

SECONDARY REFERENCE POINTS ON THE ITS-90 TEMPERATURE SCALE

The International Temperature Scale of 1990 is described in Section 1 of this *Handbook*, where the defining fixed points are listed. The Consultative Committee on Thermometry (CCT) of the International Committee on Weights and Measures (CIPM), which oversees the temperature scale, has recommended a number of secondary reference points whose values have been accurately determined with respect to the primary fixed points. The most accurate of these, referred to as “first quality points”, satisfy several criteria involving purity of the material, reproducibility, and documentation of the measurements. The CCT also lists “second quality points” that do not yet satisfy all the criteria but are still useful. Taken together,

these secondary reference points, help fill in the gaps between the primary fixed points.

The table below describes these secondary reference points. The best values resulting from the CCT evaluation are listed on both the Kelvin and Celsius scales, along with an estimate of uncertainty. Full details are given in the reference.

The entries within each quality group are listed in order of increasing temperature.

Reference

Bedford, R. E., Bonnier, G., Maas, H., and Pavese, F., *Metrologia* 33, 133, 1996.

Substance	Type of Transition	T_{90}/K	$t_{90}/^{\circ}\text{C}$	Uncert.
<i>First quality points</i>				
Zinc	Superconductive transition	0.8500	-272.300	0.0030
Aluminum	Superconductive transition	1.1810	-271.9690	0.0025
Helium (^4He)	Superfluid transition	2.1768	-270.9732	0.0001
Indium	Superconductive transition	3.4145	-269.7355	0.0025
Lead	Superconductive transition	7.1997	-265.9503	0.0025
Niobium	Superconductive transition	9.2880	-263.8620	0.0025
Deuterium ($^2\text{H}_2$)	Triple point (equilibrium D_2)	18.689	-254.461	0.001
Deuterium ($^2\text{H}_2$)	Triple point (normal D_2)	18.724	-254.426	0.001
Neon (^{20}Ne)	Triple point	24.541	-248.609	0.001
Neon	Boiling point	27.097	-246.053	0.001
Nitrogen	Triple point	63.151	-209.999	0.001
Nitrogen	Boiling point	77.352	-195.798	0.002
Argon	Boiling point	87.303	-185.847	0.001
Oxygen	Condensation point	90.197	-182.953	0.001
Methane	Triple point	90.694	-182.456	0.001
Xenon	Triple point	161.405	-111.745	0.001
Carbon dioxide	Triple point	216.592	-56.558	0.001
Mercury	Freezing point	234.3210	-38.8290	0.0005
Water	Ice point	273.15	0	
Gallium	Triple point	302.9166	29.7666	0.0001
Water	Boiling point	373.124	99.974	0.001
Indium	Triple point	429.7436	156.5936	0.0002
Bismuth	Freezing point	544.552	271.402	0.001
Cadmium	Freezing point	594.219	321.069	0.001
Lead	Freezing point	600.612	327.462	0.001
Antimony	Freezing point	903.778	630.628	0.001
Copper/71.9% silver	Eutectic melting point	1052.78	779.63	0.05
Palladium	Freezing point	1828.0	1554.8	0.1
Platinum	Freezing point	2041.3	1768.2	0.4
Rhodium	Freezing point	2236	1963	3
Iridium	Freezing point	2719	2446	6
Molybdenum	Melting point	2895	2622	4
Tungsten	Melting point	3687	3414	7
<i>Second quality points</i>				
Hydrogen	Triple point (normal H_2)	13.952	-259.198	0.002
Hydrogen	Boiling point (normal H_2)	20.388	-252.762	0.002
Oxygen	α - β transition	23.868	-249.282	0.005
Nitrogen	α - β transition	35.614	-237.536	0.006
Oxygen	β - γ transition	43.796	-229.354	0.001
Krypton	Triple point	115.775	-157.375	0.001
Carbon dioxide	Sublimation point	194.686	-78.464	0.003

Substance	Type of Transition	T_{90}/K	$t_{90}/^{\circ}\text{C}$	Uncert.
Sulfur hexafluoride	Triple point	223.554	-49.596	0.005
Gallium/20% indium	Eutectic melting point	288.800	15.650	0.001
Gallium/8% tin	Eutectic melting point	293.626	20.476	0.002
Diphenyl ether	Triple point	300.014	26.864	0.001
Ethylene carbonate	Triple point	309.465	36.315	0.001
Succinonitrile	Triple point	331.215	58.065	0.002
Sodium	Freezing point	370.944	97.794	0.005
Benzoic acid	Triple point	395.486	122.336	0.002
Benzoic acid	Freezing point	395.502	122.352	0.007
Mercury	Boiling point	629.769	356.619	0.004
Sulfur	Boiling point	717.764	444.614	0.002
Copper/66.9% aluminum	Eutectic melting point	840.957	567.807	0.010
Silver/30% aluminum	Eutectic melting point	840.957	567.807	0.002
Sodium chloride	Freezing point	1075.168	802.018	0.011
Sodium	Boiling point	1156.090	882.940	0.005
Nickel	Freezing point	1728	1455	1
Cobalt	Freezing point	1768	1495	3
Iron	Freezing point	1811	1538	3
Titanium	Melting point	1943	1670	2
Zirconium	Melting point	2127	1854	8
Aluminum oxide	Melting point	2326	2053	2
Ruthenium	Melting point	2606	2333	10