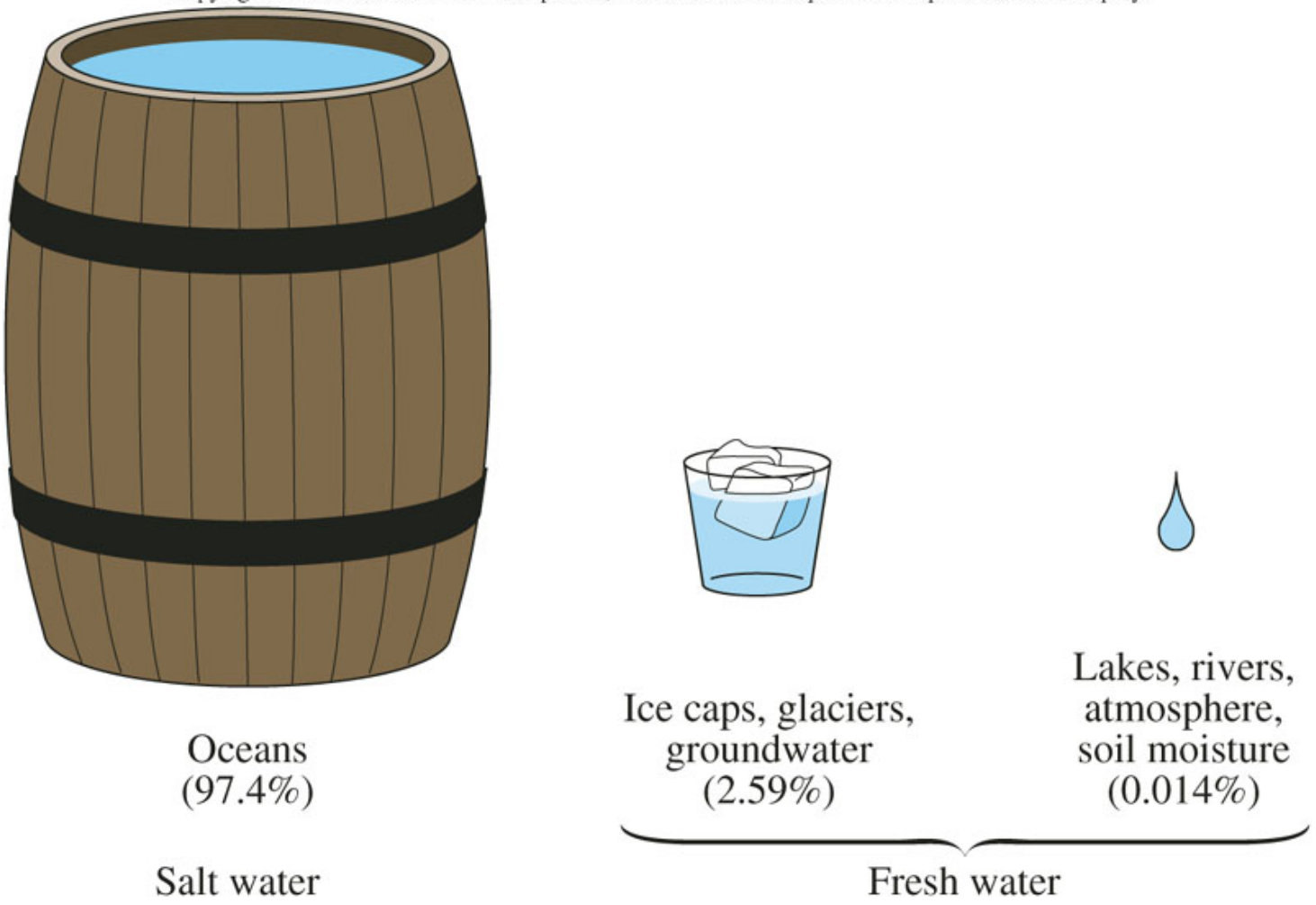


## Table 5.1 Importance of Water as a Solvent

In our bodies:

- Blood plasma is an aqueous solution containing a variety of life-supporting substances.
- Inhaled oxygen dissolves in blood plasma in the lungs allowing $O_2$ to combine with hemoglobin.
- Blood plasma carries dissolved $CO_2$ to the lungs to be exhaled.
- Blood plasma transports nutrients into all the cells and organs.
- Water helps to maintain a chemical balance by carrying wastes away.

In the environment:

- Water can transport toxic substances into, within, and out of living organisms.
- Water-soluble toxic substances, such as some pesticides, lead ions, and mercury ions, can be widely distributed.
- Water may reduce the concentrations of pollutants to safe levels by dilution or by carrying them away (or both).
- Rainwater carries substances, including those responsible for acid rain, from the atmosphere down to Earth.

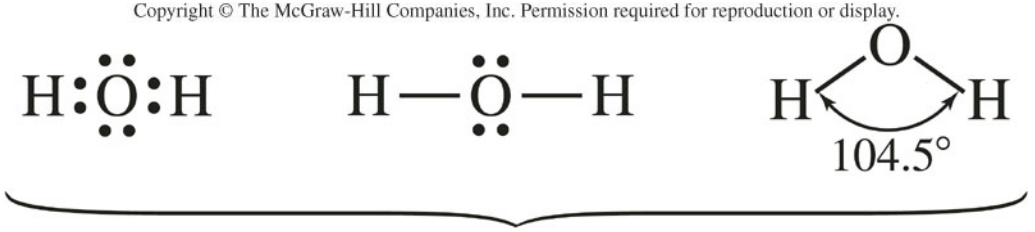
**Table 5.2** Mineral Composition of Tap Water, mg/L

| | | | |
|---|---|---|---|
| Calcium | 66 | Sulfates | 42 |
| Magnesium | 24 | Chlorides | 48 |
| Sodium | 18 | Nitrates | 6 |
| | | Fluorides | 1 |



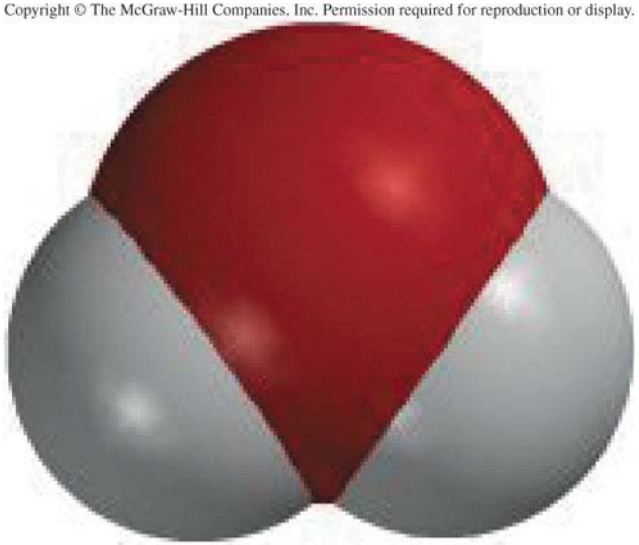
**Table 5.3** Mineral Composition of Evian, mg/L

| | | | |
|---|---|---|---|
| Calcium | 78 | Bicarbonates | 357 |
| Magnesium | 24 | Sulfates | 10 |
| Silica | 14 | Chlorides | 4 |
| | | Nitrates (N) | 1 |




