many grams of product are formed in each of the following reactions?

- Two moles of H_2 react with one mole of O_2 .
- One mole of silver nitrate reacts with one mole of sodium chloride.
- Three moles of sodium hydroxide react with one mole of phosphoric acid.

51. The following reaction was performed:



It was found that 79.847 g of Fe_2O_3 reacted with "X" to form 55.847 g of Fe and 50.982 g of X_2O_3 . Identify element X.

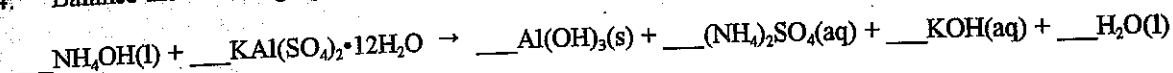
52. Do these equations follow the conservation of matter?

- $\text{Na}_2\text{SiO}_3 + 6\text{HF} \rightarrow \text{SiF}_4 + 2\text{NaF} + 3\text{H}_2\text{O}$
- $3\text{N}_2\text{O}_4 + 2\text{H}_2\text{O} \rightarrow 4\text{HNO}_3 + 2\text{NO}_2$

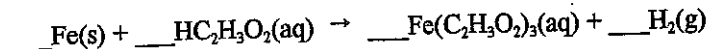
53. Fill in the blanks to balance the following chemical equations:

- $\underline{\hspace{1cm}} \text{AgI} + \underline{\hspace{1cm}} \text{Na}_2\text{S} \rightarrow \underline{\hspace{1cm}} \text{Ag}_2\text{S} + \underline{\hspace{1cm}} \text{NaI}$
- $\underline{\hspace{1cm}} (\text{NH}_4)_2\text{Cr}_2\text{O}_7 \rightarrow \underline{\hspace{1cm}} \text{Cr}_2\text{O}_3 + \underline{\hspace{1cm}} \text{N}_2 + \underline{\hspace{1cm}} \text{H}_2\text{O}$
- $\underline{\hspace{1cm}} \text{Na}_3\text{PO}_4 + \underline{\hspace{1cm}} \text{HCl} \rightarrow \underline{\hspace{1cm}} \text{NaCl} + \underline{\hspace{1cm}} \text{H}_3\text{PO}_4$
- $\underline{\hspace{1cm}} \text{TiCl}_4 + \underline{\hspace{1cm}} \text{H}_2\text{O} \rightarrow \underline{\hspace{1cm}} \text{TiO}_2 + \underline{\hspace{1cm}} \text{HCl}$
- $\underline{\hspace{1cm}} \text{Ba}_3\text{N}_2 + \underline{\hspace{1cm}} \text{H}_2\text{O} \rightarrow \underline{\hspace{1cm}} \text{Ba}(\text{OH})_2 + \underline{\hspace{1cm}} \text{NH}_3$
- $\underline{\hspace{1cm}} \text{HNO}_2 \rightarrow \underline{\hspace{1cm}} \text{HNO}_3 + \underline{\hspace{1cm}} \text{NO} + \underline{\hspace{1cm}} \text{H}_2\text{O}$

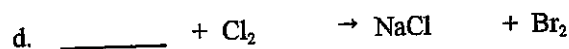
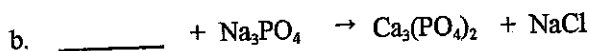
54. Balance the following equation:



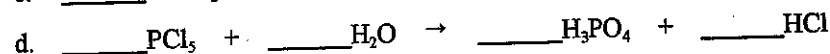
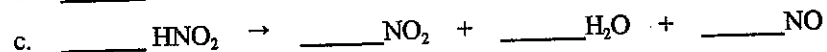
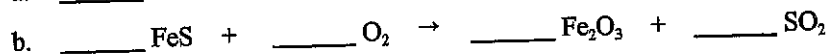
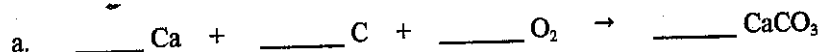
55. Balance the following equation:



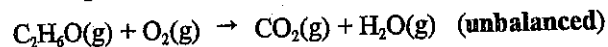
56. Complete the following reactions (making sure they are balanced):



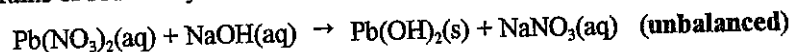
57. Balance the following equations:



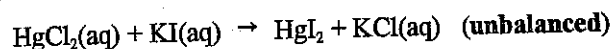
58. How many grams of water vapor can be generated from the combustion of 18.74 g of ethanol?



59. How many grams of sodium hydroxide are required to form 51.63 g of lead hydroxide?



60. How many grams of potassium iodide are necessary to completely react with 20.61 g of mercury (II) chloride?

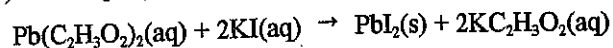


61. How many grams of oxygen are necessary to completely react with 22.8 grams of methane, CH_4 ? (Please write the entire reaction).

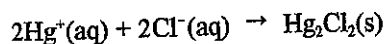
62. If, in the previous problem, only 25.9 grams of water vapor were formed, how much methane actually reacted with oxygen?

63. What mass of calcium carbonate (CaCO_3) would be formed if 248.6 g of carbon dioxide (CO_2) were exhaled into limewater, Ca(OH)_2 ? How many grams of calcium would be needed to form that amount of calcium carbonate? Assume 100% yield in each reaction.

64. The following reaction is used to form lead iodide crystals. What mass of crystal (PbI_2) could be formed from 1.0×10^3 g of lead (II) acetate [$\text{Pb(C}_2\text{H}_3\text{O}_2)_2$]?



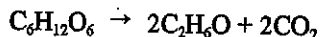
65. How many grams of precipitate (Hg_2Cl_2) would be formed from a solution containing 102.9 g of mercury that is reacted with chloride ion as follows?



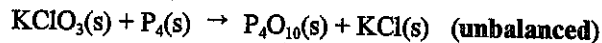
66. You were hired by a laboratory to recycle 6 moles of silver ions. You were given 150 g of copper. How many grams of silver can you recover? Is this enough copper to recycle 6 moles of silver ions?



67. Fermentation converts sugar into ethanol and carbon dioxide. If you were to ferment a bushel of apples containing 235 g of sugar, what is the maximum amount of ethanol in grams that would be produced?

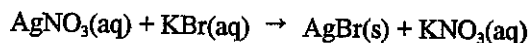


68. The reaction between potassium chlorate and red phosphorus is highly exothermic and takes place when you strike a match on a matchbox. If you were to react 52.9 g of potassium chlorate (KClO_3) with red phosphorus, how many grams of tetraphosphorus decaoxide (P_4O_{10}) would be produced?

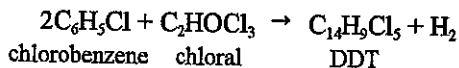


69. A reaction combines 133.484 g of lead (II) nitrate with 45.010 g of sodium hydroxide (see problem 59).
- How much lead (II) hydroxide is formed?
 - Which reactant is limiting? Which is in excess?
 - How much of the excess reactant is left over?
 - If the actual yield of lead (II) hydroxide were 80.02 g, what was the percent yield?

70. A reaction combines 64.81 grams of silver nitrate with 92.67 grams of potassium bromide.



- How much silver bromide is formed?
 - Which reactant is limiting? Which is in excess?
 - How much of the excess reactant is left over?
 - If the actual yield of silver bromide were 14.77 g, what was the percent yield?
71. A reaction proceeds between 94.6 g of KClO_3 and 65.3 g of P_4 (see problem 68).
- How much potassium chloride is formed?
 - Which reactant is limiting? Which is in excess?
 - How much of the excess reactant is left over?
 - If the actual yield of potassium chloride were 21.0 g, what was the percent yield?
72. DDT, an insecticide harmful to fish, birds, and humans, is produced by the following reaction:



In a government lab 1142 g of chlorobenzene were reacted with 485 g of chloral.

- How much DDT is formed?
- Which reactant is limiting? Which is in excess?
- How much of the excess reactant is left over?
- If the actual yield of DDT were 200.0 g, what was the percent yield?

Multiple Choice Questions

73. Which one of the following elements has been selected as the current atomic weight standard?
- A. O B. C C. H D. Na

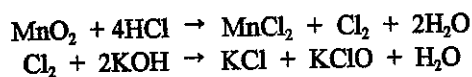
Exercises

- Write dissociation equations for the following when they are dissolved in water:
 - HF
 - SrBr₂
 - MgBr₂
 - NH₄Cl
 - NaNO₃
 - Al₂(SO₄)₃
- Write dissociation equations for the following when they are dissolved in water:
 - Na₂SO₄(s)
 - KCl(s)
 - NaOH(s)
 - Na₂CrO₄(s)
 - Mg(OH)₂(s)
 - HCOOH(l)
- Which of the following pairs of substances are miscible and which are not? Give a reason.
 - CH₃CH₂OH and H₂O
 - C₆H₆ and C₆H₁₂
 - C₆H₆ and H₂O
 - LiBr and H₂O
- Classify the following as strong, weak, or nonelectrolyte.
 - CH₃CH₂OH
 - C₁₂H₂₂O₁₁ (sugar)
 - HCl
 - NH₃
 - C₆H₁₂
- Determine whether each of the following is a strong, weak, or nonelectrolyte.
 - MgCl₂
 - C₄H₆
 - Be(OH)₂
 - HNO₃
 - CH₃COONa
- Calculate the molarity of the following solutions:
 - 49.73 g H₂SO₄ in enough water to make 500 mL of solution
 - 4.739 g RuCl₃ in enough water to make 1.00 L of solution
 - 5.035 g FeCl₃ in enough water to make 250 mL of solution
 - 27.74 g C₁₂H₂₂O₁₁ in enough water to make 750 mL solution
 - 218.7 g HCl in enough water to make 500 mL of solution
- Calculate the molarity of the following solutions:
 - 18.92 g of HNO₃ in enough water to make 500 mL of solution
 - 5.761 g of KOH in enough water to make 350 mL of solution
 - 21.18 g of Fe(NO₃)₃ in enough water to make 1.000 L of solution
 - 72.06 g of BaCl₂ in enough water to make 800 mL of solution
- Calculate the concentrations of each of the ions in the following solutions:
 - 0.25 M Na₃PO₄
 - 0.15 M Al₂(SO₄)₃
 - 0.87 M Na₂CO₃
- Calculate the concentrations of each of the ions in the following solutions:
 - 0.62 M K₂Cr₂O₇
 - 0.35 M NaOH
 - 0.14 M Co(NO₃)₂
 - 0.07 M Na₃PO₄
 - 0.23 M (NH₄)₂Cr₂O₇
 - 0.49 M Al₂(SO₄)₃
- Describe how you would prepare the following solutions:
 - 100 mL of 1 M NaCl
 - 250 mL of 1.0 M Na₂SO₄
 - 1.5 L of 0.5 M K₂Cr₂O₇

