INTERNATIONAL UNION OF
PURE AND APPLIED CHEMISTRY

DIVISION OF PHYSICAL CHEMISTRY

COMMISSION ON PHYSICOCHEMICAL
MEASUREMENTS AND STANDARDS

CATALOGUE OF PHYSICOCHEMICAL STANDARD SUBSTANCES

Approved for publication at Cortina d'Ampezzo 5 July 1969

Published in Tentative Form as IUPAC Information
Bulletin No. 2, December 1969

Final approval voted on 17 July 1971

LONDON

BUTTERWORTHS

P.A.C.—29/4—F

PHYSICAL CHEMISTRY DIVISION

COMMISSION ON PHYSICOCHEMICAL MEASUREMENTS AND STANDARDS†

CATALOGUE OF PHYSICOCHEMICAL STANDARD SUBSTANCES

For nearly the past fifty years, the Commission on Physicochemical Measurement and Standards of the International Union of Pure and Applied Chemistry has concerned itself with standardized substances of a physicochemical nature. During this time scientific development and world trade have grown faster than at any previous time. Commerce depends upon agreements regarding commodities that are bought and sold. The buyer has certain specifications for his needs, and the seller must satisfy those specifications. The specifications are some sort of comparison with a standard acceptable to both buyer and seller. Without standards, the agreement between user and producer is much more difficult to achieve. Accepted standards become part of the basic framework of commerce upon which further progress rests. Commerce and science have brought us the machine age and automation has released men from former labours and has given them time and freedom to improve their standard of living in many ways.

The machine age and automation are firmly grounded on standardized substances; hence, further growth demands that the development of additional standards match the needs of world developments. At the XXIV IUPAC Conference in Prague, 30 and 31 August 1967, the Commission discussed how best to publish information on the availability of materials standardized for given properties. It was agreed that Dr Y. Mashiko, Dr T. Plebanski and Dr D. R. Stull should draft a letter seeking information on standardized materials. The letter that was drafted interpreted a standard substance as one which reproduces a certified value of a physical property within a given accuracy and can be applied to the following types of measurements:

1. The calibration and standardization of a measuring mechanism.
2. The proof of measurement accuracy by a given method.
3. The transfer of measured quantities from one place to another.
4. The comparison of measurements made in different locations.

† *Chairman:* D. R. Stull (USA); *Vice-Chairman and Secretary:* E. F. G. Herington (UK); *Members:* I. Brown (Australia), J. Franc (Czechoslovakia), H. Kienitz (Germany), Y. Mashiko (Japan), W. W. Meinke (USA), I. I. Novikov (USSR); *Associate Members:* J. P. Cali (USA), A. Juhasz (Hungary), W. Simon (Switzerland), L. A. K. Staveley (UK), S. Sunner (Sweden), J. Terrien (France); *National Representatives:* R. P. Graham (Canada), H. Feuerberg (Germany), J. N. Mukherjee (India), M. Milone (Italy), W. M. Smit (Netherlands), T. Plebanski (Poland); *Observer:* G. Waddington (USA).

The letter was sent out by the office of Dr R. Morf, Secretary General of IUPAC, to the National Representatives of each country requesting a list of the certified substances from their country and neighbouring countries not represented on IUPAC. The replies have been merged in *Table 1*, which is intended to serve as a catalogue of standardized material. The list is believed to be incomplete; additional existing standardized materials and needs for new standardized materials should be called to the attention of this Commission. The Commission decided not to include radioactivity standards in the Table.

Commission on Physicochemical Measurement and Standards,
International Union of Pure and Applied Chemistry.

