NBS CIRCULAR *562*

SUPPLEMENT 1

Bibliography of Research on Deuterium and Tritium Compounds 1953 and 1954

UNITED STATES DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

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UNITED STATES DEPARTMENT OF COMMERCE • Sinclair Weeks, *Secretary*
NATIONAL BUREAU OF STANDARDS • A. V. Astin, *Director*

Bibliography of Research on Deuterium and Tritium Compounds 1953 and 1954

Virginia R. Johnson, Lawrence M. Brown
and Abraham S. Friedman

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Preface

Late in 1951, the Thermodynamics Section of the National Bureau of Standards became actively engaged in an Isotope Exchange Data Program, sponsored by the Atomic Energy Commission Division of Research, which involved, in part, the preparation of bibliographies of research on the hydrogen isotopes for the years subsequent to 1945. This bibliography supplements Circular 562, which covered the years 1945 to 1952. The importance of the hydrogen isotopes as research tools and the utility of these bibliographies as an aid to scientific research relating to them has prompted the compilation of this Circular.

A. V. Astin, *Director.*

Contents

Bibliography of Research on Deuterium and Tritium Compounds

Virginia R. Johnson, Lawrence M. Brown, and Abraham S. Friedman

A bibliography of 720 references to published research on the properties of deuterium and tritium compounds is given. The subject matter of each entry in the bibliography is indicated by letter codes related to a list of broad subject headings as shown in the Introduction. An index of deuterium and tritium compounds and a subject index are included.

1. Introduction

This Circular is a bibliography of research on deuterium and tritium compounds for the years 1953 and 1954. It is divided into three sections: the first contains a bibliography and author index, and the second and third contain the subject and compound indexes, respectively.

The 720 references were obtained from Chemical Abstracts for the years 1953 to 1954, inclusive.

The references in the bibliography are arranged alphabetically according to the last name of the leading author. The names of the coauthors are also included and are cross-referenced.

Each entry in the bibliography is numbered by a letter-number symbol that corresponds to the first letter of the leading author's last name and the numerical listing of the reference under that letter. This numbering system is used to identify the entries in the compound and subject indexes.

The subject matter of the references is indicated at the end of each entry by means of one or more of the letter codes related to the subject categories shown in the Principal Topics and Subject Code. In the letter codes the main headings of the subject categories are designated by two letters of the heading title, and the subheadings are represented by these two letters and one or two additional, appropriate letters. For example, the code symbol for Chemical Kinetics is Ki and that for the kinetics of photochemical reactions is KiP. The subject content was determined generally from the abstracts of the references; the original articles were consulted when the abstracts were not sufficiently informative. Review articles and abstracts are indicated as such. Research articles related to nuclear properties have been excluded, except where other pertinent information on deuterium or tritium was reported. Also the topic of Isotope Effects has been restricted primarily to the isotopes of hydrogen, whereas the topic of Isotope Separation still contains references to works on the separation of isotopes of various elements.

In preparing the compound index, the nomenclature of Lange's Handbook of Chemistry [1] has been followed. However, common synonyms of many of the compound names used therein have been entered and cross-indexed. Compounds containing tritium have been named in accordance with the modified Boughton system,[2] in which the name of the hydrogen compound is followed by "-t". No subscript has been appended to the "-t" to indicate the extent of tritium substitution. The chemical formula for each compound containing deuterium or tritium is given.

No listing has been made in the compound index under Water or Water-t for the use of water as a solvent. A lower case "s" has been used to indicate other substances used as solvents (see, for example, under Ethyl alcohol). In addition, no listing has been made in the compound index for Hydrogen, Tritium, Water, or Water-t under the subjects of Abundance, Analytical Methods, General and Review, Nuclear Properties, Separation and Atomic Spectra. References to such research may be found under these headings in the subject index.

The arrangement and the methods of coding and indexing used here and in Circular 562 are consistent with those in the Bibliography of Research on Heavy Hydrogen Compounds, by Kimball, Urey, and Kirshenbaum,[3] to which this work and Circular 562 are sequels.

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[1] Handbook Publishers, Inc., Sandusky, Ohio (1949).
[2] E. J. Crane, Ind. Eng. Chem. News, Ed. **13**, 200-01 (1935).
[3] McGraw-Hill Book Company, Inc., New York, N. Y., Ed. **1** (1949).

2. Principal Topics and Subject Code

Ab **Abundance.**
- **AbG** Geological.
- **AbO** Organic.

Ad **Adsorption and Sorption.**
- **AdC** Chromatography.
- **AdG** Gases on solids.
- **AdL** Liquids on solids.

An **Analytical Methods.**
- **AnC** Counters, cloud chambers, electrometers, ionization chambers, and photographic emulsions.
- **AnCl** Colorimetric methods.
- **AnDn** Density methods.
- **AnEl** Optical rotation.
- **AnMg** Magnetic and magnetoöptic methods.
- **AnMs** Mass spectrograph and mass spectrometer.
- **AnRf** Refractive index.
- **AnSp** Absorption spectra.
- **AnTh** Thermal conduction.