11. Describe how you would prepare the following solutions:
- a. 400 mL of 0.1 M HCl c. 1 L of 1.5 M KMnO_4
 b. 750 mL of 0.35 M $\text{Ba}(\text{NO}_3)_2$ d. 250 mL of 0.2 M AgNO_3
12. Describe how you would prepare the following solutions:
- a. 500 mL of 1.0 M H_2SO_4 from 17.8 M H_2SO_4
 b. 1.5 L of 0.25 M KMnO_4 from 1.0 M stock solution
 c. 1.0 L of 0.15 M KBrO_3 from solid KBrO_3
 d. 100 mL of 0.01 M AgNO_3 from 0.5 M stock solution
 e. 1 L of 0.5 M AgNO_3 from solid AgNO_3
13. Describe how you would prepare the following solutions:
- a. 250 mL of 0.1 M HCl from 12.5 M HCl
 b. 500 mL of 1.5 M NaCl from 7.3 M NaCl
 c. 800 mL of 0.2 M NiCl_2 from 4.6 M NiCl_2
 d. 750 mL of 0.05 M FeSO_4 from 0.1 M FeSO_4
14. A standard solution of KHP ($\text{C}_8\text{H}_5\text{O}_4\text{K}$) was made by dissolving 3.697 g of KHP in enough water to make 100.0 mL of solution. Calculate the KHP concentration.
15. A stock solution of sodium hydroxide is prepared by dissolving 120.0 g of NaOH in 500.0 mL of water. What is the molarity of the stock solution?
16. A stock solution of HCl is prepared by adding 30.00 mL of a 12.00 M HCl solution to water and diluting to a final volume of 250.0 mL. What is the molarity of the stock solution?
17. How many moles of KHP are contained in 30.00 mL of the solution in problem 14?
18. A solution of ammonium acetate ($\text{NH}_4\text{C}_2\text{H}_3\text{O}_2$) was made by dissolving 3.85 g of ammonium acetate in enough water to make 500 mL of solution. Calculate the solute concentration.
19. How many moles of ammonium acetate are contained in 17 mL of the solution in problem 18?
20. How many milliliters of 0.136 M NaOH is required to react with the H_2SO_4 in 10 mL of a 0.202 M solution? The reaction of the two is:
- $$2\text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$$
21. How many milliliters of 0.50 M $\text{Ca}(\text{OH})_2$ are required to react with the HCl in 30 mL of a 0.12 M solution. The reaction of interest is:
- $$2\text{HCl} + \text{Ca}(\text{OH})_2 \rightarrow \text{CaCl}_2 + 2\text{H}_2\text{O}$$
22. A chemistry student wants to verify the molarity of the acid stock solution prepared in problem 18, so she titrates a 25.00 mL aliquot (measured sample) with the NaOH solution described in problem 15. If she wants to use 40.00 mL of the NaOH solution as the titrant, what molarity would her NaOH solution need to be? How would she prepare 100.0 mL of that solution?
23. What is the concentration of the following in ppm?
- a. 1.0×10^{-2} g Cu^{2+} in 2.0 L of solution.
 b. The concentration of Pb^{2+} in 2.1×10^{-5} M $\text{Pb}(\text{NO}_3)_2$.

24. What is the concentration of the following in ppm?
- 6.2×10^{-3} g Be^{2+} in 750 mL of solution.
 - 255 mg NaIO_3 in 1.5 L of solution.
25. Balance the following reactions:
- $\text{C}_3\text{H}_8 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
 - $\text{K}_2\text{CO}_3 + \text{Al}_2\text{Cl}_6 \rightarrow \text{KCl} + \text{Al}_2(\text{CO}_3)_3$
 - $\text{Mg}_3\text{N}_2 + \text{H}_2\text{O} \rightarrow \text{MgO} + \text{NH}_3$
 - $\text{Ca}_3(\text{PO}_4)_2 + \text{H}_2\text{SO}_4 \rightarrow \text{CaSO}_4 + \text{H}_3\text{PO}_4$
 - $\text{KOH} + \text{H}_3\text{PO}_4 \rightarrow \text{K}_3\text{PO}_4 + \text{H}_2\text{O}$
 - $\text{KClO}_3 + \text{C}_{12}\text{H}_{22}\text{O}_{11} \rightarrow \text{KCl} + \text{CO}_2 + \text{H}_2\text{O}$
26. Complete and balance the following reactions:
- $\text{NaCl}(\text{aq}) + \text{Hg}_2(\text{NO}_3)_2(\text{aq}) \rightarrow$
 - $\text{Ca}(\text{OH})_2(\text{aq}) + \text{Na}_2\text{CO}_3(\text{aq}) \rightarrow$
 - $\text{Na}_2\text{S}(\text{aq}) + \text{FeCl}_3(\text{aq}) \rightarrow$
27. A solution contains Ag^+ , Pb^{2+} , and Fe^{3+} . If you want to precipitate the Pb^{2+} selectively, what anion would you choose?
28. Write molecular, complete ionic, and net ionic equations for the following reactions:
- aqueous sodium sulfide reacts with aqueous copper (II) nitrate
 - aqueous hydrogen fluoride reacts with aqueous potassium hydroxide to give water and aqueous potassium fluoride
29. What mass of $\text{Mg}(\text{OH})_2$ is produced when 100 mL of 0.42 M $\text{Mg}(\text{NO}_3)_2$ is added to excess NaOH solution?
30. What mass of BaSO_4 is produced when 15.0 mL of 3.00 M H_2SO_4 is added to 20.0 mL of 0.100 M BaCl_2 ?
31. Calculate the mass of CaSO_4 produced when 10 mL of 6.0 M H_2SO_4 is added to 100 mL of 0.52 M $\text{Ca}(\text{NO}_3)_2$.
32. What mass of CaCO_3 is produced when 250 mL of 6.0 M Na_2CO_3 is added to 750 mL of 1.0 M CaF_2 ?
33. A 50.00 mL sample containing chloride ion, Cl^- , is combined with 125.0 mL of a 0.02157 M AgNO_3 solution. The resulting precipitate weighs 211.6 mg. What was the concentration of the chloride ion in the original sample? Was it useful to know the amount and concentration of the AgNO_3 solution? Why or why not?
34. Calculate the mass of Al_2S_3 produced when 100 mL of 0.50 M AlCl_3 is added to 100 mL of 0.50 M Na_2S .
35. You are given the equation: $\text{AgBr} + 2\text{S}_2\text{O}_3^{2-} \rightarrow \text{Ag}(\text{S}_2\text{O}_3)_2^{3-} + \text{Br}^-$. What mass of AgBr can be dissolved by 750. mL of 0.300 M $\text{Na}_2\text{S}_2\text{O}_3$?
36. Given the following chemical equation, determine the theoretical yield of B_2H_6 if exactly 100.0 g of LiAlH_4 was allowed to react with 225 g of BF_3 .
- $$3\text{LiAlH}_4 + 4\text{BF}_3 \rightarrow 3\text{LiF} + 3\text{AlF}_3 + 2\text{B}_2\text{H}_6$$
37. What volume of 0.1379 M HCl is required to neutralize 10.0 mL of 0.2789 M NaOH solution?
38. How many mL of 1.50 M NaOH is required to neutralize 275 mL of 0.5 M H_2SO_4 ?
39. What is the molarity of a solution of HCl if it requires 29.31 mL of a 0.0923 M NaOH solution to reach a phenolphthalein endpoint for the titration of a 10.0 mL aliquot of the HCl solution?

40. Given the following two equations, determine the number of grams of manganese dioxide required to prepare enough chlorine gas to produce 25.0 g of potassium hypochlorite.



41. A titration is done using 0.1302 M NaOH to determine the molar mass of an acid. The acid contains one acidic hydrogen per molecule. If 1.863 g of the acid require 70.11 mL of the NaOH solution, what is the molar mass of the acid?
42. A 2.000 g sample of silver alloy was dissolved in nitric acid and then precipitated as AgBr. After drying, the sample of silver bromide weighed 2.000 g. Calculate the percentage of silver in the alloy.
43. Complete and balance each acid-base equation (assume complete neutralization):
- a. $\text{H}_2\text{SO}_4 + \text{NaOH} \rightarrow$
 b. $\text{H}_3\text{PO}_4 + \text{Mg}(\text{OH})_2 \rightarrow$
- c. $\text{H}_2\text{SO}_3 + \text{NaOH} \rightarrow$
 d. $\text{HC}_2\text{H}_3\text{O}_2 + \text{Ba}(\text{OH})_2 \rightarrow$
44. What volume of 0.2 M NaOH is required to neutralize 50 mL of 0.1 M H_2SO_3 ?
45. How many mL of 2.3 M HNO_3 is needed to neutralize 0.92 L of 0.5 M KOH?
46. The neutralization of a 25.00 mL sample of an unknown base requires 18.34 mL of 0.100 M HCl. Assuming that the acid-base stoichiometry is 1:1, what is the concentration of the unknown base?
47. Pennies made after 1982 contain about 97% zinc by mass. A student wants to prove this by filing the copper outside of a penny until he sees zinc and then putting the penny in a 1.00 M HCl solution. The zinc will be oxidized and the H^+ (from HCl) will be reduced:



If the entire penny has a mass of 2.80 grams, how many mL of 1.00 M HCl are required to just react with all the zinc? (You would, in reality, add much more to completely surround the penny.)

48. Assuming that the stoichiometry is 1:1, what is the concentration of an unknown acid if a 20.0 mL sample of it is neutralized with precisely 33.4 mL of 0.250 M base?
49. A 25.0 mL sample of an ammonia solution is analyzed by titration with HCl. The reaction is given below. It took 18.96 mL of 0.150 M HCl to titrate the ammonia. What is the concentration of the original ammonia solution?