Washington, USA
19 July 1971

Table 1. Substances standardized with respect to a particular physical property

Index to Contents

Table 1. Substances standardized with respect to a particular physical property

Purity moles %	Chemical name (Sample No.)	Value and accuracy	Source	Remarks
		1. ACIDIMETRIC STANDARDS		
99.99 ± 0.01	Potassium hydrogen phthalate (84 h)	99.99 ± 0.01	I	
99.98 ± 0.02	Benzoic acid (350)	99.98 ± 0.02	I	
		2. CALORIMETRIC STANDARDS, A. Heat capacity		
99.95 ±	α-Aluminium oxide (720)	See Remarks	I	Enthalpy and heat capacity certified from 273 to 2250 K. Enthalpy accurate to ±0.1 per cent heat capacity from ±0.01 per cent at lowest temperature to ±0.3 per cent at 1200 K. See certificate for full explanation of accuracy and precision.
99.99	Heptane	See Remarks	I	These materials are not certified as NBS Standard Reference Materials, but are held by the Calorimetry Conference, and are available to qualified users from E. J. Prosen at NBS. Heat capacity data are reported by Ginnings and Furukawa, *J. Am. Chem. Soc.* **75**, 522 (1953).
99.99	Benzoic acid	See Remarks	I	
99.99	α-Aluminium oxide	See Remarks	I	
		2. CALORIMETRIC STANDARDS, B. Heat of transition and fusion		
99.99+	Neopentane	(628.7 ± 0.3) cal/mol at (140.49 ± 0.05) K (740.0 ± 0.3) cal/mol at Trip. Pt 256.75 K	E	Purified by using a spinning band type distillation tower of 3 m height and an adsorption column packed with molecular sieve.
		2. CALORIMETRIC STANDARDS, C. Energy of combustion		
99.99	Benzoic acid	Certified for each batch	F	Purity derived from temperature/enthalpy curves.
—	Benzoic acid	Certified for each batch	H	Value certified by NPL, but samples prepared, purified and sold by firms, e.g. BDH and Bureau of Analyzed Samples.

99.997	Benzoic acid (39i)	(26.434 ± 0.003) kJ/g	I	Value certified when burned under, or corrected to, the specific conditions described on the certificate.
99.99	Benzophenone	Certified for each batch	F	Purity derived from temperature/enthalpy curves.
99.99	Dimethyl terephthalate		F	
99.99	Biphenyl		F	
99.99	Naphthalene		F	
99.99	Phenanthrene		F	
99.99	1,2,4,5-Tetrachlorobenzene		F	
99.993	2,2,4-Trimethylpentane (217b)	47.713 kJ/g ±0.02%	I	Value certified when burned under, or corrected to, the specific conditions described on the certificate.

2. CALORIMETRIC STANDARDS D. Solution calorimetry

99.94	2-Amino-2-(hydroxymethyl)-1,3-propanediol [Tris(hydroxymethyl) aminomethane] (724) (THAM or TRIS)	I	Certified as to purity and homogeneity. This compound is intended to serve as a uniform material for checking calorimeters in different laboratories. A numerical value for heat of solution is being studied.

3. COLOUR STANDARDS FOR SPECTROPHOTOMETERS AND TRISTIMULUS COLORIMETERS

Set of 10 plates of different colours for calibration of tristimulus colorimeters (ceramic tiles with a coloured coating).	B	The plates are available with colour specification according to any CIE observer (2° and 10°) standard illuminant, and geometry of illuminating and viewing.
Ceramic Colour Standards Set of 12 ceramic tiles consisting of 3 neutral greys and 9 spectrally selective colours for testing different types of error in colorimetric instruments.	H	Spectral reflection calibrations 300 (10) 760 nm or 300 (5) 760 nm and colorimetric quantities x, y, Y %, u, v under Illuminants A, C and D65 for any of 3 geometries of illumination and view: 0°/45°, 0°/diffuse, 8°/total.
Orange-Red Glass (2101)	I	Spectrogram taken on each glass.
Signal Yellow Glass (2102)	I	For description of spectrophotometer–tristimulus integrator system see H. J. Keegan, J. C. Schleter and D. B. Judd, *J. Res. Nat. Bur. Stand.* **66A**, 203 (1962).
Sextant Green Glass (2103)	I	
Cobalt Blue Glass (2104)	I	
Selective Neutral Glass (2105)	I	

