Chemistry

Section 1

Periodic Table of Elements

atomic mass → 1.00794
element name → hydrogen
symbol → **H**
atomic number → 1

1.00794 hydrogen **H** 1																	4.0026 helium **He** 2
6.941 lithium **Li** 3	9.012 beryllium **Be** 4											10.811 boron **B** 5	12.0107 carbon **C** 6	14.00674 nitrogen **N** 7	15.9994 oxygen **O** 8	18.9984 fluorine **F** 9	20.1797 neon **Ne** 10
22.98977 sodium **Na** 11	24.3050 magnesium **Mg** 12											26.9815 aluminium **Al** 13	28.0855 silicon **Si** 14	30.9737 phosphorus **P** 15	32.065 sulfur **S** 16	35.453 chlorine **Cl** 17	39.984 argon **Ar** 18
39.0983 potassium **K** 19	40.078 calcium **Ca** 20	44.95591 scandium **Sc** 21	47.867 titanium **Ti** 22	50.9415 vanadium **V** 23	51.9961 chromium **Cr** 24	54.938 manganese **Mn** 25	55.845 iron **Fe** 26	58.9332 cobalt **Co** 27	58.6934 nickel **Ni** 28	63.546 copper **Cu** 29	65.409 zinc **Zn** 30	69.723 gallium **Ga** 31	72.64 germanium **Ge** 32	74.9216 arsenic **As** 33	78.96 selenium **Se** 34	79.904 bromine **Br** 35	83.798 krypton **Kr** 36
85.4678 rubidium **Rb** 37	87.62 strontium **Sr** 38	88.90585 yttrium **Y** 39	91.225 zirconium **Zr** 40	92.90638 niobium **Nb** 41	95.94 molybdenum **Mo** 42	[98] technetium **Tc** 43	101.07 ruthenium **Ru** 44	102.9055 rhodium **Rh** 45	106.42 palladium **Pd** 46	107.8682 silver **Ag** 47	112.411 cadmium **Cd** 48	114.818 indium **In** 49	118.710 tin **Sn** 50	121.760 antimony **Sb** 51	127.60 tellurium **Te** 52	126.9045 iodine **I** 53	131.293 xenon **Xe** 54
132.905 cesium **Cs** 55	137.327 barium **Ba** 56	174.967 lutetium **Lu** 71	1.00794 hafnium **Hf** 72	180.9479 tantalum **Ta** 73	183.84 tungsten **W** 74	186.207 rhenium **Re** 75	190.23 osmium **Os** 76	192.217 iridium **Ir** 77	195.078 platinum **Pt** 78	196.9665 gold **Au** 79	200.59 mercury **Hg** 80	204.383 thallium **Tl** 81	207.2 lead **Pb** 82	208.980 bismuth **Bi** 83	[209] polonium **Po** 84	[210] astatine **At** 85	[222] radon **Rn** 86
[223] francium **Fr** 87	[226] radium **Ra** 88	[262] lawrencium **Lr** 103	[261] rutherfordium **Rf** 104	[262] dubnium **Db** 105	[266] seaborgium **Sg** 106	[264] bohrium **Bh** 107	[269] hassium **Hs** 108	[268] meitnerium **Mt** 109	[271] darmstadtium **Ds** 110	[272] roentgenium **Rg** 111	[285] ununbium **Uub** 112		[289] ununquadium **Uuq** 114				

138.9055 lanthanum **La** 57	140.116 cerium **Ce** 58	140.90765 praseodymium **Pr** 59	144.24 neodymium **Nd** 60	[145] promethium **Pm** 61	150.36 samarium **Sm** 62	151.964 europium **Eu** 63	157.25 gadolinium **Gd** 64	158.9253 terbium **Tb** 65	162.50 dysprosium **Dy** 66	164.930 holmium **Ho** 67	167.259 erbium **Er** 68	168.934 thulium **Tm** 69	173.04 ytterbium **Yb** 70
[227] actinium **Ac** 89	232.038 thorium **Th** 90	231.0359 protactinium **Pa** 91	238.0289 uranium **U** 92	[237] neptunium **Np** 93	[244] plutonium **Pu** 94	[243] americium **Am** 95	[247] curium **Cm** 96	[247] berkelium **Bk** 97	[251] californium **Cf** 98	[252] einsteinium **Es** 99	[257] fermium **Fm** 100	[258] mendelevium **Md** 101	[259] nobelium **No** 102

