Automatic Temperature Correction (ATC) and pH measurement

What is ATC?

The sample temperature can affect the pH electrode response (sensitivity) to pH and cause errors in measurements. Temperature compensation can be achieved automatically using Automatic. Temperature Compensation (ATC). Automatic temperature compensation requires input from a temperature sensor and constantly sends a compensated pH signal to the display. pH meters that do not have ATC are markedly less accurate.

- The pH of a sample is temperature dependent.
- The chemical compositions of samples vary, and samples may react differently to temperature
- ATC provides a manner to adjust pH electrode calibration and increases accuracy.

What does pH ATC do to the calibration?

What happens during calibration?

pH calibration must be performed with the pH meter and pH electrode using at least two pH buffers that bracket the pH values of samples before the pH of the sample is measured. For the pH meter to recognize and calibrate the pH buffers correctly, the appropriate pH buffer group must be selected and set in the set-up mode of the pH meter. During calibration, the pH meter detects the temperature measured by the temperature sensor or probe as well as the potential (mV) measured by the pH electrode. The pH meter then recognizes the pH buffer in use based on the measured potential and assigns the correct value of the pH buffer based on the measured temperature. To verify whether the pH meter has calibrated the correct value of the pH buffer at the measured temperature, refer to the pH vs temperature table on the label of the pH buffer bottle.

°C	pH Buffers at 25°C						
	1.68	4.01	6.86	7.00	9.18	10.01	12.46
0	1.67	4.01	6.98	7.12	9.46	10.32	13.47
5	1.67	4.01	6.95	7.09	9.39	10.25	13.25
10	1.67	4.00	6.92	7.06	9.32	10.18	13.03
15	1.67	4.00	6.90	7.04	9.27	10.12	12.83
20	1.68	4.00	6.88	7.02	9.22	10.06	12.64
25	1.68	4.01	6.86	7.00	9.18	10.01	12.46
30	1.69	4.01	6.85	6.98	9.14	9.97	12.29
35	1.69	4.02	6.84	6.98	9.10	9.93	12.14
40	1.70	4.03	6.84	6.97	9.07	9.89	11.99
45	1.70	4.04	6.83	6.97	9.04	9.86	11.86
50	1.71	4.06	6.83	6.97	9.01	9.83	11.73
55	1.72	4.08	6.83	6.97	8.99	9.81	11.61

Table 1: Values of pH Buffers at Different Temperatures

How does ATC affect the calibration?

The pH electrode behaviour follows the Nernst equation:

$$E = E^0 + 2.303\,(RT/nF)\log a_{H+}$$

Where E is the potential (in mV) of the sensing reference electrode, E^o is the potential of reference electrode and a_{H+} is the activity of H^+ The slope (also called sensitivity) is denoted by -2.303 RT/nF and pH is equal to -log a_{H+}. Since R (gas constant, 8.314 J//mol K), F (Faradays constant, 96485 C/mol), and n (valency of ion, 1 for H^+) are constants, the slope changes with temperature and this effect can be compensated by a pH meter with ATC capability. After calibration, the pH meter generates slope at the measured temperature according to the Nernst equation.

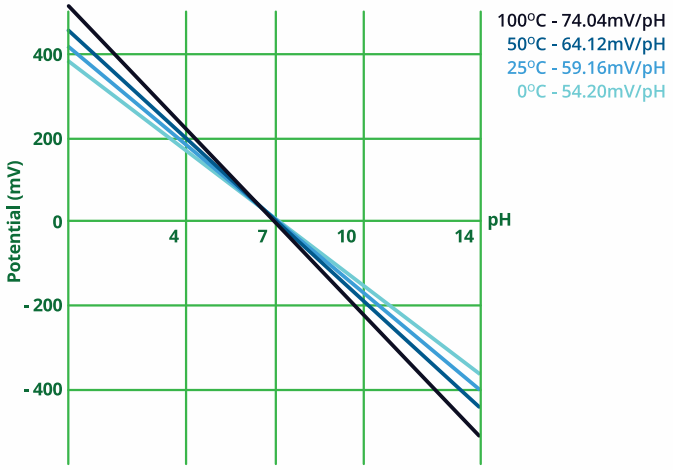


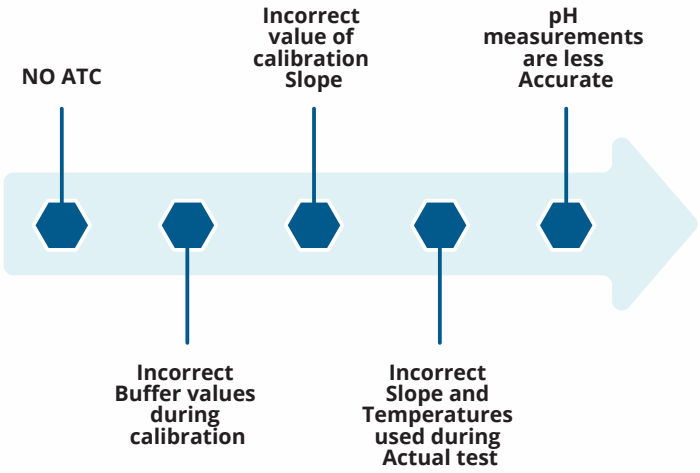
Figure 1: Theoretical slopes of an ideal pH electrode at different temperatures

During measurement, the pH meter applies the slope to calculate the pH values of samples. To obtain accurate results, samples should be at the same (or as close as possible) temperature as the pH buffers used in calibration. This can be achieved by allowing the pH buffers and samples to equilibrate at room temperature or by placing them in a water bath with temperature control.

- During calibration, ATC measures the real temperature of the buffer and assigns the exact correct value.
- During testing, ATC measures the real temperature of the sample and adjusts the slope to remain in collaboration.

Should I bother to use ATC for pH? What if I leave the temperature set at 25°C?

It is generally advisable to use ATC for pH measurements because it helps improve the accuracy and decreases or removes the need for strict temperature control of samples or buffers or both. This figure shows an example of how error in pH measurement can be introduced when an ATC is not used during testing.



In case you chose not to compensate for the temperature, then the temperature of the buffers and samples must be brought as closely as possible to each other and to the manually set meter temperature (default to 25°C).

- Keep your samples and calibration buffers as close in temperature as possible
- Use a pH meter with ATC to compensate for the remaining small differences

Does ATC adjust the measured sample pH result to the result expected at 25°C?

No, ATC cannot adjust pH value measured at one temperature to an expected pH value at another temperature (e.g. 25°C). This is because we do not know exactly how the pH of a sample behaves with temperature. If we want to know what the pH value of the sample at a certain temperature, then we must adjust the sample to that temperature and measure the pH. This is the reason why pH is frequently reported along with a temperature measurement.

Do I need an ATC probe in order to make a temperature compensated pH measurement?

No, an ATC probe is not required. Some pH electrodes (combination pH electrode with built-in temperature sensor) and meters are provided with automatic temperature compensated pH measurements. However, most laboratory pH meters are typically not programmed to correct the pH values of samples at the actual or other temperature. It is important to record the pH value together with the temperature after measuring a sample. Alternatively, temperature can be measured manually for each buffer and solution, and then entered into the meter before recording the pH measurement.

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