**(a)**





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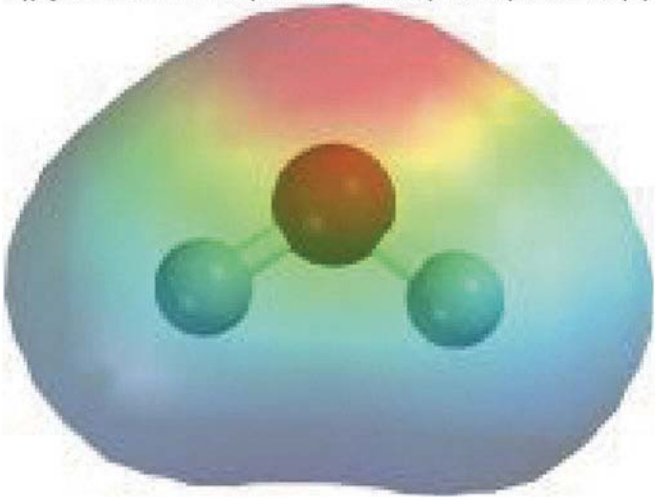


**(c)**

## Table 5.4 Electronegativity Values, Arranged by Group Number

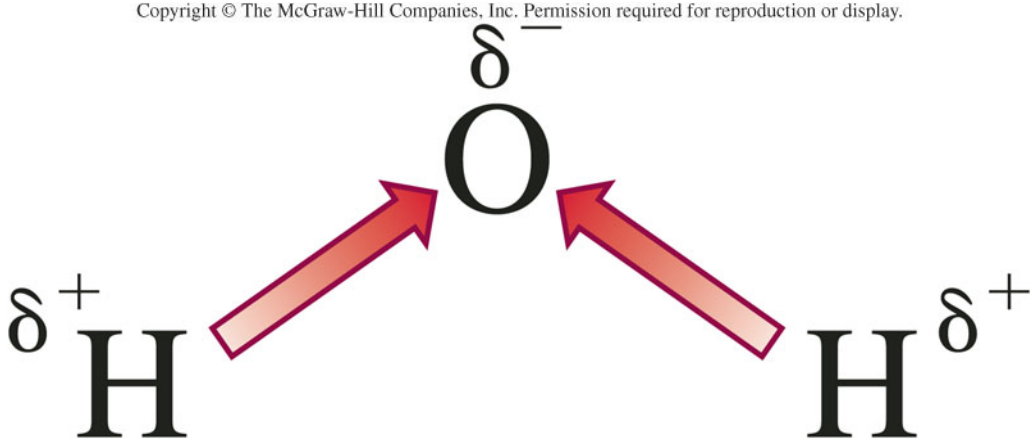
| 1A | 2A | 3A | 4A | 5A | 6A | 7A | 8A |
|---|---|---|---|---|---|---|---|
| H | | | | | | | He |
| 2.1 | | | | | | | — |
| Li | Be | B | C | N | O | F | Ne |
| 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | — |
| Na | Mg | Al | Si | P | S | Cl | Ar |
| 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.5 | 3.0 | — |

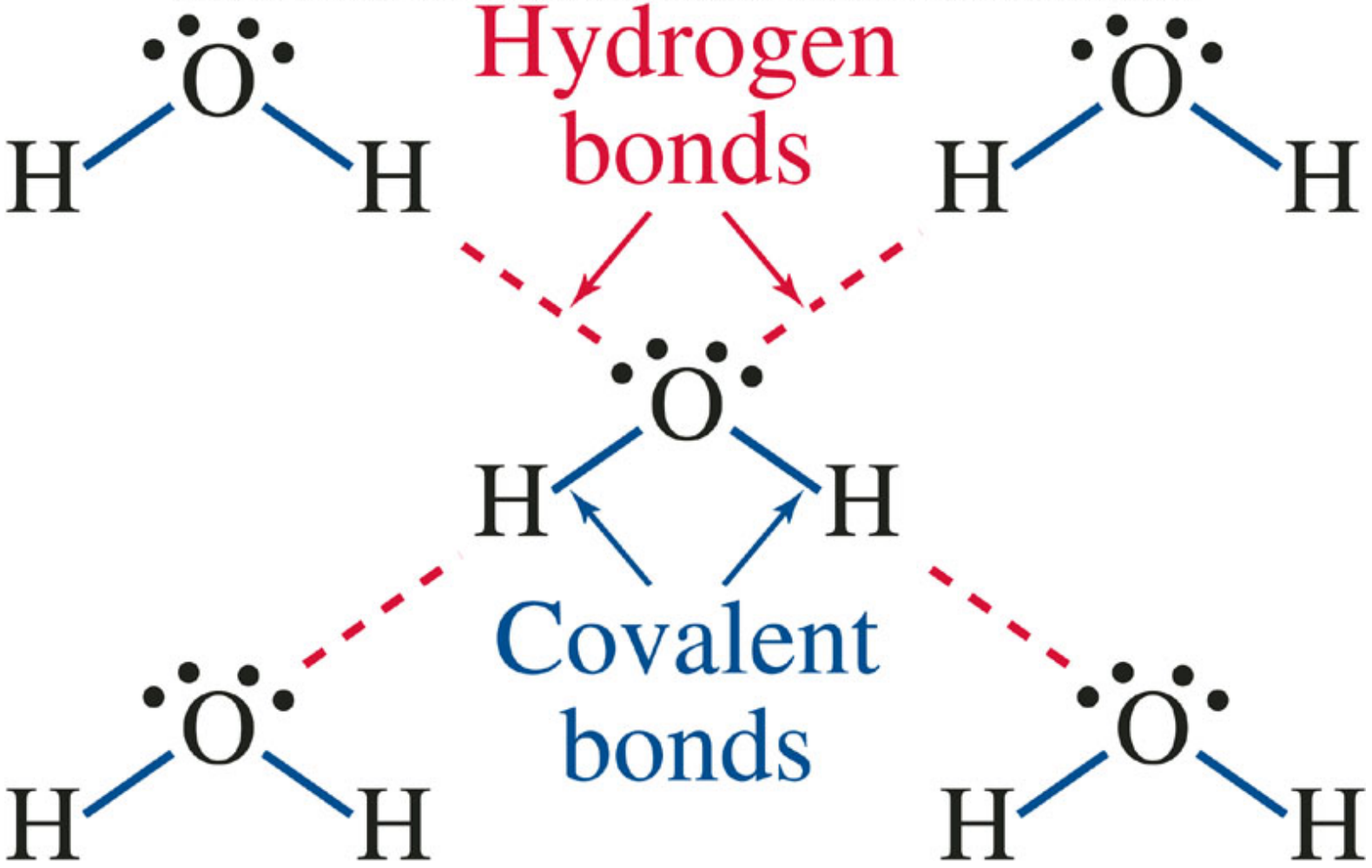
# Electronegativity value (EN)