50. Determine the oxidation number for Mn in each of the following:
- a. KMnO_4
 b. LiMnO_2
- c. MnO_2
 d. K_2MnCl_4
- e. Mn_2O_7
51. Determine the oxidation number for each atom in the following compounds or ions:
- a. H_3O^+
 b. P_4O_{10}
- c. S_8
 d. H_2CO
- e. NH_4ClO_4
52. Determine the oxidation number for each atom in the following compounds:
- a. MgBr_2
 b. Na_2SO_4
- c. $\text{Cr}_2\text{O}_7^{2-}$
 d. CaCO_3
- e. NaClF_4
 f. HNO_3

53. Balance the following oxidation-reduction reactions. Which species in each is the oxidizing agent, reducing agent?
- $\text{P} + \text{Cl}_2 \rightarrow \text{PCl}_5$
 - $\text{Sn}^{2+} + \text{Cu}^{2+} \rightarrow \text{Sn}^{4+} + \text{Cu}^+$
 - $\text{Cu} + \text{H}^+ + \text{NO}_3^- \rightarrow \text{Cu}^{2+} + \text{NO}_2 + \text{H}_2\text{O}$
 - $\text{Br}_2 + \text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}^+ + \text{Br}^- + \text{SO}_4^{2-}$
 - $\text{H}_2\text{SO}_4 + \text{HBr} \rightarrow \text{SO}_2 + \text{Br}_2 + \text{H}_2\text{O}$
54. Balance the following redox reactions. Identify the oxidizing agent and the reducing agent.
- $\text{ClO}^- + \text{H}^+ + \text{Cu} \rightarrow \text{Cl}^- + \text{H}_2\text{O} + \text{Cu}^{2+}$
 - $\text{H}_2\text{O} + \text{Cr}^{3+} + \text{XeF}_6 \rightarrow \text{Cr}_2\text{O}_7^{2-} + \text{H}^+ + \text{Xe} + \text{F}^-$
 - $\text{H}_2\text{O} + \text{SO}_3^{2-} + \text{Fe}^{3+} \rightarrow \text{SO}_4^{2-} + \text{Fe}^{2+} + \text{H}^+$
55. Balance the following in basic solution:
- $\text{P}_4 \rightarrow \text{PH}_3 + \text{HPO}_3^{2-}$
 - $\text{Cl}_2 + \text{OH}^- \rightarrow \text{Cl}^- + \text{ClO}_3^-$
 - $\text{Zn} + \text{NO}_3^- \rightarrow \text{Zn}^{2+} + \text{NH}_3$
56. Balance the following redox reactions which take place in an acid solution:
- $\text{H}_3\text{AsO}_4 + \text{Zn} \rightarrow \text{AsH}_3 + \text{Zn}^{2+}$
 - $\text{HS}_2\text{O}_3^- \rightarrow \text{S} + \text{HSO}_4^-$
 - $\text{Cr}_2\text{O}_7^{2-} + \text{Cl}^- \rightarrow \text{Cr}^{3+} + \text{Cl}_2$
 - $\text{MnO}_2 + \text{Hg} + \text{Cl}^- \rightarrow \text{Mn}^{2+} + \text{Hg}_2\text{Cl}_2$
57. Balance the following redox reactions that take place in a basic solution:
- $\text{HXeO}_4^- + \text{Pb} \rightarrow \text{Xe} + \text{HPbO}_2^-$
 - $\text{ClO}_4^- + \text{I}^- \rightarrow \text{ClO}_3^- + \text{IO}_3^-$
 - $\text{Co}(\text{OH})_3 + \text{Sn} \rightarrow \text{Co}(\text{OH})_2 + \text{HSnO}_2^-$

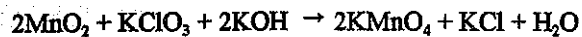
Multiple Choice Questions

58. The hydrogen atoms of the water molecule would be most attracted to which one of the following?
- A. Cl^- B. Mg^{2+} C. CH_4 D. Cl_2
59. Which of the following solvents would probably be the best one to dissolve NaBr?
- A. CH_4 C. H_2O
 B. CH_3CH_3 D. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
60. Which of the following ions would the oxygen atom of the water molecule have the greatest attraction for?
- A. Cl^- B. S^{2-} C. Mg^{2+} D. Na^+
61. Which of the following is not an electrolyte?
- A. KCl B. CH_3COOH C. NH_4Cl D. Br_2

62. A strong base is one that
- Dissociates completely into water molecules
 - Dissociates completely into hydrogen and hydride ions
 - Dissociates completely into hydrogen ions and anions
 - Dissociates completely into hydroxide ions and cations
63. Calculate the molarity when 18.5 g of nitric acid are dissolved in enough water to prepare 100.0 mL of solution.
- 2.94 M
 - 5.78 M
 - 3.51 M
 - 0.287 M
64. Calculate the molarity of a solution when 0.500 pound of silver nitrate is dissolved in enough water to prepare 16.75 L of solution.
- 1.34 M
 - 0.0795 M
 - 2.67 M
 - 0.615 M
65. How many grams of nitric acid are present in 250.0 mL of 6.70 M acid solution?
- 16.8 g
 - 106 g
 - 335 g
 - 211 g
66. How many liters of water are required to prepare a 0.1590 M silver nitrate solution if 1.00 pound of silver nitrate is used?
- 8.38 L
 - 16.8 L
 - 7.61 L
 - 36.9 L
67. Considering that calcium chloride is a strong electrolyte, what is the molarity of the chloride ions would you find in a solution prepared by mixing 8.99 g of calcium chloride with enough water to prepare 150.0 mL of solution?
- 0.540 M
 - 0.270
 - 66.00 M
 - 1.08 M
68. When 25.0 mL of a 10.6 M HCl solution is diluted to 200.0 mL, what is the final molarity of this acidic solution?
- 1.33 M
 - 2.65 M
 - 3.98 M
 - 3.53 M
69. 25.0 mL of 3.00 M hydrochloric acid solution is diluted to 100.0 mL. 10.0 mL of this solution is then diluted a second time to 100.0 mL. Calculate the molarity of the acidic solution after the second dilution.
- 0.0750 M
 - 0.0375 M
 - 1.50 M
 - 0.150 M
70. Which of the following compounds do you expect to precipitate in an aqueous solution?
- AgNO₃
 - PbSO₄
 - LiBr
 - KI
71. With which of the following solutions would you mix a silver nitrate solution to precipitate a silver salt?
- Lead sulfate solution
 - Potassium nitrate solution
 - Sodium chloride solution
 - None of the above
72. Which of the following solutions would be the best to precipitate sodium chloride?
- AgCl solution
 - AgNO₃ solution
 - KOH solution
 - None of the above
73. Which of the following solutions would form a precipitate when mixed with Ba(NO₃)₂?
- KCl
 - Pb(NO₃)₂
 - KNO₃
 - none of these

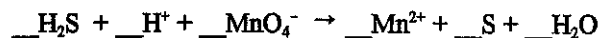
74. How many grams of $K_4Fe(CN)_6$ are required to precipitate all of the cadmium (2+) ions as $Cd_2Fe(CN)_6$ from 4.00 mL of 0.15 M cadmium chloride solution according to the following equation?
- $$K_4Fe(CN)_6 + 2 CdCl_2 \rightarrow 4KCl + Cd_2Fe(CN)_6$$
- A. 0.11 g B. 7.4 g C. 2.4 g D. 0.78 g
75. How many mL of 1.00 M sulfuric acid solution are required to precipitate out all of the barium ion from 40.0 mL of 0.250 M barium chloride solution?
- $$H_2SO_4 + BaCl_2 \rightarrow BaSO_4 + 2HCl$$
- A. 10.0 mL B. 8.25 mL C. 20.4 mL D. 5.25 mL
76. How many mL of 0.21 M phosphoric acid solution are required to precipitate all of the calcium ion from 5.00 mL of a 0.16 M calcium chloride solution?
- A. 0.63 mL B. 1.9 mL C. 2.5 mL D. 3.8 mL
77. How many grams of calcium phosphate are precipitated when 25.0 mL of 0.220 M calcium chloride solution are allowed to react with 15.0 mL of 0.880 phosphoric acid solution?
- A. 8.32 g B. 1.13 g C. 4.08 g D. 0.568 g
78. How many mL of 1.00 M KOH are required to just neutralize 600.0 mL of a 1.5 M HCl solution?
- $$KOH + HCl \rightarrow H_2O + KCl$$
- A. 900 mL B. 400 mL C. 2.50 L D. 40.0 mL
79. A 30.0 mL sample of an unknown basic solution is neutralized after the addition of 12.0 mL of a 0.15 M HCl solution. What is the molarity of the monoprotic base?
- A. 0.00240 M B. 0.375 M C. 0.0600 M D. 0.00180 M
80. 1.122 g of an unknown monoprotic base dissolved in 50.0 mL of water is titrated with 20.0 mL of a 1.00 M HCl solution. Identify the base.
- A. NaOH B. NH_3 C. KOH D. LiOH
81. Calculate the number of mL of 0.250 M LiOH required to neutralize 70.0 mL of 0.155 M H_3AsO_4 .
- $$3LiOH + H_3AsO_4 \rightarrow 3H_2O + Li_3AsO_4$$
- A. 43.4 mL B. 130 mL C. 86.8 mL D. 113 mL
82. Determine the oxidation state of oxygen in KO_2 .
- A. $-\frac{1}{2}$ B. $+\frac{1}{2}$ C. -2 D. -1
83. Determine the average oxidation number of carbon in $C_6H_{12}O_6$ (glucose).
- A. -2 B. +4 C. +2 D. 0
84. In the following reaction select the element that has undergone oxidation.
- $$5FeCl_2 + KMnO_4 + 8HCl \rightarrow 5FeCl_3 + KCl + MnCl_2 + 4H_2O$$
- A. H B. Cl C. Mn D. Fe

85. In the following reaction, select the element that is the oxidizing agent.



- A. Mn B. K C. Cl D. H

86. Balance the following equation



- A. 5, 6, 2, 2, 5, 8 B. 5, 8, 2, 3, 6, 5 C. 1, 1, 1, 1, 1, 2 D. 1, 1, 1, 1, 1, 1

87. What is the initial oxidation half-reaction for the following reaction?



- A. $\text{CuS} \rightarrow \text{Cu}^{2+} + \text{S}$ B. $(\text{SO}_4)^{2-} \rightarrow \text{SO}_2$ C. $\text{CuS} \rightarrow \text{Cu}^{2+}$ D. $(\text{SO}_4)^{2-} \rightarrow \text{S}$

