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The Method of Transformation of Chlorinity into the Amount in Grams of Chlorine per Liter at the Standard Temperature

Maizuru Marine Observatory Naobumi KOSHIMIZU

1. Introduction

Chlorinity has been one of the most essential elements for the oceanographic study in order to determine precisely the salinity which is calculated from the empirical relation by M. Knudsen between chlorinity and salinity. But Chlorinity is inconvenient for the chemical study on sea water owing to following reasons.

Chlorinity does not represent the actual amount of chlorine in a sample water. The original definition (1902) is retained also in the new definition (1939) for the Chlorine equivalent to the total halogen ions in sea water. Chlorinity is inadequate for the chemical study, for the unit is grams in a kilogram of a sea water sample. When dealing with the chemistry of sea water, other constituents are generally determined and reported on volume basis, whereas comparing directly chlorinity with the concentration of the other chemical constituents in the water is generally impossible.

Whereupon, the author devised the method of transforming the value expressed in chlorinity into the value expressed in grams in a liter at the standard temperature.

2. Application of chlorosity

The term of chlorosity was defined by IAPO 1939, and it is the property corresponding to the chlorinity expressed as grams per 20°C-liter. According to the definition, chlorosity is obtained by multiplying the chlorinity of a sea water sample by its density at 20°C. The auther annotated the definition. The definition is expressed as follows:

$$\text{Chlorosity} = \rho_{20} \cdot \text{Cl}‰$$

$$= \frac{\text{Cl(g)}}{1000\text{(g)}\,\frac{1}{\rho_{20}\text{(g/cc)}}} = \frac{\text{Cl(g)} \cdot S_{20}}{1000\text{(cc)}} = \text{Cl(g)}S_{20}/L \cdots\cdots\cdots\cdots\cdots\cdots \text{I}$$

where ρ_{20} = the density of a sea water sample at 20°C.

S_{20} = the specific gravity of a sea water sample at 20°C.

Therefore, in another words, chlorosity is obtained by multiplying the number giving grams of the chlorine equivalent to the total halogens in a sea water sample by the specific gravity at 20°C. According to the above equation, chlorinity is transformed into the value of Cl (g)S in a liter at any temperature, both dimensions agree with each other. Therefore the equation in which the value of Cl(g)S is transformed into the Chlorine may be as it is stated in the next chapter.

3. The method of the computation to transform chlorinity into grams of chlorine in a liter of a sample sea-water

The value of $\text{Cl(g)}S_t/\text{L}$ described in the previous chapter is the concentration of the

total halogens in a liter of sea water at the standard temperature. If the ratio of the concentration of Chlorine to total halogens in sea water is found empirically, the concentration of chlorine in the water is able to calculate from chlorinity at the standard temperature.

The amout of Bromine which is apparently all present as Bromine ions shows a very constant ratio to the chlorinity. The amount of Bromine is 0.0659 gram in a kilogram of sea water (THOMPSON and KORPI, 1942). The amount of Fluorine which is present as Fluoride shows a constant ratio to the chlorinity, and it is 0.0013 gram in a kilogram sea water (THOMPSON and TAYLOR, 1933). The amount of Iodine is 0.05 milligram and it is so small as to be negligible in comparison with other halogens in the water (REITH of, 1930; SCHULTZ, 1930).

Then, assuming that the Bromine and the Fluoline had been replaced by Chlorine after the primary definition the ratio of the amount of Chlorine to that of the total halogens in sea water is calculated as follows:

$$\frac{\text{The amount of chlorine}}{\text{The amount of chlorine equivalent to the total halogens}} = \frac{Cl(g)}{Cl(g)+W_{Cl}\frac{Br(g)}{W_{Br}}+W_{Cl}\frac{F(g)}{W_F}}$$

where Cl(g), Br(g), and F(g) shows reciprocally the weight in grams of the Clorine, Bromine, and the Fluorine in sea water.

W_{Cl}, W_{Br}, W_F shows reciprocally the atomic weight in grams of Chlorine, Bromine, and Fluorine.

W_{Cl}/W_F shows the ratio of the atomic weight of Chlorine to that of Fluorine.

According to THOMPSON, the concentrations of the halogens in a kilogram of sea water of the chlorinity 19.00‰ are as follows.

The Chlorine is 18.980 grams and the Bromine is 65 milligrams, and the Fluorine is 1.4 milligrams. The author calculated the ratio of the amount of Chlorine to that of the Chlorine equivalent to the total halogens according to the above data. The ratio is calculated as follows:

$$\text{The ratio} = \frac{18.980}{18.980+35.457\times\frac{65.9\times10^{-3}}{79.916}+35.457\times\frac{1.4\times10^{-3}}{19.00}}$$

$$=0.9984\cdots\cdots(\text{II})$$

According to the equation(I) the amount of the Chlorine which is equivalant to that of the total halogens in a liter of sea water is calculated by the relation as the product of S_{20} and Cl.

$$\rho_{20}\cdot Cl‰=S_{20}\cdot Cl(g/L) \quad \text{at } 20°C\cdots\cdots(\text{III})$$

The following relation is derived from the equation(II) and the equation(III):

$$[Cl^-]=0.9984\times[\text{The amount of chlorine equivalent to the total halogens}]$$

Therefore $[Cl^-]=S_{20}\cdot Cl(g)\times0.9984/L$

If the chlorinity of a sample of the water is 19.00‰, the specific gravity of the water

is 1.02427.

Then $[Cl^-] = 1.02427 \times 19.00 \times 0.9984(g/L) = 19.423(g/L)$ at 20°C

While the practical value of the chloride ion in the water obtained by THOMSON is 18.980 grams in a kilogram of the water.

Then $\rho_{20} \cdot Cl^-‰ = 1.02427 \times 18.980 = 19.441(g/L)$ at 20°C

Here $\rho_{20} \cdot Cl^-‰$ is the concentration in grams of chloride ion per 20°C-liter of the water. The difference between the value obtained by the calculation from the chlorinity and the value obtained by the practical determination is 0.018grams in 20°C-liter and the percentage of the error is 0.09.

Both of the two values are well concident reciprocally.

4. Conclusion

The author has annotated upon chlorosity, and the value in grams expressed in a kilogram may be transformed into the concentration in grams expressed in a liter of sea water at the standard temperature according to the relation between chlorinity and chlorosity.

After the primary definition of chlorinity, the author has also determined by calculation the ratio between the concentration of Chlorine and that of the Chlorine which is equivalent to the total halogens according to the data of THOMPSON. The value of the ratio is 0.9984. The concentration in grams expressed in 20°C-liter is obtained by multiplying the chlorosity by the ratio. The error of the calculation by the author's method is 0.09% for the value of Chlorine obtained by the practical analysis of sea water, and the percentage of the error is permissible in volumetric analysis.

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References

ISHIBASHI, M. 1946: The Foundamental Volumetric Analysis, **1**.

MIYAKE, Y. 1954: Geochemistry

THOMSON, T. G. 1958: A short history of oceanography with emphasis on the role played by chemistry. Journl of chemical education. **35**. p. 108.

SVERDRUP, H. U. et al, 1949: The Ocean, p. 50-53, 167.