Table 1—continued

Purity moles %	Chemical name (Sample No.)	Value and accuracy	Source	Remarks
		4. DENSITY STANDARDS		
		(Confidence level 99 %)		
99.95	Cyclohexane	(0.78789 ± 0.00001) g cm^{-3} (10°C)	G	
		(0.77854 ± 0.000005) g cm^{-3} (20°C)	G	
		(0.76910 ± 0.000005) g cm^{-3} (30°C)	G	
		(0.75957 ± 0.000005) g cm^{-3} (40°C)	G	
		(0.74996 ± 0.000005) g cm^{-3} (50°C)	G	
		(0.74025 ± 0.00001) g cm^{-3} (60°C)	G	
Unknown	Kerosene (a)	(0.81766 ± 0.00001) g cm^{-3} (10°C)	G	
		(0.81016 ± 0.000005) g cm^{-3} (20°C)	G	
		(0.80265 ± 0.000005) g cm^{-3} (30°C)	G	
		(0.79513 ± 0.000005) g cm^{-3} (40°C)	G	
		(0.78761 ± 0.000005) g cm^{-3} (50°C)	G	
		(0.78008 ± 0.00001) g cm^{-3} (60°C)	G	
Unknown	Kerosene (b)	(0.86877 ± 0.00001) g cm^{-3} (10°C)	G	
		(0.86188 ± 0.000005) g cm^{-3} (20°C)	G	
		(0.85490 ± 0.000005) g cm^{-3} (30°C)	G	
		(0.84784 ± 0.000005) g cm^{-3} (40°C)	G	
		(0.84068 ± 0.000005) g cm^{-3} (50°C)	G	
		(0.83343 ± 0.00001) g cm^{-3} (60°C)	G	
97.5	Methylcyclohexane	(0.77900 ± 0.00001) g cm^{-3} (10°C)	G	Temperature flotation method and pyknometric method.
		(0.77037 ± 0.000005) g cm^{-3} (20°C)	G	
		(0.76168 ± 0.000005) g cm^{-3} (30°C)	G	
		(0.75294 ± 0.000005) g cm^{-3} (40°C)	G	
		(0.74416 ± 0.000005) g cm^{-3} (50°C)	G	
		(0.73532 ± 0.00001 g cm^{-3} (60°C)	G	

>99.9	Toluene	(0.87597 ± 0.00001) g cm^{-3} (10°C)	G	
		(0.86668 ± 0.000005) g cm^{-3} (20°C)	G	
		(0.85735 ± 0.000005) g cm^{-3} (30°C)	G	
		(0.84797 ± 0.000005) g cm^{-3} (40°C)	G	
		(0.83854 ± 0.000005) g cm^{-3} (50°C)	G	
		(0.82906 ± 0.00001) g cm^{-3} (60°C)	G	
99.5	2.2.4-Trimethylpentane	(0.70016 ± 0.00001) g cm^{-3} (10°C)	G	
		(0.69194 ± 0.000005) g cm^{-3} (20°C)	G	
		(0.68364 ± 0.000005) g cm^{-3} (30°C)	G	
		(0.67527 ± 0.000005) g cm^{-3} (40°C)	G	
		(0.66684 ± 0.000005) g cm^{-3} (50°C)	G	
		(0.65833 ± 0.00001) g cm^{-3} (60°C)	G	
99.993 ±0.003	2.2.4-Trimethylpentane (217b)	(0.69183 ± 0.00002) g cm^{-3} (20°C)	I	Also certified for heat of combustion and refractive index.
		(0.68772 ± 0.00002) g cm^{-3} (25°C)	I	
		(0.68362 ± 0.00002) g cm^{-3} (30°C)	I	

5. DIELECTRIC CONSTANTS

	Cyclohexane	2.025 ± 0.002 (1.8 MHz. 20°C)	D
	Carbon tetrachloride	2.240 ± 0.002 (1.8 MHz. 20°C)	D
	Chlorbenzene	5.690 ± 0.002 (1.8 MHz. 20°C)	D

Purified with molecular sieve; spectroscopically pure.

6. DIFFERENTIAL THERMAL ANALYSIS†

High-purity	Potassium nitrate (758)	Equilibrium value 127.7°C Extrapolated onset 128°C Peak 135°C	I
High-purity	Indium (metal) (758)	Equilibrium value 157°C Extrapolated onset 154°C Peak 159°C	I
High-purity	Tin (metal) (758)	Equilibrium value 231.9°C Extrapolated onset 230°C Peak 237°C	I
Commercial grade	Potassium perchlorate (758) (759)	Equilibrium value 299.5°C Extrapolated onset 299°C Peak 309°C	I

† NOTE: These Standard Reference Materials are certified and issued jointly by NBS–ICTA (The US National Bureau of Standards and the International Confederation on Thermal Analysis). They are for use in calibrating the temperature scale on differential thermal analysis and related thermoanalytical equipment under the operating conditions, and are to be used only in the heating mode.