Chemistry

Lexile

Chemistry is the physical science that deals with the composition, structure, and properties of substances and also the transformations that these substances undergo. Because the study of **chemistry** encompasses the entire material universe, it is central to the understanding of other sciences.

A basic chemical theory has been formulated as the result of centuries of observation and measurement of the various elements and compounds (see **chemistry**, history of). According to this theory, matter is composed of minute particles called atoms. The more than 100 different kinds of atoms that are known are called chemical elements. Atoms of the same element or of different elements can combine together to form molecules and chemical compounds. The atoms are held together by forces, primarily electrostatic, called chemical bonds. In a chemical reaction two or more molecules can undergo various changes to form different molecules by means of breaking and making the chemical bonds.

Branches of Chemistry

Five subdivisions traditionally are used to classify various aspects of **chemistry**. The study of organic **chemistry** originally was limited to compounds that were obtained from living organisms, but now the field deals with hydrocarbons (compounds of carbon and hydrogen) and their derivatives. The study of inorganic **chemistry** includes compounds derived from all of the elements except for hydrocarbons. Biochemistry is the subdivision in which the compounds and chemical reactions involved in processes of living systems are studied.

Physical **chemistry** deals with the structure of matter and the energy changes that occur during physical and chemical changes of matter. This field provides a theoretical basis for the chemical observations of the other subdivisions. Analytical **chemistry** is concerned with the identification of chemical substances, the determination of the amounts of substances present in a mixture, and the separation of mixtures into their individual components.

Special subdivisions of **chemistry** are now recognized that account for knowledge at the interface of **chemistry** and other physical sciences. For example, recent research has involved the chemical origin of life—reactions between simple molecules at low pressures to form such complex organic molecules as proteins found in living organisms.

Astrochemistry is the interdisciplinary physical science that studies the origin and interaction of the chemical constituents, especially interstellar matter, in the universe. Geochemistry is concerned with the chemical aspects of geology—for instance, the improvement of ore processing, coal utilization, shale oil recovery—and the use of chemicals to extract oil from wells that are considered dry by ordinary standards.

Nuclear **chemistry** deals with natural and induced transformations of the atomic nucleus. Studies in this field now center on the safe and efficient use of nuclear power and the disposal of nuclear wastes. Radiochemistry deals with radioactive isotopes of chemical elements and the utilization of those isotopes to further the understanding of chemical and biochemical systems. Environmental **chemistry** is a subdivision that has as its subject the impact of various elements and compounds on the ecosphere.

Tools of Chemistry

Chemistry is a precise laboratory science, and the equipment of a chemical laboratory is usually involved with measurement. Balances are used to measure mass, pipettes and burettes to measure volume, colorimeters to measure color intensities, and thermometers to measure temperature changes. Advances in electronics and computer technology have enabled the development of scientific instruments that determine the chemical properties, structure, and content of substances accurately and precisely.

Most modern chemical instrumentation has three primary components: a source of energy, a sample compartment within which a substance is subjected to the energy, and some sort of detector to determine the effect of the energy on the sample. An X-ray diffractometer, for instance, enables the chemist to determine the arrangement of atoms, ions, and molecules that constitute crystals by means of scattering X rays (see X-ray diffraction). Most modern laboratories contain ultraviolet, visible, and infrared spectrophotometers, which use light of various wavelengths on gaseous or liquid samples. By such a means the chemist can determine the electron configuration and the arrangement of atoms in molecules. A nuclear magnetic resonance spectrophotometer subjects a sample in a strong magnetic field to radio frequency radiation. The absorption of this energy by the sample gives the chemist information concerning the bonding within molecules. Other instruments include mass spectrometers, which use electrons as an energy source, and differential thermal analyzers, which use heat.