88. What is the proper set of coefficient for the following reaction?



- A. 1, 2, 1, 3, 3, 2, 1 B. 1, 4, 1, 1, 1, 2, 1 C. 3, 2, 1, 1, 1, 3, 3 D. 4, 1, 1, 1, 2, 4, 4

Exercises

- In a science demonstration, 4 to 6 plastic bags are arranged under a $2.0\text{ m} \times 2.0\text{ m}$ piece of plywood. A volunteer stands on the plywood and others blow into the bags to "levitate" the volunteer. If four bags are used and a 140 lb person on the plywood, what is the pressure that must be supplied by each of the four blowers (in Pa)? What if 6 bags and blowers were used? (Assume the plywood has no mass.)
- How much force is required to inflate a high pressure bicycle tire to 95 pounds per square inch (655 kPa) with a hand pump that has a plunger with area of 5.0 cm^2 ?
- An object exerts a force of 500. N and sits on an area of $4.5\text{ m} \times 1.5\text{ m}$. Calculate the amount of pressure exerted by the object in torr.
- Calculate the density of mercury. (This can be done using the fact that $760\text{ mm Hg} = 101,325\text{ Pa}$.) $F = ma$ where $a = 9.81\text{ m/s}^2$. Hint: Consider a column 76.0 cm high with cross section of 1 cm^2 .
- During your travels through deep space, you discover a new solar system. You land on the outermost planet and determine that the acceleration due to gravity is 2.7 m/s^2 . If your mass back on earth is 72 kg, what force would you exert on a scale in pounds while standing on the planet's surface?
- As you proceed on to the next planet, some of your unbreakable equipment breaks, including that top-of-the-line machine which determines acceleration due to gravity.
- How do you determine the acceleration due to gravity of this planet?
 - Calculate the acceleration due to gravity if your 72 kg mass exerts a force of 18 pounds on the planet's surface.
- A diver at a depth of 100 ft (pressure approximately 3 atm) exhales a small bubble of air with a volume equal to 100 mL. What will be the volume of the bubble (assume the same amount of air) at the surface?
- What would the volume of gas contained in an expandable 1.0 L cylinder at 15 MPa ($1\text{ MPa} = 10^6\text{ Pa}$) be at 1 atm (assuming constant temperature)?
- A sample tube containing 103.6 mL of CO gas at 20.6 torr is connected to an evacuated 1.13 liter flask. (The new volume is the sum of those of the tube and flask.) What will the pressure be when the CO is allowed into the flask?
- A gas has a pressure of 3.2 atm and occupies a volume of 45 L. What will the pressure be if the volume is compressed to 27 L at a constant temperature?
- The volume of a gas (held at constant pressure) is to be used "as a thermometer." If the volume at 0.0°C is 75.0 cm^3 what is the temperature when the measured volume is 56.7 cm^3 ?
- If a 16.6 L sample of a gas contains 9.2 moles of F_2 , how many moles of gas would there be in a 750 mL sample at the same temperature and pressure?
- A 11.2 L sample of gas is determined to contain 0.50 moles of N_2 . At the same temperature and pressure how many moles of gas would there be in a 20. L sample?
- Consider a 3.57 L sample of an unknown gas at a pressure of $4.3 \times 10^3\text{ Pa}$. If the pressure is changed to $2.1 \times 10^4\text{ Pa}$ at a constant temperature, what will the new volume of the gas be?

15. Calculate the volume occupied at 87.0°C and 950. torr by a quantity of gas which occupied 20.0 L at 27.0°C and 570. torr.
16. What is the volume of 16 g of sulfur dioxide at 20.0°C and 740 torr pressure?
17. A given weight of oxygen has a volume of 100. mL at 740. mm pressure and 25.0°C . State whether the volume will be greater than 100. mL, less than 100. mL, or unchanged for each of the following new conditions (weight of oxygen remains constant).
700. mm and 25.0°C
 740. mm and 50.0°C
 2220. mm and 600.0 K
18. A quantity of gas at 27.0°C is heated in a closed vessel until the pressure is doubled. To what temperature is the gas heated?
19. A weather balloon is filled with 0.295 m^3 of helium on the ground at 18°C and 756 torr. What will the volume of the balloon be at an altitude of 10 km where the temperature is -48°C and the pressure is 0.14 atm?
20. A sample of gas occupies 3.8 L at 15°C and 1.00 atm. What does the temperature need to be for the gas to occupy 8.3 L at 1.00 atm?
21. Calculate the volume of O_2 present in a sample containing 0.89 moles of O_2 at a temperature of 40°C and a pressure of 1.00 atm.
22. Water is decomposed to $\text{H}_2(\text{g})$ and $\text{O}_2(\text{g})$ by electrolysis. By measuring the current it was determined that 0.365 moles of water decomposed. After the gases are dried and collected at 24.5°C and 757 torr, what are the volumes of each?
23. What pressure would be exerted by 50.0 g of He at 25.0°C in a volume of 350. L?
24. A vacuum line used in a research lab has a volume of 1.013 L. The temperature in the lab is 23.7°C and the vacuum line is evacuated to a pressure of 1×10^{-6} torr. How many gas particles remain?
25. A 10.5 g sample of CO_2 gas occupies a volume of 7.00 L at a pressure of 1.5 atm. What must be the temperature of the gas?
26. A flask which can withstand an internal pressure of 2500 torr, but no more, is filled with a gas at 21.0°C and 758. Torr and heated. At what temperature will it burst?
27. Calculate the number of moles present in a quantity of gas which occupies 26,880 mL at 564°C and 380. torr.
28. The density of liquid nitrogen is 0.808 g/mL at -196°C . What volume of nitrogen gas at STP must be liquefied to make 10.0 L of liquid nitrogen?
29. Calculate the volume occupied by 2.5 mol of an ideal gas at STP.
30. A hydrocarbon (compound containing only hydrogen and carbon) was analyzed to be 85.7 mass percent carbon and 14.3 mass percent hydrogen. At 26°C and 745 torr pressure a sample with a volume of 1.13 L had a mass of 1.904 g. Determine the molecular formula. (You may wish to review Chapter 3.)

... density of 7.06 g/L at a pressure of 1.50 atm and 280 K. Calculate the molar mass

32. Air is a mixture of about 21.0% oxygen and 79.0% nitrogen (we'll neglect the minor components and water vapor in this example). What is the density of air at 30.0°C and 1.00 atm?
33. HCl(g) can be prepared by reaction of NaCl with H₂SO₄. What mass of NaCl is required to prepare enough HCl to fill a 340. mL cylinder to a pressure of 151 atm at 20.0°C?
34. A sample of 26.81 mL of 0.1000 M HCl reacts completely with a rock containing 3.164 g CaCO₃. What would be the maximum theoretical volume of CO₂ collected at 30°C and 1.00 atm?
35. You are not sure whether to fill a balloon with He or hot air. To what temperature would the air have to be heated for a balloon to rise to the same height as a balloon filled with He at 25.0°C?
36. A 27.7 mL sample of CO₂(g) was collected over water at 25.0°C and 1.00 atm. What is the pressure in torr due to CO₂(g)? (The vapor pressure of water at 25.0°C is 23.8 torr.) What will the volume of CO₂(g) be at the same temperature and pressure after removing the water vapor?
37. A gas-tight vessel has a volume of 1000 m³. It is filled with air at 27°C and 1.00 atm. Assuming air to be 79% N₂ and 21% O₂ (by volume), calculate the following:
- partial pressure of N₂
 - partial pressure of O₂
38. A gaseous mixture of O₂, H₂, and N₂ has a total pressure of 1.50 atm and contains 8.20 g of each gas. Find the partial pressure of each gas in the mixture.
39. What is the effect of adding argon gas to the sample in exercise #32?
40. The mole fraction of argon in dry air is 0.00934. How many liters of air at STP will contain enough argon to fill a 35.4 L cylinder to a pressure of 150. atm at 20°C?
41. Assume that the mole fraction of nitrogen in the air is 0.8902. Calculate the partial pressure of N₂ in the air when the atmospheric pressure is 820 torr.
42. The lower limit of flammability of H₂(g) in air at room temperature and 1 atm is a partial pressure of 0.040 atm. Assuming a 4:1 ratio of N₂ to O₂ in air, what is the ratio of H₂ to O₂ at its flammability limit?
43. Calculate the temperature of a mole of oxygen molecules if the internal energy is 1.16×10^4 J. Assume ideal gas behavior.
44. Calculate the root mean square speed of O₂ gas molecules at 300. K.
45. What happens to the average kinetic energy of a mole of an ideal gas if:
- the volume is doubled resulting in a decrease in pressure at constant temperature?
 - the temperature is increased at a constant pressure?
 - absolute zero is obtained?
46. Ammonia (NH₃(g)) and HCl(g) react to form a solid precipitate, NH₄Cl. Two cotton swabs, one moistened with ammonia and the other with hydrochloric acid, are inserted into opposite ends of a 1 meter long glass tube. How far from the hydrochloric acid end of the tube would you expect to see the white NH₄Cl precipitate?

Exercises

- The visible region of the spectrum ranges from 400 nm to 700 nm. What is the frequency range of the visible spectrum?
- List the regions of the electromagnetic spectrum and the wavelengths of radiation associated with each region.
- Calculate the frequency of blue light of wavelength 4.5×10^2 nm.
- Calculate the wavelength of green light of frequency 5.7×10^{14} Hz.
- Red light with a wavelength of 670.8 nm is emitted when lithium is heated in a flame.
 - What is the frequency of this radiation?
 - What is the energy of this radiation per photon? Per mole of photons?
- It takes 6.72×10^{-18} J of energy to remove an electron from an unknown atom. What is the maximum wavelength of light that can do this?
- A carbon-oxygen double bond in a certain organic molecule absorbs radiation that has a frequency of 6.0×10^{13} s⁻¹.
 - To what region of the spectrum does this radiation belong?
 - What is the wavelength of this radiation?
 - What is the energy of this radiation per photon? Per mole of photons?
 - A carbon-oxygen bond in a different molecule absorbs radiation with frequency equal to 5.4×10^{13} s⁻¹. Does this radiation give more or less energy?
- Calculate the energy of a photon that is emitted at a wavelength of 5.69×10^3 nm.
- Calculate the energy of a mole of photons in problem 8.
- Many spectroscopists prefer using frequencies to wavelengths when describing electromagnetic radiation. Can you think of an advantage to the use of frequencies? (A main concern of spectroscopists is the energy of radiation that is either emitted or absorbed.)
- Calculate the wavelength of a thoroughbred racehorse, which weighs 600 pounds, moving with a speed of 40 mi/hr.
- What are the wavelengths associated with the following?
 - an alpha particle (mass = 6.64×10^{-27} kg) traveling at 3.0×10^6 m/s
 - a 1000 kg automobile traveling at 100 km/hr
- Calculate the energy associated with a molecule of each of the following photons:
 - Red photons of wavelength 670.0 nm
 - Yellow photons of wavelength 580.0 nm
 - Violet photons of wavelength 450.0 nm
 - X-ray photons of wavelength 0.154 nm
- Make a plot of energy vs. n for the Bohr hydrogen atom for $n = 1$ to $n = 50$.
 - What is the energy of the Bohr hydrogen atom when $n = \infty$?
 - What is the ionization energy for the Bohr hydrogen atom (i.e., the energy required to move an electron from $n = 1$ to $n = \infty$)?