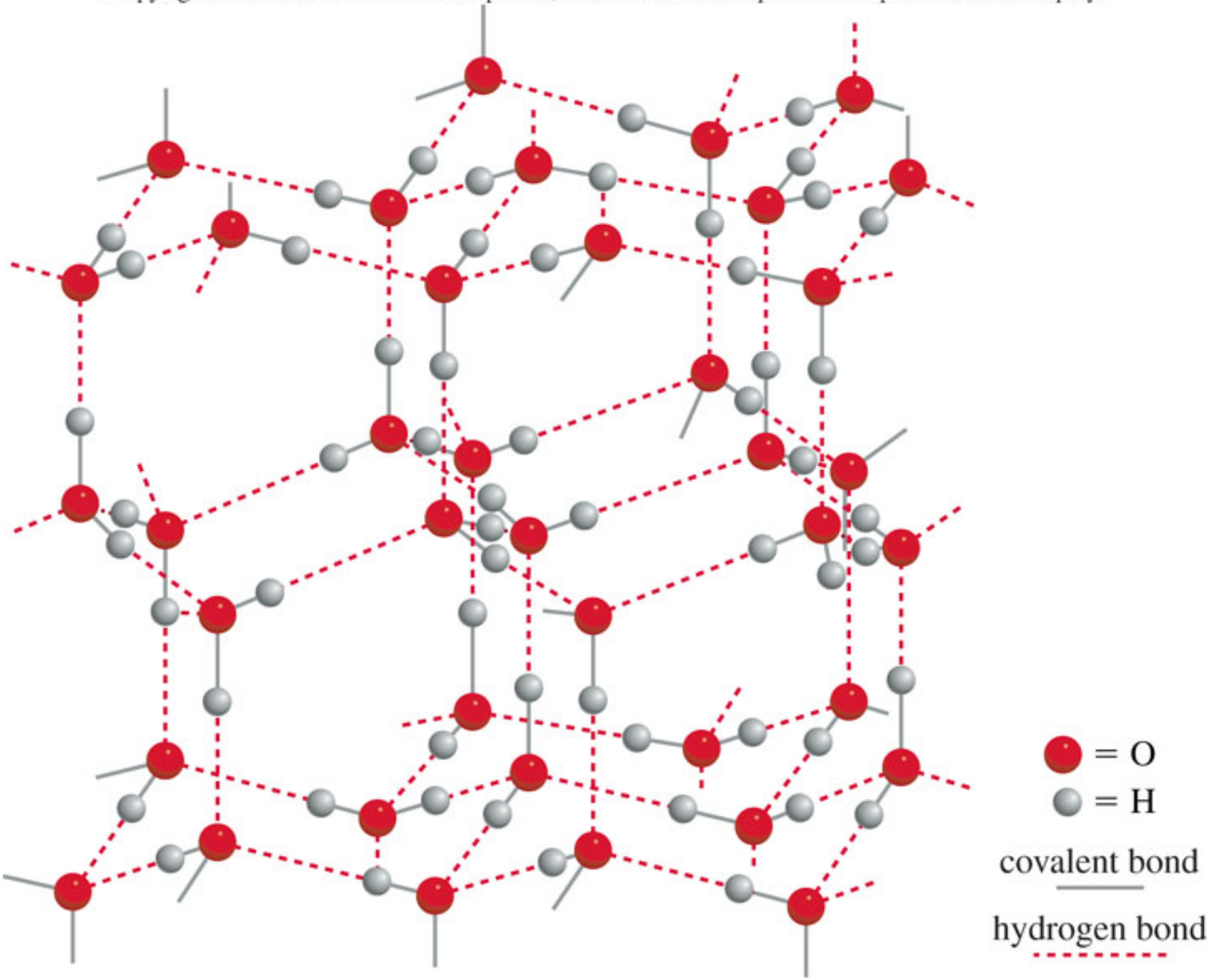
| 3.5 | 2.1 |
|---|---|

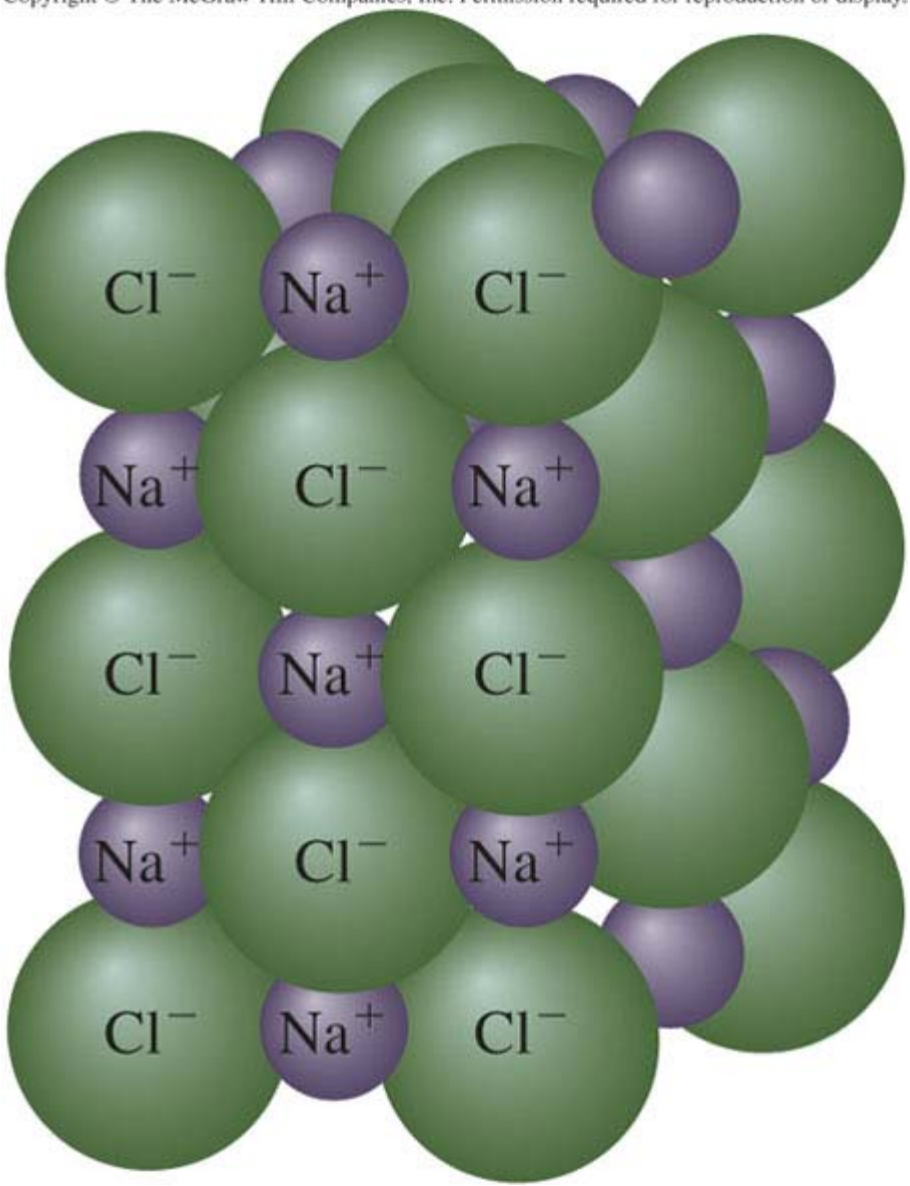

EN *difference* = 1.4











## Table 5.5 Comparison of a Sodium Atom with a Sodium Ion

| Sodium Atom | | Sodium Ion | |
|---|---|---|---|
| | Na | | $Na^+$ |
| $Na\cdot$ | 11 protons<br>11 electrons<br>*Net* charge: zero | $Na^+$ | 11 protons<br>10 electrons<br>*Net* charge: 1+ |