An entirely different class of instruments are those which use chromatography to separate complex mixtures into their components. Chemists are also using extremely short pulses of laser light to investigate the atomic and molecular processes taking place in chemical reactions at the microsecond level. These and other devices generate so much data that chemists frequently must use computers to help analyze the results.

Impact On Society

Chemistry is closely associated with four basic needs of humans: food, clothing, shelter, and medical services. The applications of **chemistry** usually bring to mind industries engaged in the production of chemicals. A significant portion of the chemical industry is engaged in the production of inorganic and organic chemicals, which are then used by other industries as reactants for their chemical processes. In the United States the great majority of the leading chemicals being produced are inorganic, and their manufacture is a multibillion-dollar industry.

The **chemistry** of polymers—large molecules made up of simple repeating units linked together by chemical bonds (see polymerization)—includes plastics, resins, natural and synthetic rubber, synthetic fibers, and protective coatings. The growth of this segment of **chemistry** has been phenomenal since the late 1930s. The fabrication of natural rubber and coatings (paints, varnishes, lacquers, and enamels) derived from natural agricultural products has been a mainstay of the chemical industry for more than 150 years.

The search for new energy sources and the improvement of existing ones are in many ways chemical problems (see fuel). At the heart of the petroleum industry are the processes of refining crude hydrocarbons into such products as gasoline and petrochemicals. The utilization of nuclear power depends heavily on the chemical preparation and reprocessing of fuel, the treatment and disposal of nuclear waste, and the problems of corrosion and heat transfer. The conversion and storage of solar energy as electrical energy is primarily a chemical process, and the development of fuel cells is based on either chemical or electrochemical technology (see electrochemistry).

Chemical research has been the basis of the pharmaceutical industry's production of drugs. The controlled introduction of specific chemicals into the body assists in the diagnosis, treatment, and often the cure of illness. Chemotherapy is a prime treatment in combating cancer.

Tremendous agricultural gains have been achieved since about 1940 as a result mainly of farmers' use of chemical fertilizers and pesticides. Other chemical industries include soap and detergent production; food processing; and the production of glass, paper, metals, and photographic supplies.

Specialized Uses

Outside the mainstream of what is traditionally considered **chemistry** is research that supports other professions. **Chemistry** is used by museums in art conservation and restoration, the dating of objects (see radiometric age-dating), and the uncovering of frauds. Forensic chemists work in crime laboratories, carrying out tests to assist law-enforcement agencies (see forensic science; forensic genetics). Toxicologists study the potentially adverse effects of chemicals on biological systems (see toxicology), as do those involved in industrial hygiene. The **chemistry** involved in sanitary engineering and sewage treatment has come to be of major importance to society as populations increase and environmental concerns intensify.

Problems

Through the use of **chemistry** and related technology, chemical substances have been produced that either immediately or eventually are harmful to humans, animals, and the environment. Pollution is not a new problem, but the combination of a rapidly growing chemical industry and the use of sophisticated detection devices has brought the extent of pollution to public attention.

The discharge and disposal of industrial waste products into the atmosphere and water supply, for example, at Love Canal, have caused grave concern about environmental deterioration (see pollution, air; pollution, water). The repeated exposure of workers to some toxic chemicals at their jobs has caused long-range health problems (see diseases, occupational). In addition, the use of some pesticides and herbicides can cause long-term toxicity, the effects of which are still only partially understood. The safe storage and disposal of chemical and biological warfare agents and nuclear waste continue to be a serious problem. An advance in chemical technology almost always involves some trade-off with regard to an alteration of the environment.