15. Calculate the wavelength of light that must be absorbed by a hydrogen atom in its ground state to reach the excited state of $\Delta E = +2.914 \times 10^{-18}$ J.
16. How much energy is required to ionize a mole of hydrogen atoms?
17. Calculate the wavelength of light emitted in the spectral transition of $n = 4$ to $n = 2$ in the hydrogen atom.
18. What region of the spectrum would you look in to find the radiation associated with the $n = 4$ to $n = 1$ transition of the Bohr hydrogen atom?
19. What region of the spectrum would you look in to find the radiation associated with the spectral transition of $n = 3$ to $n = 2$ in the hydrogen atom?
20. Use the wave mechanical model to explain the quantized nature of the orbits of a hydrogen atom.
21. A chemistry book lists the radius of the hydrogen orbital as 1\AA . Will the electron ever be further than 1\AA from the nucleus?
22. Even on the planet Mars, the probability of finding an electron of an atom on the nose of Mona Lisa (otherwise known as La Gioconda) is not zero. Explain.
23. Which of the following sets of quantum numbers are allowed?
 - a. $n = 7, l = 7, m_l = 0$
 - b. $n = 7, l = 0, m_l = 1$
 - c. $n = 7, l = 5, m_l = -3$
 - d. $n = 3, l = -1, m_l = 0$
 - e. $n = 0, l = 0, m_l = 0$
24. What is the maximum number of electrons that can be accommodated in
 - a. All orbits of $n = 4$
 - b. All the $4f$ orbitals
 - c. All the $5g$ orbitals
25. Write $n, l, m_l,$ and m_s quantum numbers for the 5 electrons of a boron atom.
26. Account for the fact that a p subshell containing three electrons has one in each orbital rather than two in one orbital and the third in the other.
27. What is the electron configuration for calcium?
28. How does the electron configuration of barium compare with that of calcium?
29. How many half-filled orbitals do each of the following have in the ground state?

a. O	d. Mn	f. Cf
b. B	e. K	g. Zn
c. Ar		
30. Indicate the higher of the two energy states in each of the following pairs:

a. $3d$ or $4s$	b. $4p$ or $5s$	c. $4s$ or $4p$
-----------------	-----------------	-----------------
31. An element, "X", combines with calcium to give the salt CaX_2 . The element has its highest energy electrons in the $4p$ level. What is "X"?

32. In which orbital would an electron have a greater likelihood of being near the nucleus: 4f or 6s?
33. Which group in the periodic table contains elements with the highest ionization energies? Which period in the periodic table contains elements with the highest ionization energies?
34. Order the following groups from smallest to largest radius.
- | | |
|---|---|
| a. Ar, Cl ⁻ , K ⁺ , S ²⁻ | c. Na, Mg, Ar, P |
| b. C, Al, F, Si | d. I ⁻ , Ba ²⁺ , Cs ⁺ , Xe |
35. Arrange the following atoms in order of increasing Z_{eff} for the highest-energy electron:
Te, In, Mg, Ga, Xe, Ca.
36. Which of the following will have the most exothermic electron affinity? The least?
- | | |
|--------------|--|
| a. Ge, Si, C | b. Cl, Cl ⁻ , Cl ⁺ |
|--------------|--|
37. Properties of the alkali metals are discussed in Section 7.13. List some properties that you would expect for the alkaline earths, Be, Mg, Ca, Sr, and Ba.
38. Which elements are metalloids and why are they called metalloids?

Multiple Choice Questions

39. The frequency of an electromagnetic wave is 15×10^{13} hertz. Calculate its wavelength in meters.
- | | | | |
|---------------------------|---------------------------|------------------------|---------------------------|
| A. 2.0×10^{-6} m | B. 6.6×10^{-9} m | C. 5.0×10^5 m | D. 5.0×10^{-5} m |
|---------------------------|---------------------------|------------------------|---------------------------|
40. Calculate the wavelength of an electromagnetic wave with a frequency of 1.7×10^{14} Hz.
- | | | | |
|------------------------|-----------------------------|-------------------------|---------------------------|
| A. 5.9×10^6 m | B. 0.67×10^{-15} m | C. 0.33×10^8 m | D. 1.8×10^{-6} m |
|------------------------|-----------------------------|-------------------------|---------------------------|
41. Carbon absorbs energy at a wavelength of 150 nm. The total amount of energy emitted by a carbon sample is 1.98×10^5 J. Calculate the number of carbon atoms present in the sample, assuming that each atom emits one photon.
- | | | | |
|--------------------------|--------------------------|--------------------------|-----------------------|
| A. 1.50×10^{23} | B. 2.50×10^{19} | C. 1.48×10^{20} | D. 1.65×10^5 |
|--------------------------|--------------------------|--------------------------|-----------------------|
42. Calculate the wavelength of a photon traveling at a velocity of 0.01 c (speed of light). $c = 3.0 \times 10^8$ m/s.
- | | | | |
|----------------------------|----------------------------|----------------------------|----------------------------|
| A. 3.4×10^{-55} m | B. 1.3×10^{-15} m | C. 1.9×10^{-28} m | D. 1.9×10^{-28} m |
|----------------------------|----------------------------|----------------------------|----------------------------|
43. An electron has an associated wavelength of 1.0×10^{-6} m. Calculate the velocity of the electron in m/s.
- | | | | |
|-----------|-------------|------------|------------|
| A. 45 m/s | B. 91.3 m/s | C. 730 m/s | D. 458 m/s |
|-----------|-------------|------------|------------|
44. A particle has a velocity equal to 0.25 c and a wavelength of 1.3×10^{-16} m. Calculate the mass of the particle in kilograms. $c = 3.0 \times 10^8$ m/s
- | | | | |
|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| A. 1.7×10^{-20} kg | B. 6.8×10^{-26} kg | C. 8.5×10^{-19} kg | D. 3.3×10^{-28} kg |
|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
45. A photon with an energy of 5.0×10^{-20} J strikes an electron. All of the photon's energy is converted into kinetic energy of the electron. Calculate the velocity of the electron after the strike, assuming it was at rest before the energy transfer.
- | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|
| A. 1.2×10^5 m/s | B. 2.4×10^4 m/s | C. 1.2×10^3 m/s | D. 3.3×10^5 m/s |
|--------------------------|--------------------------|--------------------------|--------------------------|

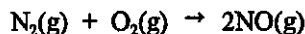
46. The Heisenberg Uncertainty Principle states that:
- Both position and momentum of a particle cannot be known precisely at the same time
 - The position and the momentum of the particle cannot be known precisely at any time
 - The probability of finding an electron nearby a nucleus is related to the square of its wave function
 - The probability of finding an electron nearby an atom is at least 95%
47. The depiction of an "s" electron orbital as a three dimensional sphere is not completely correct because:
- The electron orbitals are not spheres, but vary in shape from spheres to octagons
 - The electron orbitals are not three dimensional, rather they are n-dimensional depending on the probability of an electron being nearby a nucleus
 - The depiction is correct, and is the best fit to experimental data.
 - The electron orbitals are waves, rather than spheres
48. How many quantum numbers are required to describe the electrons of any system?
- A. 1 B. 3 C. 4 D. 2
49. How many distinct magnetic quantum numbers are possible if the angular momentum quantum number is 6?
- A. 13 B. 7 C. 12 D. 3
50. If the principal quantum number is 3, how many values of the angular momentum quantum are possible?
- A. 3 B. 4 C. 5 D. 2
51. Which of the following quantum number sets is unacceptable?
- A. 1, 0, 0 B. 6, 2, 0 C. 4, 3, 3 D. 4, 2, 3
52. Arrange the following numbers to obtain an acceptable set of quantum numbers for an electron: 4, 5, -2
- A. 4, 5, -2 B. -2, 5, 4 C. 5, -2, 4 D. 5, 4, -2
53. A g-orbital has an angular momentum value equal to 4. How many total electrons can the g-orbitals hold?
- A. 18 B. 10 C. 6 D. 2
54. The Pauli exclusion principle states:
- The position and velocity of an electron can never be known precisely at the same time.
 - No two electrons in the system can have the same quantum numbers.
 - The spin number must be $-\frac{1}{2}$ for the first electron in an orbital, and $\frac{1}{2}$ for the second one.
 - The azimuthal number can never be the same for two electrons in two identical orbitals of two different atoms.
55. The Pauli exclusion principle is violated by one of the following electron systems
- A. 1, 0, 0, $\frac{1}{2}$ 1, 0, 0, $\frac{1}{2}$ C. 4, 3, -3, $\frac{1}{2}$ 4, 3, -3, $-\frac{1}{2}$
B. 5, 4, -2, $\frac{1}{2}$ 5, 4, -2, $-\frac{1}{2}$ D. 3, 2, -2, $\frac{1}{2}$ 3, 2, -2, $-\frac{1}{2}$
56. Which of the following sets is unacceptable for any electron systems?
- A. 3, 2, 3, $-\frac{1}{2}$ B. 2, 0, 0, $\frac{1}{2}$ C. 2, 1, 1, $-\frac{1}{2}$ D. 2, 1, -1, $\frac{1}{2}$
57. We first encounter a d-electron in what row of the periodic table?
- A. 3 B. 6 C. 4 D. 2

Exercises

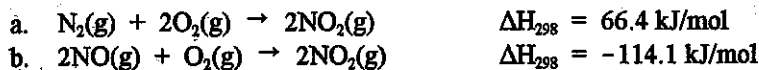
- A system does 3 J of work on the surroundings and 12 J of work are added to the system.
 - What is the energy change of the system?
 - Of the surroundings?
- One hundred joules of work are required to compress a gas. At the same time, the gas gives off 23 J of heat to the surroundings. What is the energy change of the system?
- A gas expands from 10 L to 20 L against a constant pressure of 5 atm. During this time it absorbs 2 kJ of heat. Calculate the work done in kJ.
- A piston expands against 1.00 atm of pressure, from 11.2 L to 29.1 L. This is done without any transfer of heat.
 - Calculate the change in energy of the system.
 - Calculate the change in energy for the above change if, in addition, the system absorbs 1,037 J of heat from the surroundings.
- If the internal energy of a thermodynamic system is decreased by 300 J when 75 J of work is done *on* the system, how much heat was transferred, and in which direction, to or from the system?
- How much work is done by a system where pressure is kept constant but the volume changes from 20 L to 0.5 L (1.00 atm)?
- A gas is compressed against a constant pressure of 3.4 atm from 27.9 L to 16.3 L. During this process, there is a heat gain by the system of 122 J. Calculate the change in energy of the system.
- If 596 J of heat are added to 29.6 g of water at 22.9°C in a coffee cup calorimeter, what will be the final temperature of the water?
- A 5.037 g piece of iron heated to 100.°C is placed in a coffee cup calorimeter that initially contains 27.3 g of water at 21.2°C. If the final temperature is 22.7°C, what is the specific heat capacity of the iron (J/g°C)?
- Calculate the heat necessary to convert 10.0 g of water (just melted) at 0°C to water at 20°C, assuming that the specific heat remains constant at 1 cal/g°C.
- The specific heat of aluminum is 0.89 J/g°C. How much energy is required to raise the temperature of a 15.0 gram aluminum can 18°C?
- One liter of an ideal gas at 0°C and 10 atm was allowed to expand to 1.89 L against a constant external pressure of 1 atm, at a constant temperature. The enthalpy change (ΔH) for this process is -901 J. Calculate q , w , and ΔE .
- The heat capacity of a bomb calorimeter was determined by burning 6.79 g of methane (heat of combustion = -802 kJ/mol) in the bomb. The temperature changed by 10.8°C.
 - What is the heat capacity of the bomb?
 - A 12.6 g sample of acetylene, C_2H_2 , produced a temperature increase of 16.9°C in the same calorimeter. What is the heat of combustion of acetylene (kJ/mol)?
- A sample of C_6H_5COOH (benzoic acid) weighing 1.221 g was placed in a bomb calorimeter and ignited in a pure O_2 atmosphere. A temperature rise from 25.24°C to 31.67°C was noted. The heat capacity of the calorimeter was 5.020 kJ/°C and the combustion products were CO_2 and H_2O . Calculate the ΔH in kJ/mol for the reaction.