## Table 5.6 Comparison of a Chlorine Atom with a Chloride Ion

| Chlorine Atom | | Chloride Ion | |
|---|---|---|---|
| | Cl | | $Cl^-$ |
| $:\dot{\underset{\cdot\cdot}{Cl}}\cdot$ | 17 protons<br>17 electrons<br>*Net* charge: zero | $[:\underset{\cdot\cdot}{Cl}:]^-$ | 17 protons<br>18 electrons<br>*Net* charge: 1− |

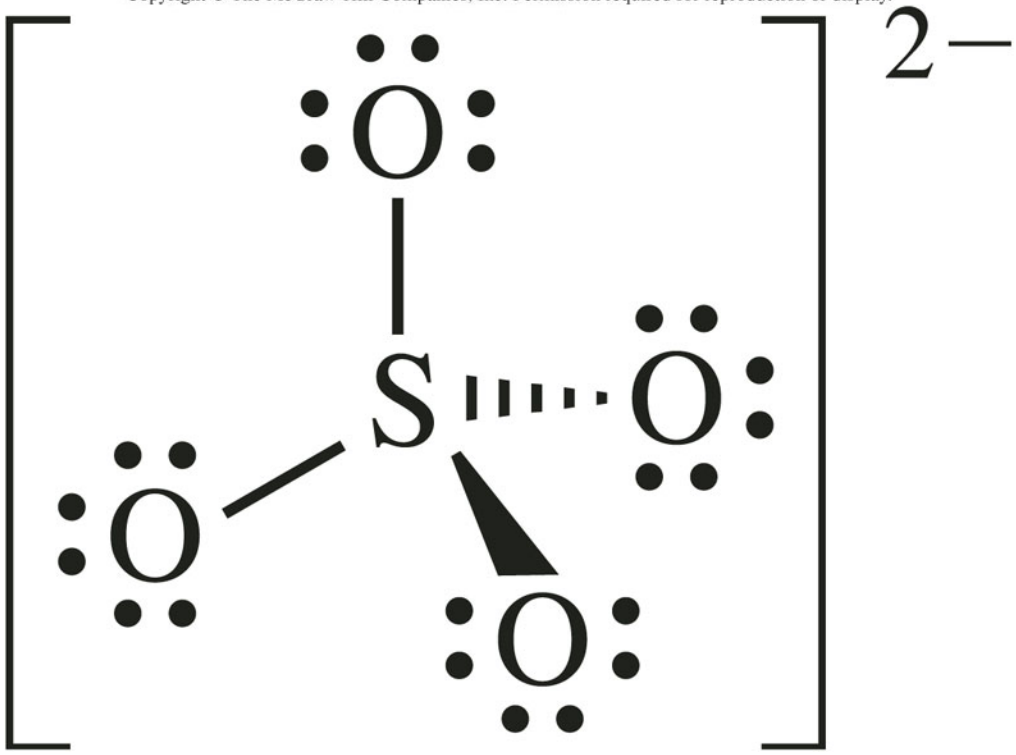
## Table 5.7 Common Polyatomic Ions

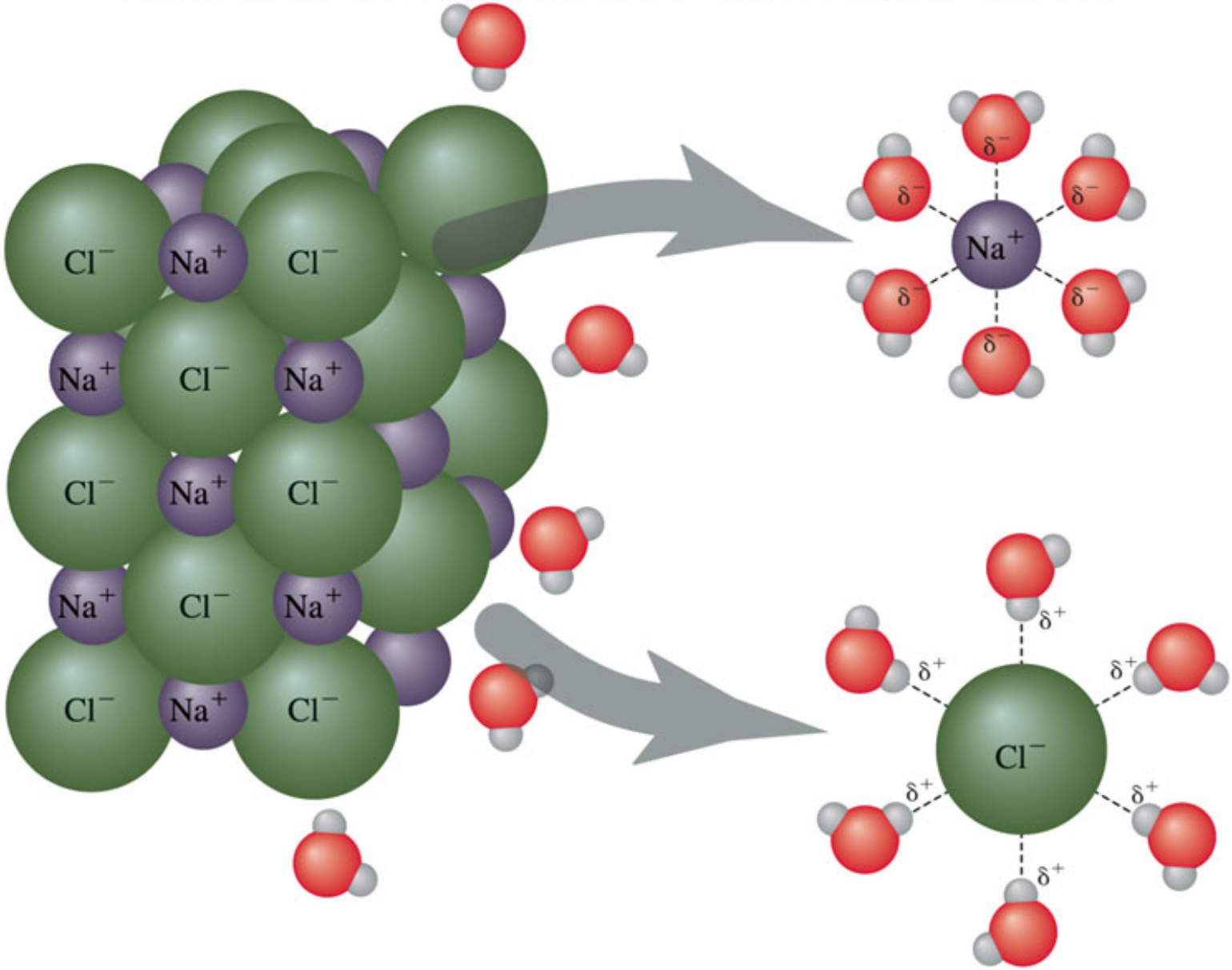
| Name | Formula | Name | Formula |
|---|---|---|---|
| acetate | $C_2H_3O_2^-$ | nitrite | $NO_2^-$ |
| bicarbonate* | $HCO_3^-$ | phosphate | $PO_4^{3-}$ |
| carbonate | $CO_3^{2-}$ | sulfate | $SO_4^{2-}$ |
| hydroxide | $OH^-$ | sulfite | $SO_3^{2-}$ |
| hypochlorite | $OCl^-$ | ammonium | $NH_4^+$ |
| nitrate | $NO_3^-$ | | |

* Also called the hydrogen carbonate ion.