Challenges and Trends

Much of the future of **chemistry** will lie in providing answers to such technological problems as the creation of new sources of energy and the eradication of disease, famine, and environmental pollution. The improvement of the safety of existing chemical products, for example, pesticides, is another challenge. Research into the chemical complexities of the human body may reveal new insights into a variety of diseases and dysfunctions. The improvement of industrial processes will serve to minimize the use of energy and raw materials, thereby diminishing negative environmental effects.

Norman V. Duffy

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Name ____________________ Date ____ / ____ / ____

ELEMENTAL SYMBOLS

Provide the chemical symbols for the elements listed below.

1 bromine ________
2 calcium ________
3 carbon ________
4 chlorine ________
5 copper ________
6 fluorine ________
7 Gold ________
8 helium ________
9 hydrogen ________
10 iron ________
11 lead ________
12 magnesium ________
13 manganese ________
14 neon ________
15 nitrogen ________
16 phosphorus ________
17 potassium ________
18 silver ________
19 sodium ________
20 sulfur ________

Provide the name for the element corresponding to the chemical symbols below.

21 Ag ____________
22 Al ____________
23 Au ____________
24 C ____________
25 Ca ____________
26 Cu ____________
27 F ____________
28 Fe ____________
29 H ____________
30 Hg ____________
31 I ____________
32 K ____________
33 Na ____________
34 Ni ____________
35 O ____________
36 P ____________
37 Pb ____________
38 S ____________
39 Sn ____________
40 Zn ____________

Water Mixtures, Types of

Lexile

Chemists marvel at water's ability to dissolve other substances. Seawater contains over 70 elements dissolved in mineral form. This has earned water the somewhat-exaggerated title of "universal solvent." Water can also speed reactions between the chemicals dissolved in it. Many of these reactions would never take place in its absence.

Water in Mixtures

Pure water contains only water molecules. Each molecule consists of two hydrogen atoms bonded to one oxygen atom.

More commonly, water contains other substances. In other words, it is part of a mixture. There are several types. In homogeneous **mixtures**, one cannot see different components. Such **mixtures** look uniform. In heterogeneous **mixtures**, one can see distinct particles.

Heterogeneous **mixtures** include suspensions. In suspensions, particles can settle out of the mix. Muddy water is an example. It consists of soil particles that can settle, leaving the water clear.

Homogeneous **mixtures** include colloids and solutions. In a colloid, one substance disperses completely into another. The particles become too small to see. But they are large enough to scatter light. Thus, colloids are cloudy.

Blood is a colloid. It consists of cells and other substances dispersed in plasma. Plasma is mostly water.

In solutions, the different components are mere molecules. The most-abundant ingredient is called the solvent. The less-abundant ingredients are solutes. Sugar water is a solution. Water is the solvent, and sugar is the solute.

The solute molecules are too small to scatter light. Thus, solutions are clear. But they may be colored.

Water as a Solvent

As mentioned, water is a remarkable solvent. This quality traces to the water molecule's structure. Each molecule's oxygen end has a slightly negative charge. At the opposite end, its hydrogen atoms have a slightly positive charge. This turns each water molecule into a tiny magnet. It enables water to pull apart many compounds. Salts are good examples. They consist of positively charged and negatively charged ions. Water attracts these charged ions to its opposite poles. As a result, salts dissolve readily in water.

Rain and runoff remove salts and other minerals from soil and rocks. Rivers carry these dissolved minerals to the ocean. There, they concentrate to make seawater salty. Groundwater also delivers dissolved minerals to the roots of plants.

Water can also dissolve gases. Fish extract dissolved oxygen gas when they breathe underwater. Water carries away their exhaled carbon dioxide.

Concentration

Solutions come in different concentrations. Concentration refers to the amount of solute dissolved in the solvent. A dilute solution has a relatively small amount of solute. A concentrated solution has a relatively large amount. Sugar water is a familiar example. It consists of sugar dissolved in water. Extremely sweet sugar water has a higher sugar concentration than slightly sweet sugar water.

