

Standard Reference Material[®] 187f
Sodium Tetraborate Decahydrate (Borax)
(pH Standard)

CERTIFICATE OF ANALYSIS

Purpose: The certified values delivered by this Standard Reference Material (SRM) are intended for calibrating electrodes for pH measuring systems. SRM 187f Sodium Tetraborate Decahydrate ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 10 \text{H}_2\text{O}$) was prepared to ensure high purity and uniformity. However, this SRM is certified **ONLY** as a pH standard [pH(S)], not as a pure substance.

Description: A unit of SRM 187f consists of 30 g of sodium tetraborate decahydrate.

Certified Values: A NIST certified value is a value for which NIST has the highest confidence in its accuracy in that all known or suspected sources of bias have been investigated or taken into account [1]. The pH(S) and the expanded uncertainty, U , of this solution as a function of temperature are given in Table 1. The certified pH(S) values correspond to $\lg(1/a_{\text{H}})$, where a_{H} is the conventional activity of the hydrogen (hydronium) ion referred to the standard state ($p = 1 \text{ atm} = 1.013 25 \times 10^5 \text{ Pa}$) on the scale of molality. The values were derived from potential measurements of cells without liquid junction by the primary measurement method [2,3].

The expanded uncertainty in the certified value, U , is calculated as $U = ku_c(y)$, where $u_c(y)$ is the “combined standard uncertainty” calculated according to the ISO/JCGM Guide [4]. The value of $u_c(y)$ represents the combined effect of the following uncertainty components: extrapolation to obtain the acidity function, $p(a_{\text{H}}\gamma_{\text{Cl}})^\circ$; standard electrode potentials, E° ; material heterogeneity; molality of HCl, b_{HCl} , used for determining E° ; measured cell potentials; correction to the standard pressure for H_2 gas; mean activity coefficient of HCl at b_{HCl} ; gas constant; temperature; Faraday constant; the molality of NaCl; and the uncertainty of the conventional calculation of $\log \gamma_{\text{Cl}}$ (Bates-Guggenheim convention [5]). Current expert opinion [2,6] has assessed the uncertainty attributable to the Bates-Guggenheim convention as 0.010 pH (95 % confidence interval). The value of $u_c(y)$ has been multiplied by a coverage factor, k , obtained by the Student’s t -distribution for effective degrees of freedom at the given temperature and a 95 % confidence level. **NOTE:** These certified values apply **ONLY** to a 0.01 mol/kg solution prepared from SRM 187f. Minor variations of pH(S) values may be expected to occur between SRM lots.

Traceability: The measurand is the pH of the specified buffer solution. The certified values in Table 1 are metrologically traceable to the International System of Units (SI) of amount-of-substance and mass and to the convention [5] used to define ionic activity, including its uncertainty [2,6].

Non-Certified Values: Non-certified values are provided in Appendix A.

Period of Validity: The certified values delivered by **SRM 187f** are valid within the measurement uncertainty specified until **31 August 2032**. The certified values are nullified if the material is stored or used improperly, damaged, contaminated, or otherwise modified.

Maintenance of Certified Values: NIST will monitor this SRM over the period of its validity. If substantive technical changes occur that affect the certification, NIST will issue an amended certificate through the NIST SRM website (<https://www.nist.gov/srm>). Before making use of any of the values delivered by this material, users should verify they have the most recent version of this documentation, available through the NIST SRM website (<https://www.nist.gov/srm>).

Table 1. Certified pH(S) Values and Expanded Uncertainties (95 % Confidence)

Temperature (°C)	pH(S)	Combined Standard Uncertainty, $u_c(y)$	Coverage Factor, k	Expanded Uncertainty, U
5	9.401	0.005 2	1.96	0.010
10	9.342	0.005 1	1.96	0.010
15	9.288	0.005 1	1.96	0.010
20	9.239	0.005 1	1.96	0.010
25	9.195	0.005 1	1.96	0.010
30	9.155	0.005 4	1.96	0.010
35	9.120	0.005 3	1.96	0.010
37	9.107	0.005 2	1.96	0.010
40	9.088	0.005 2	1.96	0.010
45	9.059	0.005 2	1.96	0.010
50	9.034	0.005 2	1.96	0.010

Safety: Consult the Safety Data Sheet (SDS) for hazard information.

Storage: SRM 187f is stable when stored in its original container, with the cap tightly closed, in a dry environment, and under normal laboratory temperatures. Do not store in a desiccator before use.

Use: Use as received. SRM 187f must not be dried in an oven. A solution of molality 0.01 mol/kg is recommended for the calibration of pH measuring systems.