**Table 5.8** Writing the Formula for an Ionic Compound

| Aluminum Cation | Sulfate Anion | Aluminum Sulfate |
|---|---|---|
| $Al^{3+}$ | $SO_4^{2-}$ | |
| $Al^{3+}$ | $SO_4^{2-}$ | $Al_2(SO_4)_3$ |
| | $SO_4^{2-}$ | |
| $2(+3) = +6$ | $3(-2) = -6$ | Electrically neutral |





# Not all ionic compounds are soluble



**Table 5.9** **Generalizations About the Solubility of Ionic Compounds in Water**

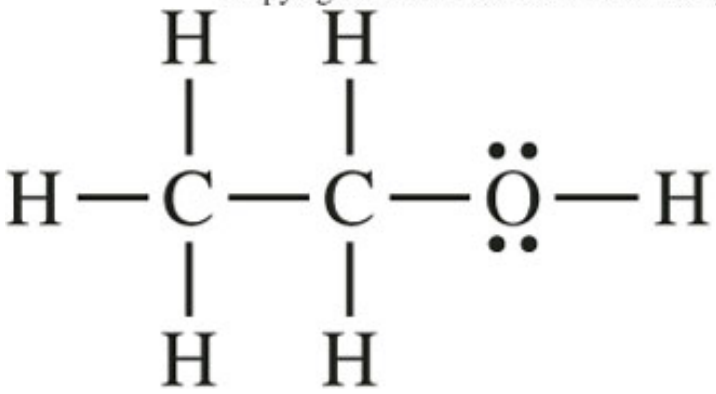
All **sodium, potassium,** and **ammonium** ($NH_4^+$) compounds are soluble.
All **nitrates** are soluble.
Most **chlorides** are soluble (except silver, some mercury, and lead chlorides).
Most **sulfates** are soluble (except strontium, barium, and lead sulfate).
Most **carbonates** are insoluble* (except those with Group 1A or $NH_4^+$ cations).
Most **hydroxides** and **oxides** are insoluble (except those with Group 1A or $NH_4^+$ cations).
Most **sulfides** are insoluble (except those with Group 1A or $NH_4^+$ cations).

* "Insoluble" means that the compounds have extremely low solubility in water (less than 0.01 M). All ionic compounds have at least a very small solubility in water.

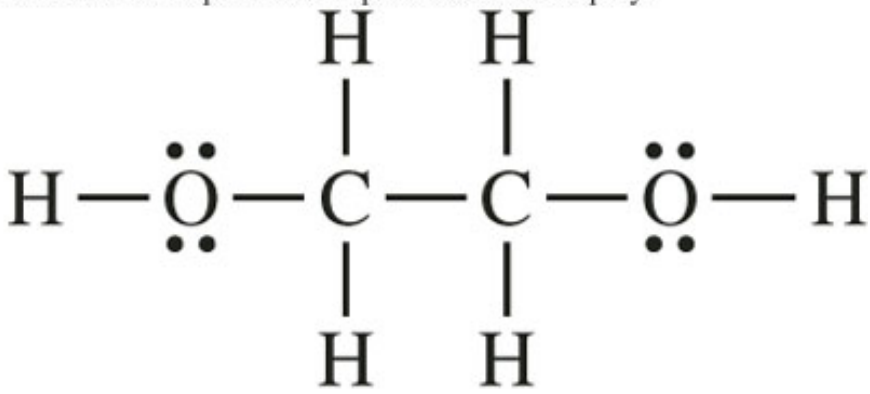
## Table 5.10 Environmental Consequences of Solubility

| Source | Ions | Solubility and Consequences |
|---|---|---|
| Salt deposits | sodium and potassium halides* | These salts are soluble. Over time, they dissolve from the land and wash into the sea. Thus, oceans are salty and sea water cannot be used for drinking without expensive purification. |
| Agricultural fertilizers | nitrates | All nitrates are soluble. The runoff from fertilized fields carries nitrates into surface and groundwater. Nitrates are toxic, especially for infants. |
| Metal ores | sulfides and oxides | Most sulfides and oxides are insoluble. Minerals containing iron, copper, and zinc are often sulfides and oxides. If these minerals had been soluble in water, they would have been washed out to sea long ago. |
| Mining waste | mercury, lead | Most mercury and lead compounds are insoluble. They are leached slowly from waste piles into rivers and lakes where they contaminate water supplies. |

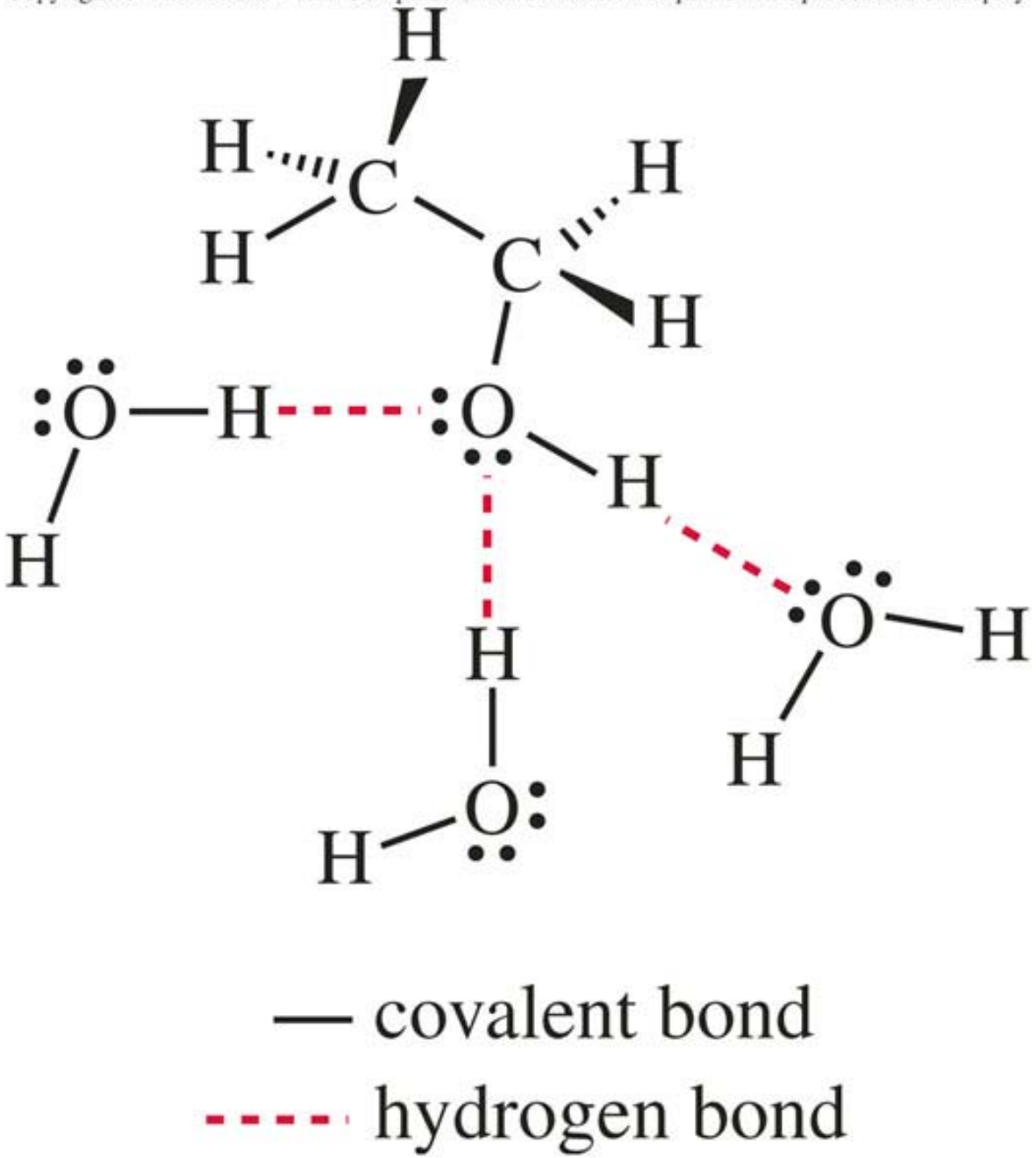
* Halides are the anions in Group 7, such as $Cl^-$ and $I^-$.