Table 1—continued

Purity moles %	Chemical name (Sample No.)	Value and accuracy	Source	Remarks
		6. DIFFERENTIAL THERMAL ANALYSIS—*continued*		
Analysed reagent	Silver sulphate (758) (759)	Equilibrium value — Extrapolated onset 424°C Peak 433°C—	I	The equilibrium value for the transitional temperature reported for this material is currently under review. A value of 430°C has been reported.
Natural quartz	Silica (759) (760)	Equilibrium value 573°C Extrapolated onset 571°C Peak 574°C	I	
Analysed reagent	Potassium sulphate (759) (760)	Equilibrium value 583°C Extrapolated onset 582°C Peak 588°C	I	
Analysed reagent	Potassium chromate (759) (760)	Equilibrium value 665°C Extrapolated onset 665°C Peak 673°C	I	
Analysed reagent	Barium carbonate (760)	Equilibrium value 810°C Extrapolated onset 808°C Peak 819°C	I	
Analysed reagent	Strontium carbonate (760)	Equilibrium value 925°C Extrapolated onset 928°C Peak 938°C	I	
		7. MOLAR CONDUCTANCE		
Pure analytical KCl, doubly recrystallized and heated at 500°C	Potassium chloride	0.1 mol dm^{-3} (116.8 ± 0.1) S cm^{-1} (20°C) 0.01 mol dm^{-3} (127.7 ± 0.1) S cm^{-1} (20°C)	D	

8. MOLECULAR WEIGHT OF POLYMERS

	Polystyrene (Narrow molecular weight distribution) (705)	M_n 170 900 ± 580 M_w 179 300 ± 740 M_z 189 800 ± 2100	I	M_n = Number-average molecular weight (measured by osmotic pressure). M_w = Weight-average molecular weight (measured by light scattering). M_z = Weight-average molecular weight (measured by sedimentation equilibrium). $M_z : M_w : M_n = 1.12 : 1.07 : 1$
	Polystyrene (Broad molecular weight distribution) (706)	M_w 257 800 ± 930 M_z 288 100 ± 9600	I	$M_z : M_w : M_n = 2.9 : 2.2 : 1$

9. MÖSSBAUER DIFFERENTIAL CHEMICAL SHIFT FOR IRON-57

Single crystals grown from solution of ACS grade salt	Sodium pentacyanonitrosylferrate (III) dihydrate (725) (Sodium nitroprusside)	(0.0000 ± 0.0002) cm/s at 25°C	I	Average value of electric quadrupole splitting (0.1726 ±0.0002) cm/s.

10. pH STANDARDS

99.5 ± 0.5	Borax	9.22 ± 0.02 at 20°C	G	Solution 0.01 mol dm^{-3}
Unknown	Calcium hydroxide	12.45 ± 0.05 at 25°C	G	Saturated solution at 25°C.
	Potassium dihydrogen phosphate and Disodium hydrogen phosphate	6.86 ± 0.02 at 25°C	D	Purity specified, by pH measurements. Mixture of 0.025 mol dm^{-3} solutions.
99.9 ±0.1	Potassium dihydrogen phosphate and Disodium hydrogen phosphate	6.88 ± 0.02 at 20°C	G	Mixture of 0.025 mol dm^{-3} solution. (See note on page 610.)
99.5 ±0.5	Potassium dihydrogen phosphate (186 Ic) and Disodium hydrogen phosphate (186 IIb)	6.981 ± 0.005 (0°C) 6.920 ± 0.005 (10°C) 6.878 ± 0.005 (20°C) 6.850 ± 0.005 (30°C) 6.835 ± 0.005 (40°C) 6.830 ± 0.005 (50°C)	I	Purities meet ACS Specifications. Water of conductivity less than 2×10^{-6} S cm^{-1} 0.025 mol kg^{-1} KH_2PO_4 + 0.025 mol kg^{-1} Na_2HPO_4.

Table 1—continued

Purity moles %	Chemical name (Sample No.)	Value and accuracy	Source	Remarks
		10. pH STANDARDS—*continued*		
		6.836 ± 0.005 (60°C) 6.845 ± 0.01 (70°C) 6.859 ± 0.01 (80°C) 6.877 ± 0.01 (90°C) 7.531 ± 0.005 (0°C) 7.469 ± 0.005 (10°C) 7.426 ± 0.005 (20°C) 7.397 ± 0.005 (30°C) 7.381 ± 0.005 (38°C) 7.377 ± 0.005 (40°C) 7.364 ± 0.005 (50°C)		0.008695 mol kg^{-1} KH_2PO_4 + 0.03043 mol kg^{-1} Na_2HPO_4.
	Potassium hydrogen phthalate	4.00 ± 0.02 at 25°C	D	Purity specified, by pH measurements in 0.05 mol dm^{-3} solution.
99.9 ± 0.1	Potassium hydrogen phthalate	4.00 ± 0.01 at 20°C	G	Solution 0.05 mol dm^{-3} (See note on page 610.)
	Potassium hydrogen phthalate	Certificate issued that each batch satisfies British Standards Specification	H	Certificate issued by NPL but samples prepared and sold by firms e.g. BDH.
	Potassium hydrogen phthalate (185d)	4.012 ± 0.005 (0°C) 4.002 ± 0.005 (10°C) 4.003 ± 0.005 (20°C) 4.014 ± 0.005 (30°C) 4.033 ± 0.005 (40°C) 4.058 ± 0.005 (50°C) 4.089 ± 0.005 (60°C) 4.12 ± 0.01 (70°C) 4.16 ± 0.01 (80°C) 4.20 ± 0.01 (90°C)	I	Purity meets ACS Specifications. Values certified for 0.05 mol kg^{-1} solution. Water of conductivity less than 2×10^{-6} S cm^{-1}.
	Potassium hydrogen tartrate	3.56 ± 0.02 at 25°C	D	Purity specified by pH measurements in saturated solution at 25°C.

