Special.

ELEMENTARY CHEMISTRY.

WATER.—*Continued.*

Relation of Water to Heat.

(1) *Expansion and Contraction.*

Exp. 3.—Take a small thin flask, fit it with a cork, through which passes a small glass tube about 2ft. long. Fill the flask with cold boiled water, insert the cork, taking care that there are no air-bubbles entangled beneath it, and press it into the bottle until the small tube is about half full. Now heat the flask, and the liquid slowly rises in the tube *Water, therefore, expands by heat.* This property water shares with other substances. It may be said to be a law of nature that inorganic substances expand when heated.

Next immerse the flask in a mixture of snow or pounded ice and half its weight of common salt; or a mixture of sulphate of soda (Glauber's salt) and hydrochloric acid will do equally well, the salt being just covered with the acid. As the water cools the liquid sinks in the tube, becomes stationary, and then begins to rise. If a thermometer could be plunged into the water in the flask it would be found to mark 4°C. or 39·2°F. when the water began to rise. The expansion of the liquid goes on till a sudden check is observed; if the flask is then examined it will probably be found to be cracked and to contain ice. *Thus water when cooling contracts till the temperature of 4° C. or 39·2° F. is reached, and when further cooled it expands.* If similar experiments are made with other liquids, such as alcohol, oils, etc., they will be found to contract, but not to expand again as the temperature is reduced. Thus water is the great exception to the general law, and in this respect stands alone amongst liquids hitherto examined.

But water not only expands in this unique way before it freezes, but in the act of freezing, it undergoes a large and further expansion. This expansion, exerting an almost irresistible force, plays an important part in the disintegration and splitting of rocks during the winter. The same cause leads to the bursting of water-pipes. Water shares this property with a few other substances, such as cast-iron, bismuth, and antimony. This property of water is of the greatest moment to mankind. If it obeyed the ordinary law, our lakes and rivers would become masses of solid ice, and all animal life in them would perish. The heat of summer would be unable to undo the effects of the winter's cold, and the climate would be so altered as to render any but equatorial regions almost uninhabitable.

(2) *Boiling.*

At ordinary temperatures water is continually giving off invisible vapor, which diffuses into the surrounding atmosphere. *When the temperature is reached at which the pressure (tension) of its vapor is equal to that of the atmosphere at the time, it is said to boil.* This temperature is 100°C. at 760° mm. pressure, or 212°F. at 30 inches barometric pressure. Since the boiling point depends on atmospheric pressure, it will be lowered at high elevations. It has been found that in ascending mountains the boiling is lowered 1°F. for every 590 feet.

(3) *Latent Heat of Water.*

When ice at 0°C. melts it absorbs *without elevation of temperature* as much heat as would raise the temperature of an equal weight of water from 0°C. to 79°C This quantity of heat is required to change the state from solid to liquid water, and is spoken of as its *latent heat.* When water freezes, or becomes solid, this amount of heat, which is necessary to keep the water in the liquid form, and is, therefore, termed the *heat of liquidity,* is evolved or rendered sensible.

(4) *Latent Heat of Steam.*

When water is converted into steam a large quantity of heat becomes latent, since, notwithstanding the continuous action of the fire the temperature remains constant. Water, like all other bodies, requires more heat for its existence as a gas than as a liquid. One gram of steam at 100°C. passed into ice-cold water can raise the temperature of 536 grams of the latter 1°C. *The latent heat of steam is, therefore, 536 thermal units*—a thermal unit being the *amount of heat required to raise a unit weight of water through 1° C.* When water evaporates or passes into the gaseous state, heat is absorbed, and so much heat may thus be abstracted from water that it may be made to freeze by its own evaporation.

Water as a Solvent.—Water is the most valuable known solvent, there being few substances solid, liquid, or gaseous, which are absolutely insoluble in it. As a rule, the power of water to dissolve liquids increases with the temperature, while the solubility of gases is greater at low than at high temperatures.

Impurities in Water.—Natural waters are never free from dissolved impurities. They contain gaseous, liquid, or solid impurities, varying according to the source from which they are derived, and the nature of the soil or rocks over which they have flowed. If water containing carbonic acid percolates through cretaceous rocks, the carbonic acid combines with the insoluble calcium carbonate, forming soluble calcium bicarbonate (Art. 132). Of the solid matter dissolved in drinkable waters, the greater part is usually made up of calcium salts, generally accompanied by small quantities of magnesium salts.

Lime in Water.

Exp. 4.—Half-fill a test-tube with water, add a little lime-water, and pass carbon dioxide through it; it first becomes milky and then clear again. Now add a solution of ammonium oxalate, $(NH_4)_2C_2O_4$, or oxalic acid, $H_2C_2O_4$; the water becomes turbid. Again, half-fill the test-tube with water, and add a little plaster of Paris, $CaSO_4$, shake well and filter. Now add ammonium oxalate or oxalic acid, and the water becomes turbid. *Hence, ammonium oxalate or oxalic acid is a test for lime.*

Six grains of lime per gallon will yield a slight turbidity, 16 grains a distinct precipitate, and 30 grains a large precipitate soluble in nitric acid.

If the water contains calcium bicarbonate the reaction is—

$$H_2Ca(CO_3)_2 + (NH_4)_2C_2O_4 = CaC_2O_4 + 2NH_4HCO_3$$

Calcium bicarbonate. Ammonium oxalate. Calcium oxalate. Ammonium bicarbonate.