15. When 1.50 L of 1.00 M Na_2SO_4 solution at 30.0°C is added to 1.50 L of 1.00 M $\text{Ba}(\text{NO}_3)_2$ solution at 30.0°C in a calorimeter, a white solid (BaSO_4) forms. The temperature of the mixture increases to 42.0°C . Assuming that the specific heat capacity of the solution is $6.37 \text{ J}/^\circ\text{C g}$ and that the density of the final solution is 2.00 g/mL , calculate the enthalpy change per mole of BaSO_4 formed.

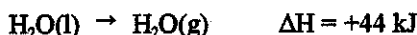
16. Calculate ΔH for



given:

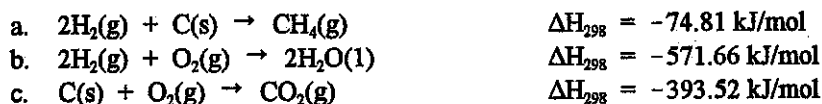


17. For the reaction:

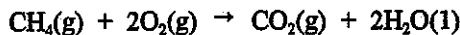


How much heat is evolved when 9.0 grams of water vapor is condensed to liquid water?

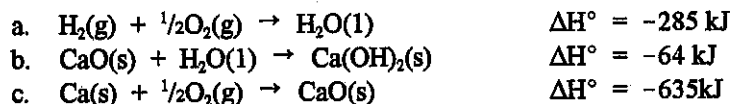
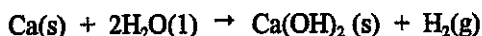
18. Given



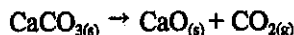
Calculate ΔH for



19. Given the following thermochemical data, calculate the ΔH° for:

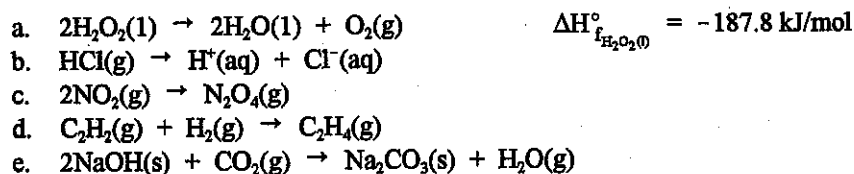


20. Calculate the value for ΔH° for the following reaction



Use the following data: the heats of formation of calcium carbonate, calcium oxide, and carbon dioxide are 288.6, 151.9, and 94.1 kcal/mol respectively.

21. Using standard heats of formation (Appendix 4 in your textbook), calculate ΔH for the following reactions.



22. Calculate the standard change in enthalpy for the following thermite reaction by using enthalpies of formation:



NOTE: This reaction occurs when a mixture of powdered aluminum and iron (III) oxide are ignited with a magnesium fuse.

23. The heat released when HNO_3 reacts with NaOH is 56 kJ/mole of water produced. How much energy is released when 400.0 mL of 0.200 M HCl is mixed with 500.0 mL of 0.150 M NaOH ? How does this compare with the answer to Problem 80 in your textbook? Why?

Multiple Choice Questions

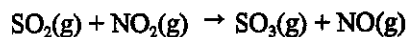
24. When zinc reacts with hydrochloric acid, hydrogen gas is released. In this system the release of the hydrogen gas is counteracted by an outside force which results in a smaller volume by the end of the reaction. The work done by the outside force:
- A. Is negative on the system
B. Is positive on the surroundings
C. Is positive on the system
D. Is zero
25. A piano is brought upstairs by two workers. Due to a mistake of one of the workers, the piano rolls down the stairs and finally comes to a rest by the outside door. Which sequence best describes the energy transformations for the piano from the moment it is being brought upstairs, to when it stops by the door?
- A. Potential energy \rightarrow Kinetic energy \rightarrow Thermal energy of the ground and piano
B. Ground energy \rightarrow Potential energy \rightarrow Thermal energy \rightarrow Kinetic energy of the piano
C. Potential energy \rightarrow Kinetic energy \rightarrow Potential energy \rightarrow Thermal energy of the piano and ground
D. Kinetic energy \rightarrow Potential energy \rightarrow Kinetic energy
26. A piston performs a work of 210 J on the surroundings, while the cylinder in which it is placed expands from 10 to 25 L . At the same time 45 J of heat is transferred from the surroundings to the system. Against what pressure was the piston working?
- A. 14 atm
B. 11 atm
C. 17 atm
D. 254 atm
27. As a system increases in volume, it releases 52.5 J of energy in the form of heat to the surroundings. The piston is working against a pressure of 10.25 atm . The final volume of the system is 58.0 L . What was the initial volume of the system if the energy of the system decreased by 102.5 J ?
- A. 62.9 L
B. 53.1 L
C. 48 L
D. 68 L
28. A 500.0 g sample of an element, at 195°C , is dropped into an ice-water mixture. 109.5 g of ice melts and an ice-water mixture remains. Calculate the specific heat of the element and determine which element it is.
- A. Zn
B. Ba
C. Pb
D. Ag
29. What is the final temperature, in $^\circ\text{C}$, when 20.0 g of water at 80°C is mixed with 20.0 g of water at 25°C ?
- A. 12°C
B. 7.0°C
C. 8.8°C
D. 52.5°C
30. Benzoic acid, $\text{C}_7\text{H}_6\text{O}_2$, is a standard used in determining the heat capacity of a calorimeter. ΔH° of combustion of the benzoic acid is $3.22 \times 10^3 \text{ kJ/mol}$. 0.5 g of benzoic acid is burned in a calorimeter containing 1000.0 g of water. The change in temperature of the calorimeter was 3°C . Calculate the heat capacity of the calorimeter in J/K .
- A. 450 J/K
B. 210 J/K
C. 4025 J/K
D. 2307 J/K

Exercises

- Given 8 molecules in the two-bulb set up described in Table 16.1 in your textbook, calculate the relative probability of finding all 8 molecules in the left-hand bulb. What does this tell you regarding entropy and probability?
- Which of the following pairs of substances is likely to have the higher positional entropy?
 - HCl(aq) or HCl(g)
 - $P_4(s)$ or $P_4O_{10}(g)$
 - $O_2(g)$ or $P_4O_{10}(g)$
 - $H_2O(s)$ or $H_2O(l)$
 - $NO_2(g)$ or $N_2O_4(g)$
 - Ar(g) at 5 atm or Ar(g) at 0.30 atm.
- Predict the sign of the entropy change for each of the following processes.
 - Potassium hydroxide pellets are dissolved in water.
 - Solid ammonium dichromate is burned to give solid chromium oxide, water vapor, and nitrogen gas.
 - Saturated calcium acetate is mixed with ethanol to form a gel.
- Predict the sign of the entropy change for each of the following reactions:
 - $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$
 - $NH_4Cl(s) \rightarrow NH_3(g) + HCl(g)$
 - $H_2(g) + Br_2(g) \rightarrow 2HBr(g)$
- When water freezes, is there an increase in entropy? Explain.
- Calculate ΔS_{sur} for each of the following reactions at 25°C and 1 atm:
 - $Br(l) \rightarrow Br(g)$ $\Delta H = +31 \text{ kJ}$
 - $2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(g)$ $\Delta H = -2857 \text{ kJ}$
- A chemical reaction gives a change in entropy of the universe of -48 J/K. Is the process spontaneous? Why or why not?
- Which of the following values represent spontaneous processes? Which ones are exothermic (from the point of view of the system)?
 - $\Delta S_{sys} = +358 \text{ J/K}$, $\Delta S_{sur} = -358 \text{ J/K}$
 - $\Delta S_{sys} = -358 \text{ J/K}$, $\Delta S_{sur} = -52 \text{ J/K}$
 - $\Delta S_{sys} = -358 \text{ J/K}$, $\Delta S_{sur} = +463 \text{ J/K}$
 - $\Delta S_{sys} = +358 \text{ J/K}$, $\Delta S_{sur} = -463 \text{ J/K}$
- Given the following values for ΔH , ΔS , and T, determine whether each of the following sets of data represent spontaneous or nonspontaneous processes.

	$\Delta H(kJ)$	$\Delta S(J/K)$	$T(K)$
a.	-16	50	300
b.	12	40	300
c.	-5	-20	200
d.	-5	20	200
e.	-5	-20	500
- Given the following ΔH and ΔS values, determine the temperature at which the reactions would be spontaneous
 - $\Delta H = 10.5 \text{ kJ}$; $\Delta S = 30 \text{ J/K}$
 - $\Delta H = 1.8 \text{ kJ}$; $\Delta S = 113 \text{ J/K}$
 - $\Delta H = -11.7 \text{ kJ}$; $\Delta S = -105 \text{ J/K}$

11. Predict the sign of the entropy change for each of the following processes:
- evaporating a beaker of ethanol at room temperature
 - cooling nitrogen gas from 80°C to 20°C
 - freezing liquid bromine below its melting point (-7.2°C)
12. The heat of fusion for actinium is 10.50 kJ/mol. The entropy of fusion is 9.6 J/K mol. Calculate the melting point of actinium.
13. At a constant temperature of 298 K, calculate ΔS_{sys} and ΔS_{univ} for the free expansion of 3.0 L of an ideal gas at 1.0 atm to 11.0 L.
14. The heat of vaporization for protactinium is 481 kJ/mol. The entropy of vaporization is 109 J/K mol. Calculate the boiling point of protactinium. Compare with the actual value of approximately 4500 K.
15. If the molar heat of vaporization of ethanol is 39.3 kJ/mol and its boiling point is 78.3°C, calculate ΔS for the vaporization of 0.50 mol ethanol.
16. The normal boiling point of diethyl ether is 308 K. The enthalpy of vaporization is 27.2 kJ/mol. Calculate ΔS for the vaporization of 1.0 mol of diethyl ether under these conditions.
17. The melting point of silicon is 1683 K. The heat of fusion is 46.4 kJ/mol. Calculate the entropy of fusion of silicon.
18. Determine whether the following chemical change is spontaneous:

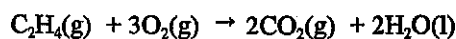


19. Predict the sign of ΔS° for each of the following reactions:
- $\text{Sr}(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{SrO}(\text{c})$ (c) = crystalline
 - $2\text{Al}(\text{s}) + 3\text{F}_2(\text{g}) \rightarrow 2\text{AlF}_3(\text{s})$
20. Using Appendix 4, calculate the standard enthalpy changes for the following reactions at 25°C:
- $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$
 - $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$
 - $\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{HCl}(\text{g})$
21. Using data from Appendix 4 in your textbook, calculate ΔS° for each of the following reactions:
- $\text{CH}_4(\text{g}) + \text{N}_2(\text{g}) \rightarrow \text{HCN}(\text{g}) + \text{NH}_3(\text{g})$
 - $2\text{Ag}_2\text{O}(\text{s}) \rightarrow 4\text{Ag}(\text{s}) + \text{O}_2(\text{g})$
 - $\text{Cd}(\text{s}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{CdO}(\text{s})$
22. Using data for ΔH° and ΔS° in Appendix 4 in your textbook, calculate ΔG° (at 25°C) for each of the reactions in problem 21.
23. Calculate ΔG° for each of the reactions in problem 21 using ΔG° data from Appendix 4 in your textbook. How do these compare with your answers from problem 22?