99.9 ± 0.1	Potassium hydrogen tartrate	3.56 ± 0.02 at 25°C	G	Saturated solution at 25°C. (See note on page 610.)
'Assay close to 100%'	Potassium hydrogen tartrate (188)	3.557 ± 0.005 (25°C) 3.552 ± 0.005 (30°C) 3.547 ± 0.005 (40°C) 3.549 ± 0.005 (50°C) 3.560 ± 0.005 (60°C) 3.580 ± 0.01 (70°C) 3.609 ± 0.01 (80°C) 3.674 ± 0.01 (90°C)	I	Water of conductivity less than 2×10^{-6} S cm^{-1} saturated solution at 25°C.
		3.711 ± 0.005 (0°C) 3.671 ± 0.005 (10°C) 3.647 ± 0.005 (20°C) 3.635 ± 0.005 (30°C) 3.632 ± 0.005 (40°C) 3.639 ± 0.005 (50°C) 3.651 ± 0.005 (60°C)		0.01 mol kg^{-1} solution.
99.9 ± 0.1	Potassium trihydrogen dioxalate	1.68 ± 0.01 at 20°C	G	Solution 0.05 mol dm^{-3} (See note on page 610.)
'Close to 100%'	Potassium trihydrogen dioxalate (189)		I	Values certified for 0.05 mol kg^{-1} solution.
	$KHC_2O_4 \cdot H_2C_2O_4 \cdot 2H_2O$	pH(S) 1.670 ± 0.005 (10°C) 1.675 ± 0.005 (20°C) 1.683 ± 0.005 (30°C) 1.694 ± 0.005 (40°C) 1.707 ± 0.005 (50°C) 1.723 ± 0.005 (60°C) 1.743 ± 0.01 (70°C) 1.766 ± 0.01 (80°C) 1.792 ± 0.01 (90°C)		The liquid junction potential of the common pH cell displays a considerably greater variability in solutions of pH less than 2.5 and more than 11.5. For this reason, potassium tetroxalate is not recommended as a primary standard, but as a secondary standard for pH.
	Sodium hydrogen carbonate (191)	10.321 ± 0.005 (0°C) 10.181 ± 0.005 (10°C) 10.064 ± 0.005 (20°C)	I	Purities meet ACS Specifications. Water of conductivity less than 2×10^{-6} S cm^{-1} 0.025 mol kg^{-1} $NaHCO_3$ + 0.025 mol kg^{-1} Na_2CO_3.
	Sodium carbonate (192)	9.968 ± 0.005 (30°C) 9.891 ± 0.005 (40°C) 9.831 ± 0.005 (50°C)		