Ethanol



Ethylene glycol



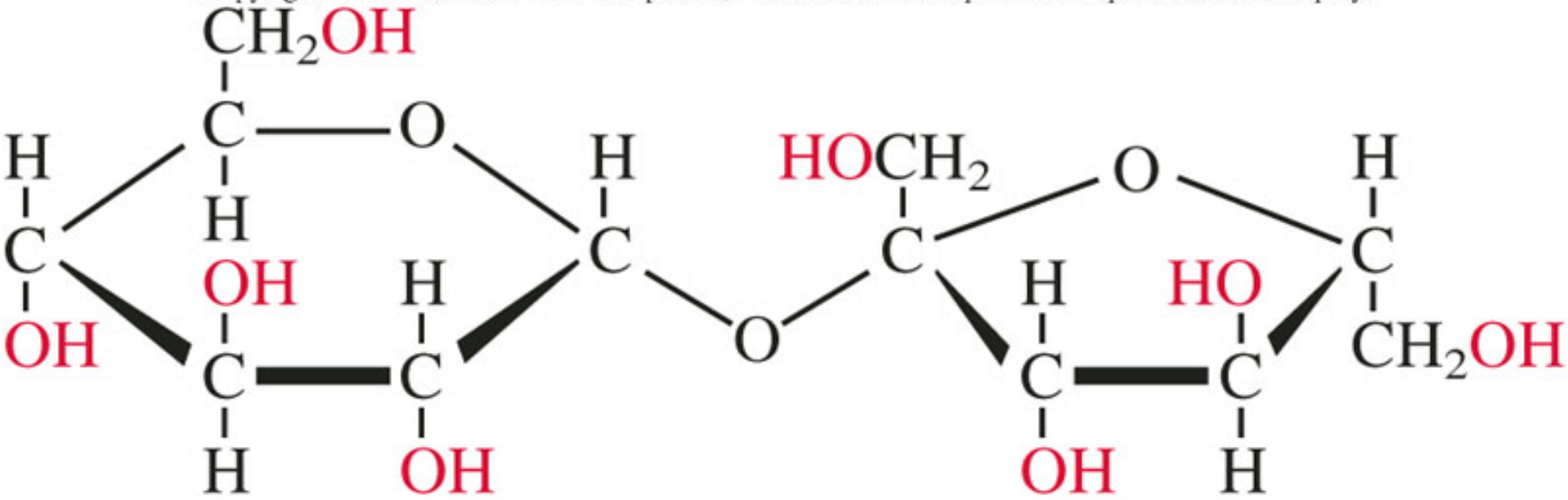


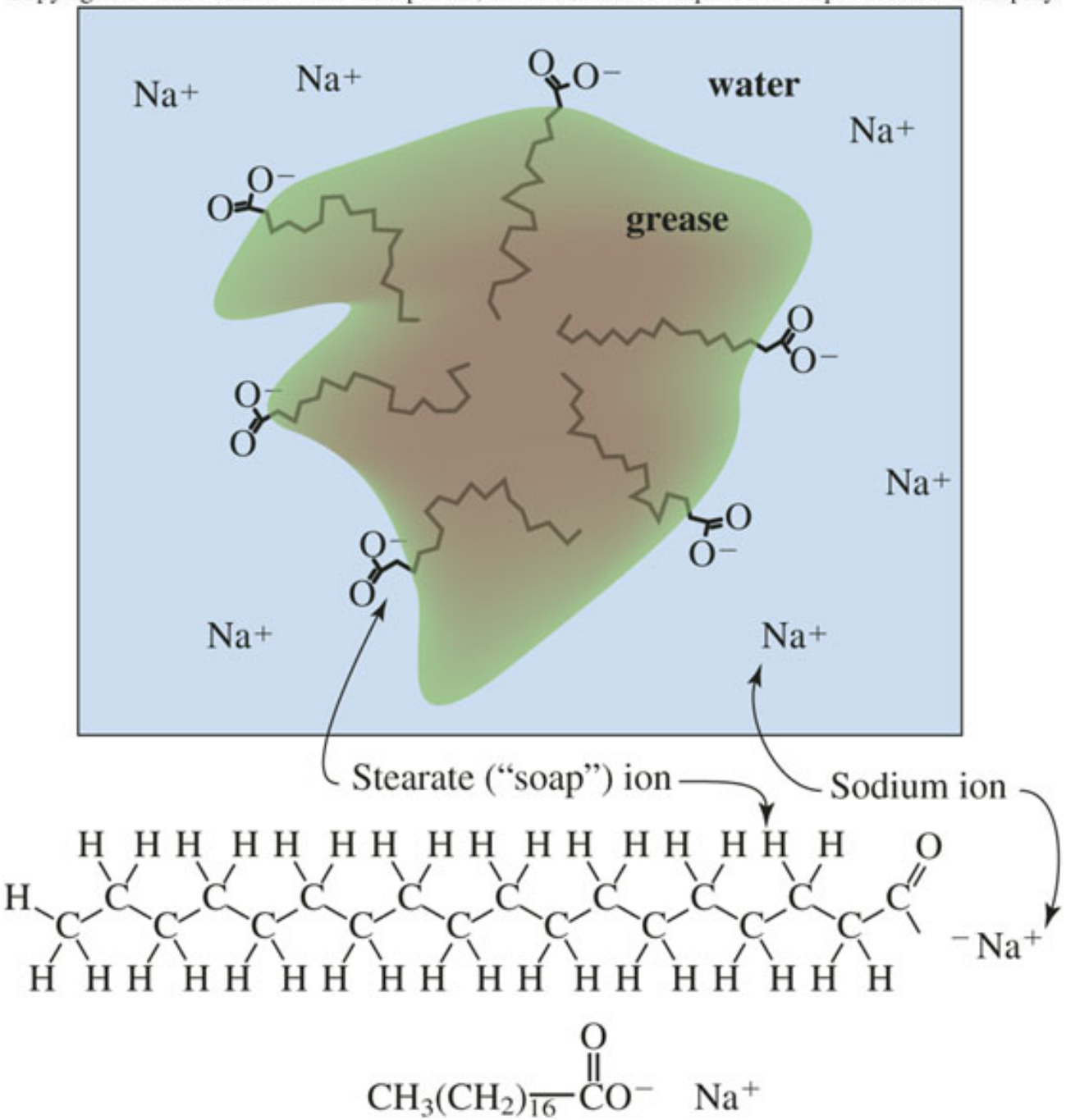
**Table 5.11** MCLGs and MCLs (in ppm) for Selected Pollutants in Drinking Water