Saturation

Water can dissolve only so much of a substance. A cup of tea, for example, dissolves only so much sugar. Add more, and the extra settles to the bottom. Similarly, only so much salt will dissolve in a given amount of water. A solution that is holding all the solute it can hold is called saturated. Further solute will not dissolve.

Heat increases water's saturation point. One sees this in everyday life. One can dissolve more salt or sugar in hot liquids than in cold ones.

Sometimes, one can create supersaturated solutions. Mix sugar in hot water. When the water cools, it holds more sugar than it normally would at room temperature. But supersaturated solutions are unstable. Disturb it and the extra solute may come out of solution.

Solubility of Substances in Water

Solubility is the extent to which one substance will dissolve in another. For instance, 36 grams of salt will dissolve in 100 grams of water at room temperature. Two substances are called insoluble if they will not form a solution. Oil, for example, is insoluble in water.

Like Dissolves Like

Water is a polar molecule. It readily dissolves other polar substances.

Temperature and Solubility

As mentioned, heat increases water's ability to dissolve solids such as salt and sugar. This is because heat energy helps solids break apart.

By contrast, gases become less soluble with increasing temperature. Gas molecules must slow down, or lose energy, to enter liquid. Heat only encourages them to break free.

What about the solubility of liquids in liquids? Temperature changes have little effect either way.

Pressure and Solubility

Increased pressure encourages gases to dissolve in water. This is why we keep soda bottles capped tightly. The cap prevents gas from escaping. This increases pressure inside the bottle. The increased pressure, in turn, keeps more bubbles dissolved in the water. When we open the bottle, gas escapes and pressure decreases. We see the fizz of gas rushing out of solution.

Chemical Properties of Water

Water reacts differently with different substances. Many metals react with water. At the extreme, metallic sodium can produce explosive reactions in water at room temperature.

Many common compounds react with water to form acids or bases. Water reacts with carbon dioxide to produce carbonic acid. This weak acid is found in blood and other body fluids. Calcium oxide and water combine to form calcium hydroxide. This base is used in plasters and cement.

Water also reacts with many salts. Water and ammonium chloride form an acidic solution. Water and sodium carbonate form a basic solution. Water and sodium chloride (table salt) produce a neutral solution.

Water can also form unique compounds called hydrates. The blue crystals of copper sulfate pentahydrate are a beautiful example. Inside each crystal, every copper sulfate molecule is surrounded by five water molecules.

Substances Found in Water

Because it is such a good solvent, water is seldom found in pure form in nature. As mentioned, seawater contains many kinds of mineral salts. Fresh water contains these same salts in smaller quantities. Both fresh and ocean water contain dissolved oxygen.

Other dissolved substances are not so desirable. Water can become polluted by animal, human, and industrial waste. Fortunately, nature continually filters and purifies water. Soil is especially good at filtering groundwater clean. But natural purification methods are no match for the waste of modern industries and populations. Today, most communities need sewer-treatment and water-purification plants.

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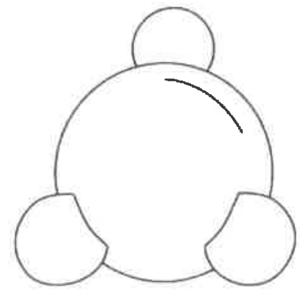
SUBSTANCES AND MIXTURES



If a specific chemical formula can be written for a material can be provided (e.g., elements or compounds), the material is called a "substance." Other materials in which the components or parts are not chemically boned are termed "mixtures."

In the table below, classify the following materials as substances or mixtures by writing S or M respectively in the empty boxes.

1	air		11	milk	
2	alcohol		12	nail polish	
3	blood		13	nitrogen	
4	cake batter		14	oxygen	
5	carbon dioxide		15	salt water	
6	coffee		16	sodium	
7	cola		17	soil	
8	eggs		18	soup	
9	ice cream		19	table salt	
10	iron		20	water