Table 1—continued

Purity moles %	Chemical name (Sample No.)	Value and accuracy	Source	Remarks
		10. pH STANDARDS—*continued*		
	Sodium tetraborate (187a) $Na_2B_4O_7 \cdot 10H_2O$	9.464 ± 0.005 (0°C) 9.332 ± 0.005 (10°C) 9.225 ± 0.005 (20°C) 9.139 ± 0.005 (30°C) 9.068 ± 0.005 (40°C) 9.011 ± 0.005 (50°C) 8.962 ± 0.005 (60°C) 8.921 ± 0.01 (70°C) 8.885 ± 0.01 (80°C) 8.850 ± 0.01 (90°C)	I	Purity meets ACS Specifications. Values certified for 0.05 mol kg^{-1} solution. Water of conductivity less than 2×10^{-6} S cm^{-1}.
	Note for Source G: whenever possible pH value is being standardized versus platinum hydrogen electrode.			
		11. pD STANDARDS		
	Potassium dihydrogen phosphate (2186-I)	7.504 ± 0.01 (10°C) 7.449 ± 0.01 (20°C)	I I	Purities meet ACS Specifications. 0.025 mol kg^{-1} KH_2PO_4 + 0.025 mol kg^{-1} Na_2HPO_4.
	Disodium hydrogen phosphate (2186-II)	7.411 ± 0.01 (30°C) 7.387 ± 0.01 (40°C) 7.377 ± 0.01 (50°C)		
	Sodium hydrogen carbonate (2191)	10.924 ± 0.01 (10°C) 10.794 ± 0.01 (20°C)	I I	Purities meet ACS Specifications. 0.025 mol kg^{-1} $NaHCO_3$ + 0.025 mol kg^{-1} Na_2CO_3.
	Sodium carbonate (2192)	10.684 ± 0.01 (30°C) 10.595 ± 0.01 (40°C) 10.527 ± 0.01 (50°C)		

12. REDOX STANDARDS

Arsenic trioxide (83c)	99.99 ± 0.02	I	Purity meets ACS Specifications.
Potassium dichromate (136b)	99.98 ± 0.02	I	
Sodium oxalate (40g)	99.95 ± 0.02	I	

13. REFRACTIVE INDEX STANDARDS

(Confidence level 95 %)

99.95	2,2,4-Trimethylpentane	1.39139 ± 0.00002 n_D (20°C)	G
99.993 ± 0.002	2,2,4-Trimethylpentane (217b)		I

Wavelength Å	*20°C Å*	*25°C*	*30°C*
6678.1	1.38918	1.38672	1.38426
6562.8	1.38947	1.38700	1.38454
5892.6	1.39147	1.38900	1.38652
5460.7	1.39318	1.39070	1.38822
5015.7	1.39546	1.39296	1.39046
4861.3	1.39641	1.39391	1.39140
4358.3	1.40031	1.39778	1.39525

Uncertainty of all values less than 0.00002.
Also used as a calorimetric heat of combustion and density standard.

(Confidence level 95 %)

97.5	Methylcyclohexane	1.42394 ± 0.00002 n_D (20°C)	G
99.95	Cyclohexane	1.42635 ± 0.00002 n_D (20°C)	G
>99.9	Toluene	1.4968 ± 0.0001 n_D (20°C)	G
>99	1-Bromonaphthalene	1.6585 ± 0.0001 n_D (20°C)	G
—	Optical glass 'Crown'	1.51843 ± 0.00002 n_D (20°C)	G

14. SACCHARIMETRIC (POLARIMETRIC) STANDARDS

Sucrose (17)	α(546.1 nm, 20°C) = 78.342°	I	Concentration 26 g/100 cm³. Moisture less than 0.01 %, ash less than 0.003 %, reducing substances less than 0.02 %.
	α(589.25 nm, 20°C) = 66.529°		Concentration 26 g/100 cm³.
D-Glucose (41a)	α(D, 20°C) = 52.7°	I	α(546.1 nm, 20°C) = 62.032°. Ash less than 0.01 %, moisture less than 0.1 %.

Table 1—continued

Purity mass %	Water content mass %	Chemical name	Value and accuracy $W\ m^{-1}\ K^{-1}$	Source	Remarks
			15. THERMAL CONDUCTIVITY STANDARDS		
99.98	—	Platinum	$(70.25 + 0.0075\,t) \pm 0.5\%$	C	$0°C < t < 100°C$.
99.0	0.05	Propyl alcohol	$(0.1575 - 0.000230\,t) \pm 0.5\%$	C	$10°C \leqslant t \leqslant 40°C$.
99.8	0.1	Isopropyl alcohol	$(0.1395 - 0.000202\,t) \pm 0.5\%$	C	$10°C \leqslant t \leqslant 40°C$.
99.5	0.1	Butyl alcohol	$(0.1534 - 0.000211\,t) \pm 0.5\%$	C	$10°C \leqslant t \leqslant 55°C$.
99.8	0.05	*sec*-Butyl alcohol	$(0.1400 - 0.000203\,t) \pm 0.5\%$	C	$10°C \leqslant t \leqslant 55°C$.
99.2	0.05	Isobutyl alcohol	$(0.1353 - 0.000166\,t) \pm 0.5\%$	C	$10°C \leqslant t \leqslant 55°C$.

