Borderless Science Seeks for Seamless Standards: Standard State Pressure Should Be 101.325 kPa

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Who cares? – Nobody. That's why *standard* have to be single.

In the present days, thermodynamic quantities of substances significantly contribute to a variety of scientific research including space science, environmental science, nano-materials science, and so on. In other words, we study in the borderless world of science, where thermodynamic quantities are handled and discussed everywhere by many scientists who are not familiar enough to chemical thermodynamics. Under such circumstances, some definition which is very specific to chemical thermodynamics not only makes people hesitate to utilize thermodynamic quantities but also misleads them to wrong usage.

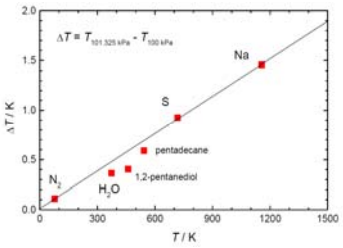
Standard state pressure (SSP), $P^\ominus$ = 100 kPa, which has been recommended by IUPAC in 1981 [1], is such an undesirable definition. The recommendation insists that *SSP is effective only in chemical thermodynamics with no relation to any other standard pressures*, such as standard atmosphere. However, even in chemical thermodynamics, conventional standard pressure, $P^\ominus$ =101.325 kPa, which had been widely accepted before, has been still utilized. Actually, *Handbook of Chemistry* 5th ed. (2004), edited by the Chemical Society of Japan, adopted $P^\ominus$ =101.325 kPa for convenience.

Many people do not care SSP, when they use standard thermodynamic quantities. However, standard entropies of gaseous substances under the IUPAC SSP are larger than those under the conventional SSP by 0.11 J K^{-1} mol^{-1}. The *standard* boiling points under the IUPAC SSP have differed from the normal boiling points under standard atmosphere since the IUPAC recommendation. In fact, the *standard* boiling point of water is 99.61 °C, while the normal one 99.974 °C.

In 1648, Pascal and Perrier showed that the height of mercury was due to atmospheric pressure.

Berzelius defined in *Lehrbuch der Chemie* that the boiling point was the vaporization temperature at P = 0.76 mHg.

Boiling point is an important thermodynamic quantity. Difference between normal and IUPAC standard boiling points is not ignorable.



Gibbs energy of formation accumulates the small difference of standard entropy.

$2Na(cr) + S(cr) + 10H_2(g) + 7O_2(g) = Na_2SO_4.10H_2O$ at T = 298.15 K.

Difference of $\Delta_f G^\ominus_m(Na_2SO_4.10H_2O, cr)$ = 0.56 kJ mol^{-1} under two standard state pressures.
It induces an error on the incongruently melting point by 2 K at most.

Standard atmosphere, 101.325 kPa is a cultural heritage.

All standards should be on a common basis in the current borderless sciences. At the same time, we have to know that standards have been a kind of cultural heritage. Atmospheric pressure on the ground has been recognized to be 76 cmHg since 17 c. Berzelius defined in *Lehrbuch der Chemie* that the boiling point was the vaporization temperature at P = 0.76 mHg. The conventional SSP had been accepted on such a common cultural basis of science as well as the other standard pressures. Nevertheless, in 1981, IUPAC violently recommended the new SSP against the common culture. In 2004, JSCTA annual assembly decided that the IUPAC recommendation should be withdrawn.

We welcome any comments and hope your supports. Your comments should be addressed to the corresponding author: nagano@chem.sci.osaka-u.ac.jp

[1] IUPAC Physical Chemistry Division Commission on Thermodynamics, *Pure Appl. Chem.*, 1982, **54**, 1239-1250.

Standard state pressure should be exactly same as *standard atmosphere*, 101.325 kPa.