24. Using Appendix 4, calculate ΔG° for the combustion of ethane (C_2H_6):



25. Calculate ΔG° for the following reaction:



26. Calculate ΔG° for the following reactions at 25°C :
- $2\text{MgO}(s) \rightarrow 2\text{Mg}(s) + \text{O}_2(g)$
 - $\text{CH}_4(g) + 2\text{O}_2(g) \rightarrow \text{CO}_2(g) + 2\text{H}_2\text{O}(l)$
27. Calculate ΔG° for the following reactions:
- $2\text{Mg}(s) + \text{O}_2(g) \rightarrow 2\text{MgO}(s)$
 - $2\text{C}_2\text{H}_2(g) + 5\text{O}_2(g) \rightarrow 4\text{CO}_2(g) + 2\text{H}_2\text{O}(l)$
 - $\text{N}_2(g) + \text{O}_2(g) \rightarrow 2\text{NO}(g)$
28. Given the following data:
- $\text{N}_2(g) + 2\text{O}_2(g) \rightarrow 2\text{NO}_2(g) \quad \Delta G^\circ = 104 \text{ kJ}$
 - $2\text{NO}(g) + \text{O}_2(g) \rightarrow 2\text{NO}_2(g) \quad \Delta G^\circ = -70 \text{ kJ}$
- Calculate ΔG° for $\text{N}_2(g) + \text{O}_2(g) \rightarrow 2\text{NO}(g)$.
29. Using Appendix 4, calculate ΔG° for each of the following reactions at 298 K :
- $2\text{Cu}_2\text{O}(s) + \text{O}_2(g) \rightarrow 4\text{CuO}(s)$
 - $\text{C}_2\text{H}_5\text{OH}(l) \rightarrow \text{C}_2\text{H}_4(g) + \text{H}_2\text{O}(g)$
30. State the enthalpy and entropy conditions under which ΔG° for a reaction must be “-”.
31. Calculate ΔG° for the following reaction at 25°C (use Appendix 4):
- $$2\text{H}_2(g) + \text{O}_2(g) \rightleftharpoons 2\text{H}_2\text{O}(l)$$
32. Given the following data:
- $2\text{H}_2(g) + \text{C}(s) \rightarrow \text{CH}_4(g) \quad \Delta G^\circ = -51 \text{ kJ}$
 - $2\text{H}_2(g) + \text{O}_2(g) \rightarrow 2\text{H}_2\text{O}(l) \quad \Delta G^\circ = -474 \text{ kJ}$
 - $\text{C}(s) + \text{O}_2(g) \rightarrow \text{CO}_2(g) \quad \Delta G^\circ = -394 \text{ kJ}$
- Calculate ΔG° for $\text{CH}_4(g) + 2\text{O}_2(g) \rightarrow \text{CO}_2(g) + 2\text{H}_2\text{O}(l)$.
33. Calculate ΔG at 600 K for the following reaction:
- $$\text{P}_4(g) + 5\text{O}_2(g) \rightleftharpoons \text{P}_4\text{O}_{10}(s),$$
- where the initial pressures are $P_{\text{P}_4} = 0.52 \text{ atm}$ and $P_{\text{O}_2} = 2.1 \times 10^{-3} \text{ atm}$.
34. Calculate the equilibrium constant, K , at 25°C for each of the reactions in problem 21.
35. Calculate ΔG_f° (in kcal/mol) and determine whether the reaction will occur spontaneously.
- $$\text{I}_2(s) + \text{Cl}_2(g) \rightleftharpoons 2\text{ICl}(g)$$
36. If $R = 1.99 \text{ cal/mol K}$, calculate K_p for the dissociation of HCl given that:
- $$\frac{1}{2}\text{H}_2(g) + \frac{1}{2}\text{Cl}_2(g) \rightleftharpoons \text{HCl}(g) \quad \Delta G_f^\circ = -22.7 \text{ kcal}$$
- What does this say about the tendency of this dissociation?
37. The value of the equilibrium constant for a given reaction is $K = 6 \times 10^{-23}$. What does that indicate about the spontaneity of the reaction?

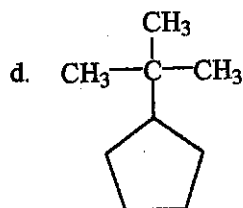
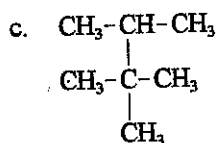
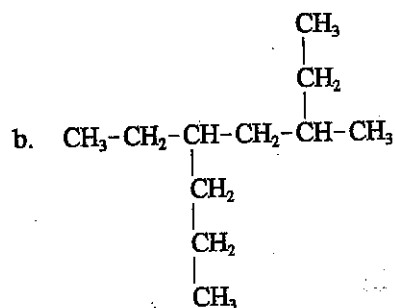
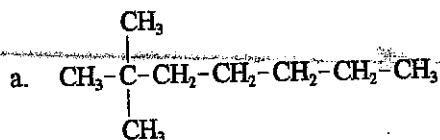
38. The value of the equilibrium constant for a given reaction is $K = 8 \times 10^{58}$. What does this tell us regarding the speed of the reaction?
39. We said in Chapter 14 that at 25°C , $K_w = 1.0 \times 10^{-14}$. Calculate K_w thermodynamically and compare it to our Chapter 14 value for the reaction:
- $$\text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}^+(\text{aq}) + \text{OH}^-(\text{aq})$$
40. Calculate K_p for the following reaction at 25°C : $2\text{H}_2\text{O}(\text{g}) \rightleftharpoons 2\text{H}_2(\text{g}) + \text{O}_2(\text{g})$.

Multiple Choice Questions

41. A state of higher entropy means:
- A. A lower number of possible arrangements
 B. A higher number of possible arrangements
 C. Lower probabilities to reach a possible state
 D. Lower probabilities to be reached
42. Which of the following processes would result in a decrease of entropy?
- A. Freezing
 B. Melting
 C. Evaporating
 D. An expanding gas
43. Four distinct vessels (each with a different capacity) hold 2.3 moles of a particular gas each. Which system has the highest total entropy?
- A. 1.0 L
 B. 0.2 L
 C. 0.15 L
 D. 0.5 L
44. Which of the following processes has a the lowest probability of being achieved?
- A. A feather flying away from the ground
 B. A rock rolling down the hill
 C. Water freezing into ice at 273 K
 D. A piece of paper flying away from the ground
45. Which of the following processes must be spontaneous?
- A. $\Delta S_{\text{surr}} > 0$, $\Delta S_{\text{sys}} > 0$
 B. $\Delta S_{\text{surr}} > 0$, $\Delta S_{\text{sys}} < 0$
 C. $\Delta S_{\text{univ}} < 0$, $\Delta S_{\text{sys}} > 0$
 D. $\Delta S_{\text{surr}} < 0$
46. Which of the following conditions would ensure a spontaneous process?
- A. $\Delta S_{\text{surr}} > 0$
 B. $\Delta S_{\text{sys}} < 0$
 C. $\Delta S_{\text{sys}} < 0$
 D. $\Delta S_{\text{univ}} > 0$
47. Heat is released during a particular process. This means that:
- A. The process is spontaneous under all conditions
 B. $\Delta S_{\text{surr}} > 0$
 C. The process tends to be spontaneous
 D. $\Delta S_{\text{sys}} > 0$
48. Which of the following processes would you expect to be spontaneous?
- A. $\Delta S_{\text{surr}} = 25 \text{ J/K}$, $\Delta S_{\text{sys}} = -27 \text{ J/K}$
 B. $\Delta S_{\text{surr}} = 25 \text{ J/K}$, $\Delta S_{\text{sys}} = 27 \text{ J/K}$
 C. $\Delta S_{\text{univ}} = -20 \text{ J/K}$, $\Delta S_{\text{sys}} = -20 \text{ J/K}$
 D. $\Delta S_{\text{surr}} = -80 \text{ J/K}$, $\Delta S_{\text{sys}} = 20 \text{ J/K}$
49. Which of the following processes do you expect to be the most spontaneous at the respective temperature, if $\Delta S_{\text{sys}} = 0 \text{ J/K}$?
- A. $\Delta H = 25 \text{ kJ}$, $T = 28^\circ\text{C}$
 B. $\Delta H = -475 \text{ kJ}$, $T = 28^\circ\text{C}$
 C. $\Delta H = -260 \text{ kJ}$, $T = 273 \text{ K}$
 D. $\Delta H = -300 \text{ kJ}$, $T = 208 \text{ K}$

Exercises

1. Name the following compounds using IUPAC nomenclature.



2. Write structure for the following systematic names.

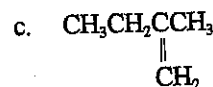
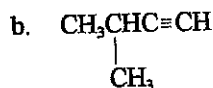
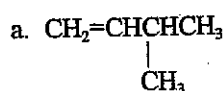
- 1-ethyl-3-propylcyclohexane
- 1,1,2-trichloroethane

3. Are saturated hydrocarbons (alkanes) soluble in water?

4. Explain why the chair conformation of cyclohexane is more stable than the boat form.

5. Which of these has the higher boiling point, n-octane or n-heptane? Which, if either, has a melting point above 25°C? Which, if either, is soluble in water?