Purity moles %	Chemical name (Sample No.)	Value and accuracy	Source	Remarks
		16. THERMOMETRIC FIXED POINTS		
99.999	Aluminium metal	Freezing point (660 C)[b]	C	Thermodynamic temperatures.
	Aluminium (44e)	Freezing point (660.3 ± 0.2 C)[b]	I	International Temperature Scale (1968).
99.99	Benzoic acid	Freezing point (122 C)[b]	F	Purity derived from temperature/enthalpy curves.
99.99	Benzophenone	Freezing point (48 C)[b]	F	
99.99	Dimethyl terephthalate	Freezing point (142 C)[b]	F	
99.99	Biphenyl	Freezing point (70 C)[b]	F	
99.999	Cadmium metal	Freezing point (321 C)[b]	C	Thermodynamic temperatures.
	Copper (45d)	Freezing point (1084.8 ± 0.5 C)[b]	I	International Temperature Scale (1968).
99.998	Gold metal	Freezing point (1064.43 C)[a]	C	Thermodynamic temperatures.
	Lead (49e)	Freezing point (327.493 ± 0.005 C)[b]	I	International Temperature Scale (1968).
99.99	Naphthalene	Freezing point (80 C)[b]	F	Purity derived from temperature/enthalpy curves.
99.996	Neopentane	Transition point (−132 C)[b]	E	Purified by using a spinning band type distillation tower of 3 m height and an adsorption column packed with molecular sieve.
		Triple point (−16 C)[b]	E	
99.99	Phenanthrene	Freezing point (100 C)[b]	F	Purity derived from temperature/enthalpy curves.
99.994	Silver metal	Freezing point (961.93 C)[a]	C	Thermodynamic temperatures.
>99.9	Silver–copper eutectic	Freezing point (779 C)[b]	C	Thermodynamic temperatures.
99.99	1,2,4,5-Tetrachlorobenzene	Freezing point (140 C)[b]	F	Purity derived from temperature/enthalpy curves.

99.99	Sodium	Freezing point (97 C)[b]	F	Purity derived from temperature/enthalpy curves.
99.999	Sulphur	Boiling point (444 C)[b]	C	Thermodynamic temperatures.
99.999	Tin metal	Freezing point (231 C)[b]	C	Thermodynamic temperatures.
	Tin (42f)	Freezing point (231.940 ± 0.005 C)[b]	I	International Temperature Scale (1968).
99.999	Zinc metal	Freezing point (419.58 C)[a]	C	Thermodynamic temperatures.
99.9999	Zinc (740)	Freezing point (419.58 C)[a]	I	Fixed point on International Practical Temperature Scale of 1968.

NOTE. Temperature of the primary fixed points for calibration on the International Practical Temperature Scale of 1968 (IPTS-68) are indicated by the superscript a. Secondary reference points carry a nominal temperature value for general information only, and are indicated by the superscript b. The temperature certified by the standardizing laboratory appears only on the certificate provided with the sample.

17. VAPOUR PRESSURE STANDARD

99.9968	Neopentane	35.793 ± 0.017 kN m^{-2} (256.750 K)	E	Purified by using a spinning band type distillation tower of 3 m height and an adsorption column packed with molecular sieve.

18. VISCOSITY STANDARDS

Centipoise = $cP = 10^{-3}$ kg m^{-1} s^{-1}

unknown	AS 2.5 oil	1.9 (0.03 %)* at 310.9 K (100°F)	A	Newtonian liquid†.
unknown	AS 7.5 oil	6.0 (0.03 %)* at 310.9 K (100°F)		
unknown	AS 25 oil	21 (0.04 %)* at 310.9 K (100°F)		
unknown	AS 75 oil	65 (0.05 %)* at 310.9 K (100°F)		
unknown	AS 200 oil	175 (0.08 %)* at 310.9 K (100°F)		
unknown	AS 600 oil	530 (0.2 %)* at 310.9 K (100°F)		

Note for Source A: * Nominal standard error of the dynamic viscosity.
† These liquids also certified as to nominal density and kinematic viscosity.