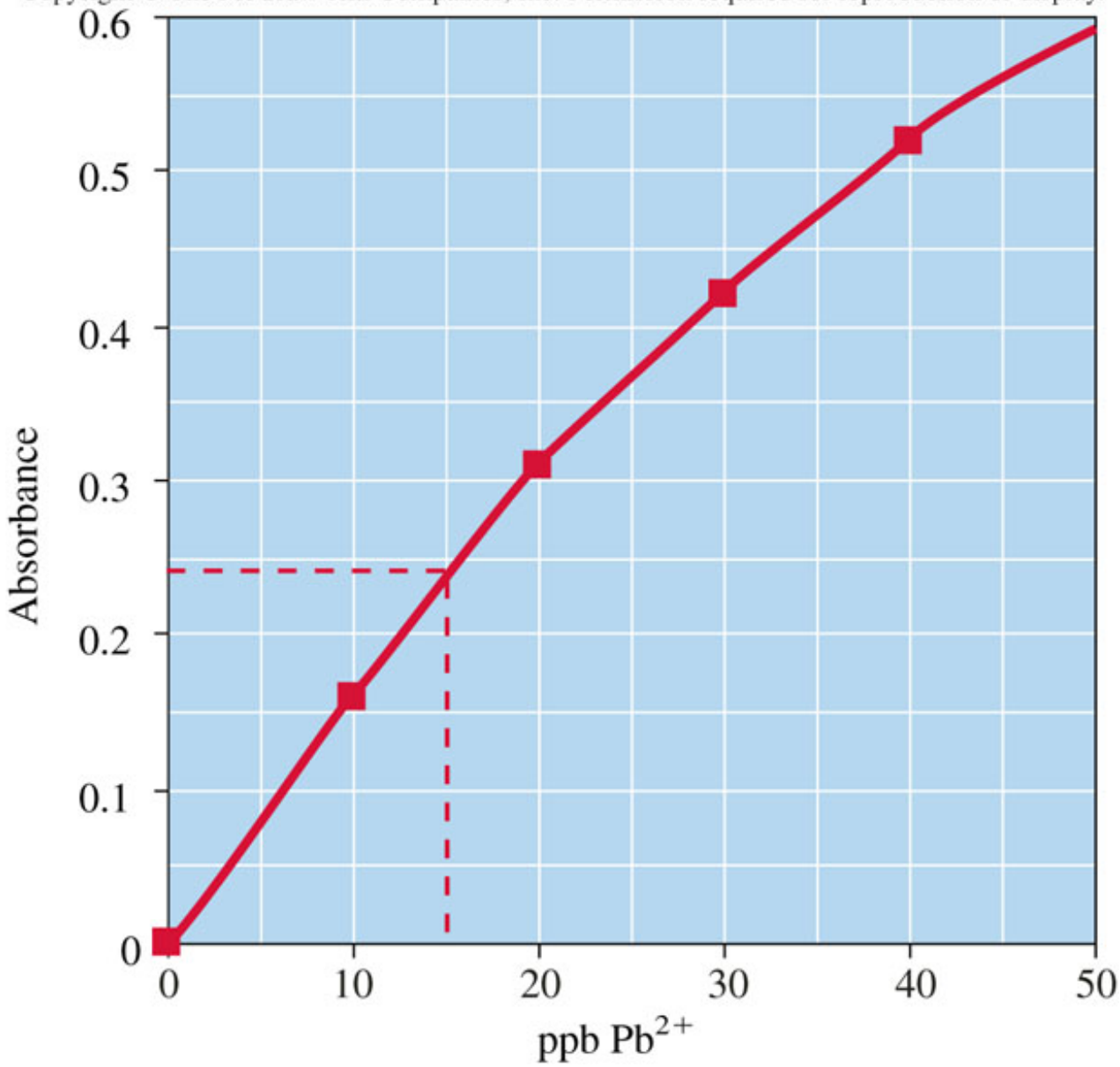
| Pollutant | MCLG | MCL |
|---|---|---|
| Cadmium ($Cd^{2+}$) | 0.005 | 0.005 |
| Chromium ($Cr^{3+}$, $CrO_4^{2-}$) | 0.1 | 0.1 |
| Lead ($Pb^{2+}$) | 0 | 0.015 |
| Mercury ($Hg^{2+}$) | 0.002 | 0.002 |
| Nitrate ($NO_3^-$) | 10 | 10 |
| Benzene ($C_6H_6$) | 0 | 0.005 |
| Trihalomethanes ($CHCl_3$, etc.) | 0 | 0.080 |

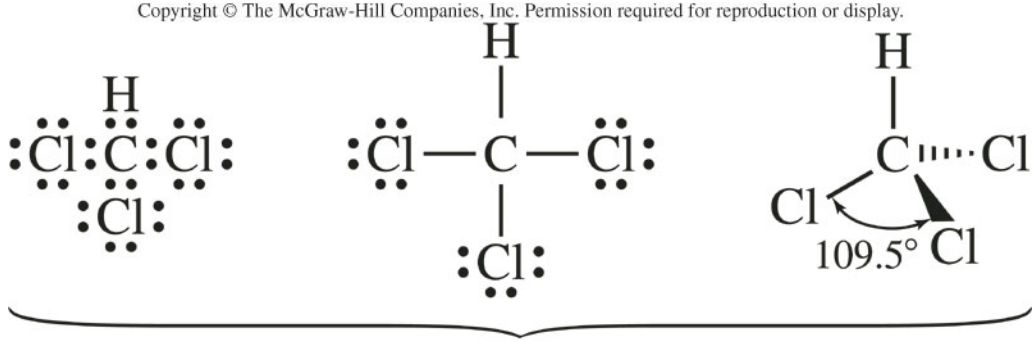
**Table 5.12** Classification of Water Hardness

| Classification | mg/L (ppm) | grains/gal* |
|---|---|---|
| Soft | 0–17.1 | 0–1 |
| Slightly hard | 17.1–60 | 1–3.5 |
| Moderately hard | 60–120 | 3.5–7.0 |
| Hard | 120–180 | 7.0–10.5 |
| Very Hard | 180 & over | 10.5 & over |

* One grain of hardness per gallon equals 17.1 mg/L (ppm). Many water-softening companies will test your water and report its hardness in grains/gallon.