Source Water for Solution Preparation: The water used in the preparation of the SRM 187f buffer solution should be protected from atmospheric carbon dioxide. This water must be prepared either by (1) boiling of distilled water (conductivity < 2 $\mu\text{S}/\text{cm}$) for 10 min and guarding it with a soda-lime tube while cooling or (2) dispensing water directly from a deionization-based point-of-use system into the vessel used to prepare the buffer solutions (resistivity > 17 $\text{M}\Omega\cdot\text{cm}$, conductivity < 0.06 $\mu\text{S}/\text{cm}$). The prepared solution should be protected against evaporation and contamination.

Preparation of the 0.01 mol/kg Solution: Quantities denoted by m' and associated numerical factors in this paragraph include the effect of air buoyancy, i.e., they correspond to the balance indication in units of mass obtained in the laboratory (the *balance reading*). Weigh by difference approximately 3.7 g of SRM 187f, m'_{187f} , to an accuracy of 1 mg, into a clean, dry 1 L polyethylene bottle. Add a weighed quantity of CO_2 -free water, equal to 261.841 multiplied by m'_{187f} , to an accuracy of 0.1 g. Shake until the solid has totally dissolved. Gravimetric preparation in this manner eliminates the need to weigh exactly predetermined masses of solid samples. Proportionately smaller quantities of each SRM may be used in this preparation, provided that m'_{187f} exceeds 0.42 g.

Stability of the Prepared Solution: The solution should be discarded after one month, or sooner if sediment appears or if it has been exposed repeatedly to air containing carbon dioxide. To avoid contamination of the buffer solution with atmospheric carbon dioxide, keep the bottle capped except when removing a portion of the solution.

Source of Material: The sodium tetraborate decahydrate ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 10 \text{H}_2\text{O}$) was obtained from a commercial company. This material conforms to the specifications of the American Chemical Society for primary standard chemicals [7].

REFERENCES

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Certain commercial equipment, instruments, or materials may be identified in this Certificate of Analysis to adequately specify the experimental procedure. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

Users of this SRM should ensure that the Certificate of Analysis in their possession is current. This can be accomplished by contacting the Office of Reference Materials 100 Bureau Drive, Stop 2300, Gaithersburg, MD 20899-2300; telephone (301) 975-2200; e-mail srminfo@nist.gov; or the Internet at <https://www.nist.gov/srm>.

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APPENDIX A

Non-Certified Values: A NIST non-certified value does not meet NIST criteria for certification and is provided with an associated uncertainty that may not include all sources of uncertainty [1]. The respective pH(S) values in Table A1 are identical to those in Table 1 but are listed to the number of decimal places reported for the expanded uncertainty, U_R :

$$U_R = k_R u_c(\text{measurement}),$$

where k_R is the coverage factor for U_R . The quantities U_R and $u_c(\text{measurement})$ each include all components associated with the measurement method and assessment of material heterogeneity, but **DO NOT** include the uncertainty [2,6] of the Bates-Guggenheim convention [5]. To attain traceability to the NIST non-certified pH(S) values for SRM 187f when traceability to the SI units is not necessary, the uncertainty of the Bates-Guggenheim convention is excluded from the uncertainty calculation.

Table A1. Non-Certified pH(S) Values and Expanded Non-Certified Uncertainties (95 % Confidence)

Temperature (°C)	pH(S)	Combined Standard Uncertainty, $u_c(\text{measurement})$	Non-Certified Coverage Factor, k_R	Expanded Uncertainty, U_R
5	9.401 3	0.001 3	2.08	0.002 8
10	9.341 7	0.001 2	2.09	0.002 4
15	9.287 8	0.001 0	2.04	0.002 1
20	9.239 0	0.001 0	2.02	0.001 9
25	9.195 1	0.001 0	2.03	0.002 0
30	9.155 4	0.001 9	2.01	0.003 8
35	9.119 8	0.001 7	1.98	0.003 3
37	9.106 6	0.001 6	1.97	0.003 1
40	9.087 9	0.001 5	1.96	0.002 9
45	9.059 3	0.001 5	1.96	0.002 9
50	9.033 8	0.001 4	1.96	0.002 8

Period of Validity: The non-certified values are valid within the measurement uncertainty specified until **31 August 2032**. The value assignments are nullified if the material is stored or used improperly, damaged, contaminated, or otherwise modified.

Maintenance of Non-Certified Values: NIST will monitor this material to the end of its period of validity. If substantive technical changes occur that affect the non-certified values during this period, NIST will update this Certificate of Analysis. Before making use of any of the values delivered by this material, users should verify they have the most recent version of this documentation, available through the NIST SRM website (<https://www.nist.gov/srm>).

***** End of Appendix A *****