Centipoise = $cP = 10^{-3}$ kg m^{-1} s^{-1}
Confidence level > 95 %

—	Mineral oil	1–1000 (20°C) 0.2 %	F	Newtonian liquids.
—	Polymer solutions	2000–20000 (20°C) 0.5 %	F	
—	Polymer solutions	2000–200000 (20°C) 1 %	F	
—	Polymer solution	2000–20000 poise = P = 10^{-1} kg m^{-1} S^{-1} (20°C) 2 %	F	

Table 1—continued

Purity moles %	Chemical name (Sample No.)	Value and accuracy	Source	Remarks
		18. VISCOSITY STANDARDS—*continued*		
		Centipoise = $cP = 10^{-3}\,kg\,m^{-1}\,s^{-1}$		
		Confidence level > 95%		
Unknown	Mineral oil	1.414 (±0.1%) (20°C)	G	
Unknown	Mineral oil	5.896 (±0.1%) (20°C)	G	
Unknown	Mineral oil	9.090 (±0.1%) (20°C) 3.766 (±0.2%) (50°C)	G	
Unknown	Mineral oil	19.19 (±0.1%) (20°C) 6.232 (±0.2%) (50°C)	G	
Unknown	Mineral oil	59.18 (±0.2%) (20°C) 13.85 (±0.3%) (50°C) 128.4 (±0.2%) (20°C)	G	
Unknown	Mineral oil	23.73 (±0.3%) (50°C) 8.008 (±0.4%) (80°C) 167.4 (±0.2%) (20°C)	G	
Unknown	Mineral oil	28.43 (±0.3%) (50°C) 9.203 (±0.4%) (80°C) 363.5 (±0.2%) (20°C)	G	
Unknown	Mineral oil	52.68 (±0.3%) (50°C) 14.97 (±0.4%) (80°C) 424.4 (±0.2%) (20°C)	G	
Unknown	Mineral oil	50.73 (±0.3%) (50°C) 13.56 (±0.4%) (80°C) 597.3 (±0.2%) (20°C)	G	
Unknown	Mineral oil	76.65 (±0.3%) (50°C) 20.01 (±0.4%) (80°C) 1298 (±0.2%) (20°C)	G	
Unknown	Mineral oil	154.3 (±0.3%) (50°C) 37.15 (±0.4%) (80°C)	G	

Unknown	Silicone oil	245.000 (±1.5%) (20°C)	G	
Unknown	Silicone oil	317.000 (±2 %) (20°C)	G	Measured by the use of rotating cylinder viscometer and of 'Viscowage'/viscobalance.

Note for Source G: All values are given for materials actually in stock. Determined by the use of long (400 mm) capillary tube suspended level Ubbelohde viscometers.

18. VISCOSITY STANDARDS (Glasses)

Soda–lime silica glass (710)
composition
SiO_2 70.5%
Na_2O 8.7%
K_2O 7.7%
CaO 11.6%
Sb_2O_3 1.1%
SO_3 0.2%
R_2O_3 0.2%

$$\log_{10}\eta = -1.626 + \frac{4236.118}{t - 266}$$

$\sigma = 0.020$

(t in °C)

I

Softening point (avg.) 724°C
Annealing point (avg.) 546°C
Strain point (avg.) 504°C

Lead–silica glass (711)
composition
SiO_2 46.0%
PbO 45.32%
K_2O 5.62%
Na_2O 2.50%
R_2O_3 0.56%

$$\log_{10}\eta = -1.621 + \frac{4254.649}{t - 1521}$$

$\sigma = \pm 0.035$

(t in °C)

I

Softening point (avg.) 602°C
Annealing point (avg.) 432°C
Strain point (avg.) 392°C

The Countries reporting:

A. Australia	Commonwealth Scientific and Industrial Research Organization National Standards Laboratory University Grounds, City Road Chippendale, NSW 2008
B. Germany	Bundesanstalt für Materialprüfung Unter den Eichen 87, D-1 Berlin 45
C. Germany	The Physikalische-Technische Bundesanstalt 33 Braunschweig, Bundesalle 100 Federal Republic of Germany
D. Hungary	National Office of Measures Németölgyi ut 37–39, sz. Budapest XII, Hungary
E. Japan	The Government Chemical Industrial Research Institute of Tokyo 1-Chome, Honmachi, Shibuya-Ku Tokyo, Japan
F. Netherlands	Institute for Physical Chemistry TNO Utrechtseweg 48, P.O. Box 108 Zeist, The Netherlands
G. Poland	Division of Physico-Chemical Metrology National Board for Quality Control and Measures, 2, Elektoralna Street, Warsaw, Poland
H. United Kingdom	National Physical Laboratory Teddington, Middlesex, England
I. United States	Office of Standard Reference Materials US Department of Commerce National Bureau of Standards Washington, DC, 20234, USA