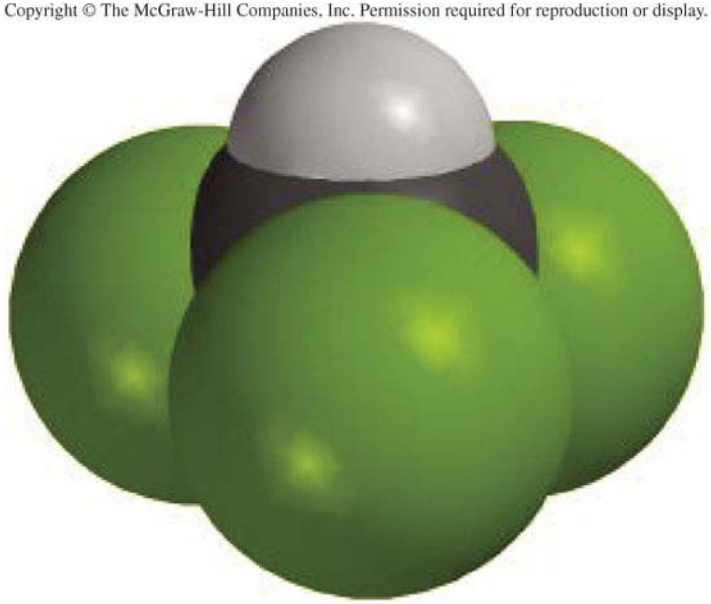







(a)





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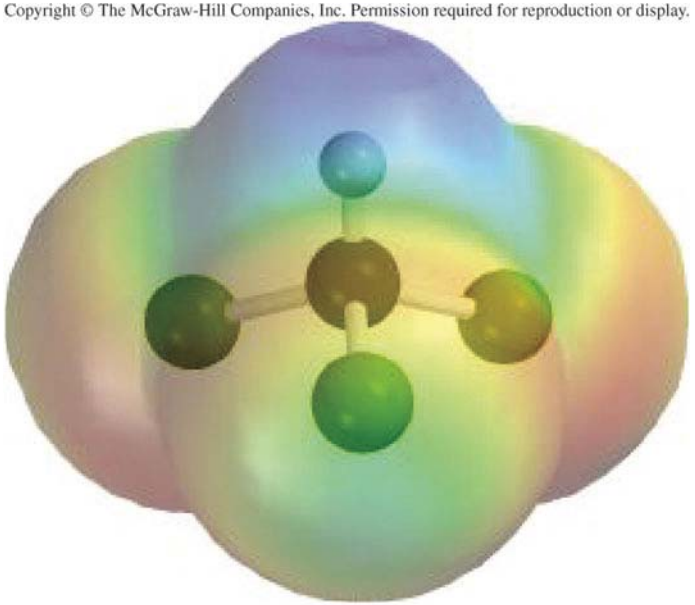

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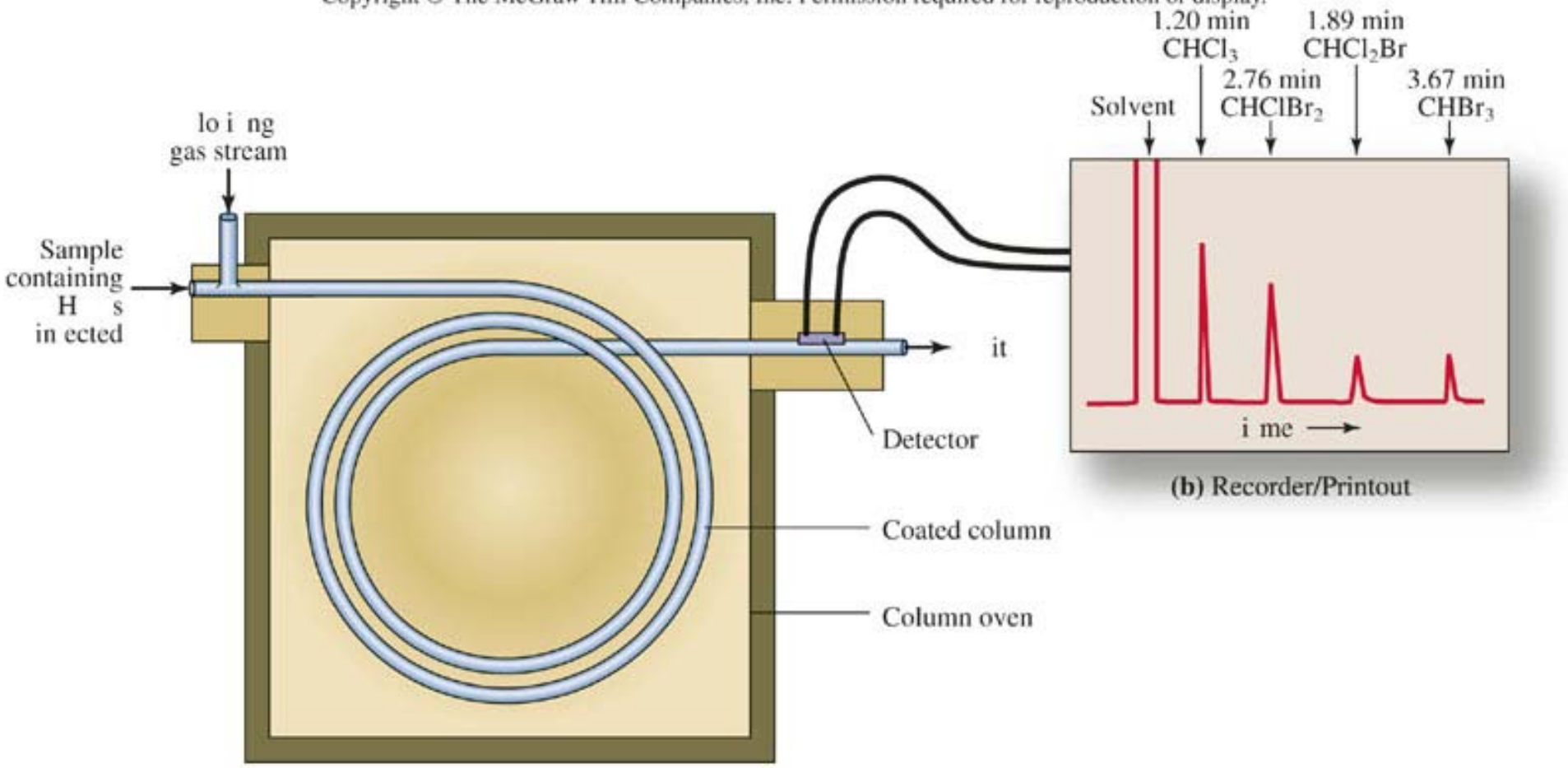


**(a)** A simplified gas chromatography apparatus.