6. Match the following structures with their correct systematic name.



1. 3-methyl-1-butyne

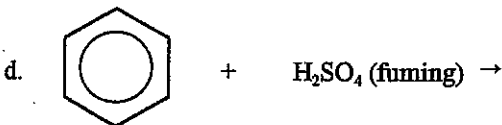
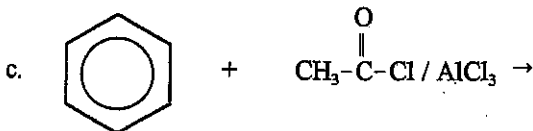
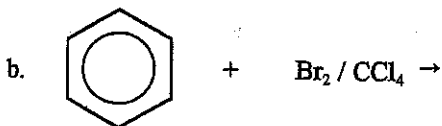
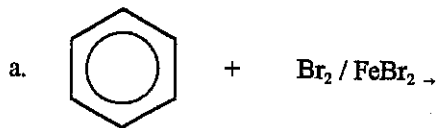
2. 3-methyl-1-butene

3. 2-methyl-1-butene

7. What products would form after hydrogenation of 2-methyl-1-butene? After halogenation (Cl₂)?

8. Why, in general, are alkenes more reactive in addition reactions than alkanes?

9. What are the products of the following reactions?



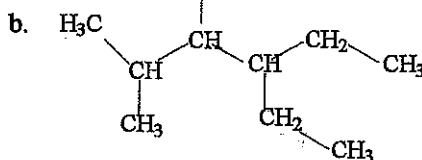
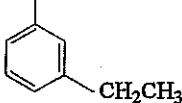
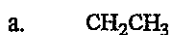
10

Draw these organic molecules:

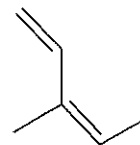
- Para-dichlorobenzene
- 2,3,5-trifluoro-1-heptane

11

Name each of the following:



c.



12

How many isomers are there of:

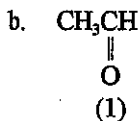
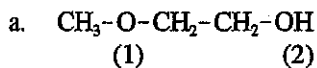
- | | | |
|----------------------|-----------------------|-----------------------|
| a. Monochlorobenzene | c. Trichlorobenzene | e. Pentachlorobenzene |
| b. Dichlorobenzene | d. Tetrachlorobenzene | |

13. Arrange the molecules in order from lowest to highest boiling points:

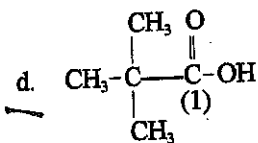
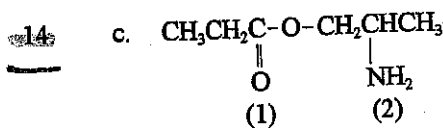
benzene, ethane, isobutane, pentadecane

14

Name the functional group(s) in each of the following compounds:

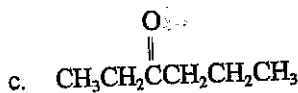
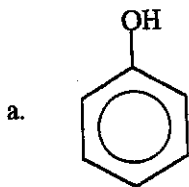


(Name the compound)

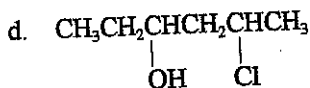


15. Write the structural formula for the following: isopropyl alcohol, methylamine, ethyl iodide, salicylic acid, acetone.

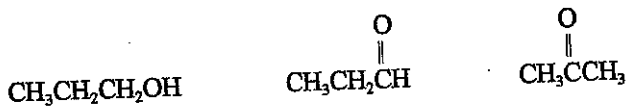
16. Name the following compounds or give their structure:



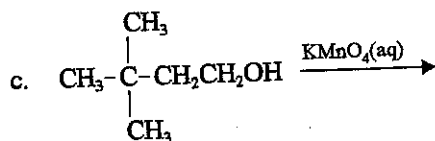
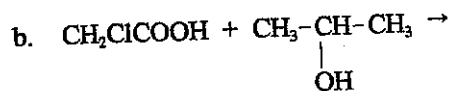
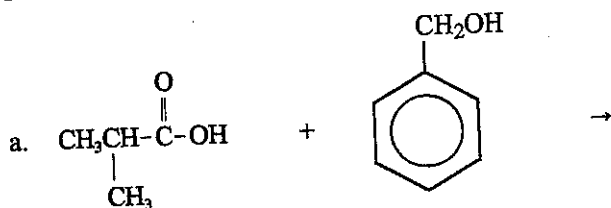
b. 3-chlorobenzaldehyde



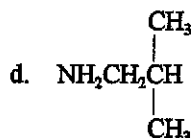
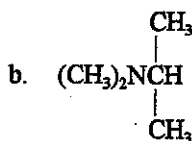
17. Arrange the molecules in order from lowest to highest boiling point:



18. Name the reactants in each equation below. Give the structure of the products that would form.



19. Label the following amines as 1°, 2°, or 3°.



20. Draw structural formulas for all possible isomers having the molecular formula $\text{C}_4\text{H}_{10}\text{O}$. Label all the alcohols as primary, secondary, or tertiary. Label all other compounds according to functional groups.

21. Define or explain the following terms:

a. dimer

c. copolymer

e. polymer

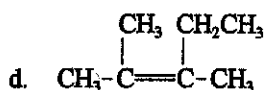
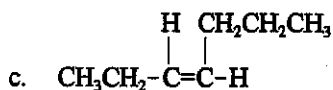
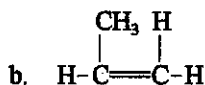
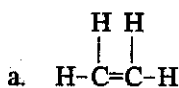
b. free radical

d. homopolymer

22. Distinguish between addition polymerization and condensation polymerization.

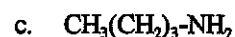
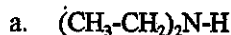
23. Write the cis- and trans- chair conformations of 1,2-dichlorocyclohexane.

24. Arrange the following alkenes from most stable to least stable. (Hint: stability is directly related to the substitution of the double bond.)



25. Alcohols are capable of forming strong hydrogen bonds to each other making them polar. Why is ethyl alcohol greatly soluble in water while heptyl alcohol is almost insoluble in water?

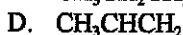
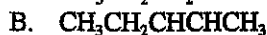
26. Arrange the following amines from the highest to the lowest boiling point. Give an explanation of your answer.



27. Using the free radical mechanism in your textbook as a guide, draw a complete arrow-pushing mechanism for the formation of teflon.

Multiple Choice Questions

28. Which one of the following hydrocarbons is saturated?



29. What is the number of possible isomers for C_4H_8 ?

A. 6

B. 3

C. 5

D. 2

30. How many carbons are in the longest chain of 4-chloro-5-ethyl-2,2-dimethyldecane?

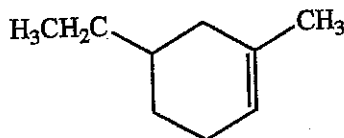
A. 10

B. 6

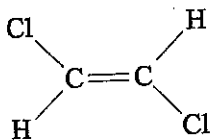
C. 7

D. 9

81. How many total carbons are in 4-chloro-5-ethyl-2,2-dimethyldecane?
 A. 10. B. 14. C. 15 D. 13
82. 1,1,2-trimethylcyclopentane is an isomer of which one of the following compounds?
 A. nonane B. isoheptane C. 2-isopropyl-pentane D. isohexane
83. How many total hydrogens are there in 3,3,6-triethyl-6-methyldecane?
 A. 38 B. 36 C. 17 D. 54
34. Which one of the following compounds can react with chlorine gas to produce 1,2-dichlorocyclohexane?
 A. hexane B. cyclohexene C. 3-methylcyclohexane D. 2-methylhexane
35. Which one of the following cyclic compounds do you expect to be most stable based on bond angle?
 A. cyclopropane B. cyclobutane C. cyclopentane D. cycloheptane
36. When ethane is converted to ethylene (CH_2CH_2), the carbon atoms:
 A. are oxidized B. are reduced C. act as oxidizers D. are unchanged
37. Butadiene is a hydrocarbon that can be described by which one of the following terms?
 A. a four carbon ring C. a five carbon chain
 B. a six carbon ring D. unsaturated hydrocarbon
38. What is the bond angle between H-C-C in acetylene?
 A. 180° B. 90° C. 109° D. 120°
39. What is the proper name of the following compound?



40. What is the proper name of the following compound?



- A. 4-ethyl-2-methylcyclohexene C. 4-ethyl-2-methylcyclohex-1-ene
 B. 5-ethyl-1-methyl-cyclohexene D. 2-methyl-5-ethylcyclohex-1-ene
41. With what would you react 2,2,3-trichloro-nonadiene, in order to convert it to 2,2,3-trichlorononane?
 A. oxygen B. hydrogen gas C. chlorine gas D. water
42. When hydrogen reacts with butadiene to produce butane, hydrogen acts as:
 A. reducing agent B. oxidizing agent C. dehydrating agent D. base

43. A benzene compound with bromine in the 1 and 3 positions has the common name of:
A. o-dibromobenzene B. p-dibromobenzene C. m-dibromobenzene D. dibromobenzene
44. Nitrobenzene can be produced by reacting benzene with which one of the following compounds?
A. nitric acid B. nitrogen dioxide C. nitrogen oxide D. nitrogen
45. 3-chlorotoluene can be produced by reacting which of the following reagents?
A. benzene with chlorine gas and methane B. benzene with HCl and methane
C. benzene with methyl chloride and HCl D. benzene with chlorine gas and methyl chloride
46. Which one of the following statements is not true about catalytic cracking?
A. It is a process that breaks down large molecules by breaking carbon-carbon bonds.
B. It is conducted at high temperatures.
C. It is easier to control than pyrolysis.
D. It can also include hydrocracking.
47. The process by which hexane is converted into methylcyclopentane is known as:
A. esterification B. pyrolysis C. catalytic reforming D. isomerization
48. Which one of the following process is not used to increase octane rating?
A. polymerization B. alkylation C. isomerization D. esterification
49. Which one of the following compounds is a secondary alcohol?
A. 2-butanol B. butanol C. neopentyl alcohol D. hexanol
50. Which one of the following alcohols would you expect to have the highest boiling point?
A. methanol B. propanol C. decanol D. hexanol
51. How many different ketones are possible in a six carbon straight chain?
A. 1 B. 2 C. 4 D. 6
52. Oxidation of which one of the following compounds would lead to an aldehyde?
A. cyclohexanol B. 2-Butanol C. methanol D. phenol
53. What functional group(s) are present in the this compound: $\text{CH}_3\text{CHOHCOOH}$?
A. acid B. alcohol, acid C. ketone, acid D. ether, acid
54. The following compound can be prepared by reacting which one of the following pairs of reagents?
$$\text{CH}_3\text{CH}_2\text{CH}_2\text{COOCH}_2\text{CH}_3$$

A. butyric acid with ethanol B. butyraldehyde with ethanoic acid
C. ethanoic acid with butyrate D. 2-butanone with acetaldehyde
55. Which one of the following amines is a primary amine?
A. diethylamine B. 1-aminohexane C. trimethylamine D. diphenylamine