Bi **Biological Effects of Deuterium and Tritium Compounds and of Deuterons and Tritons.**
- **BiB** Botanical.
- **BiC** Biochemical.
- **BiZ** Zoological.

Ec **Electrochemical Properties.**
- **EcC** Conductivities and mobilities.
- **EcO** Overvoltage.
- **EcP** Electrode potentials.

El **Electromagnetic and Optical Properties (Except Spectra).**
- **ElCl** Color Effects.
- **ElD** Dielectric constants and dipole moments.
- **ElGd** Gas discharges.
- **ElMg** Magnetic susceptibilities and Curie constants.
- **ElMm** Magnetic moments.
- **ElMr** Magnetic rotatory power.
- **ElP** Polarization.
- **ElRe** Paramagnetic resonances.
- **ElRf** Refractive index and molar refraction.
- **ElRo** Optical rotatory power.
- **ElSc** Light scattering.
- **ElT** Relaxation times.

Eq **Chemical Equilibria.**
- **EqG** Gaseous.
- **EqH** Heterogeneous.
- **EqI** Ionic
- **EqL** Liquid and solution.

Ge **General and Review.**

In **Indicator and Tracer Techniques.**
- **InA** Age determinations.
- **InBi** Biological.
- **InKi** Reaction kinetics.
- **InSo** Solubility determinations.
- **InSp** Spectra.
- **InSt** Structure determinations.

Is **Isotope Effects.**
- **IsCr** Crystal structure.
- **IsEl** Electromagnetic properties.
- **IsEq** Chemical equilibria.
- **IsKi** Reaction kinetics.
- **IsMs** Mass spectra.
- **IsSp** Spectra.
- **IsTh** Thermodynamic properties.

Ki **Chemical Kinetics.**
- **KiB** Biochemical.
- **KiG** Gaseous.
- **KiH** Heterogeneous.
- **KiI** Ionic.
- **KiL** Liquid and solution.
- **KiP** Photochemical.
- **KiR** Radiochemical.
- **KiS** Solid state.

Me **Mechanical Properties.**
- **MeAc** Acoustic properties.
- **MeD** Density and molar volume.
- **MeDf** Diffusion.
- **MeSt** Surface tension.
- **MeV** Viscosity.

No **Nomenclature.**

Nu **Nuclear Properties.**
- **NuB** Beta ray spectra.
- **NuH** Hyperfine strusture.
- **NuIn** Interactions (absorption of radiation, ranges, and scattering).
- **NuM** Masses and binding energies.
- **NuMg** Magnetic moments.
- **NuQ** Quadrupole moments.
- **NuR** Reactions.
- **NuRe** Magnetic resonances.
- **NuS** Spins, states, and wave functions.
- **NuSt** Statistics.

Sd **Solid State.**
- **SdCr** Crystal structure (including electron, neutron, and X-ray diffraction).
- **SdEc** Elastic constants.
- **SdEl** Electromagnetic properties.
- **SdNu** Nuclear properties.
- **SdSp** Spectra.
- **SdTr** Transitions (including phase transitions).

Se **Isotope Separation.**
- **SeAc** Acoustics.
- **SeAd** Adsorption (including chromatography and ion exchange).
- **SeCf** Centrifuging.
- **SeCh** Chemical reaction.
- **SeCr** Crystallization.
- **SeDf** Diffusion (including thermal diffusion).
- **SeDs** Distillation.
- **SeEl** Electrolysis.
- **SeEm** Electromagnetic methods.
- **SeMs** Mass spectrometer and mass spectrograph.
- **SeSo** Solubility.

So **Solubility.**
- **SoG** Gases in solids.
- **SoH** In H_2O, HDO, and D_2O.
- **SoI** In inorganic solvents.
- **SoO** In organic solvents.

Sp **Spectra and Spectroscopic Constants.**
- **SpA** Atomic (line).
- **SpEl** Molecular electronic.
- **SpFl** Fluorescence.
- **SpM** Microwave.
- **SpVi** Vibrational (including Raman).
- **SpX** X-ray.

Sr **Mass Spectroscopy and Mass Spectrography.**

St **Molecular Structure.**
- **StA** Molecular association.
- **StD** Molecular constants (interatomic distances, bond angles, moments of inertia, and force constants).
- **StDi** Electron, neutron, and X-ray diffraction.

Sy **Synthesis and Preparation of Compounds.**

Th **Thermodynamic and Related Properties.**
- **ThD** Diffusion and heat conduction.
- **ThF** Thermodynamic functions for pure substances and reactions between them (E, H, S, C_v, C_p, F, K, ΔH, ΔS, ΔE, ΔC_p, ΔF, data of state, and thermal expansion).
- **ThP** Phase equilibria (melting points, triple points, boiling points, heats of transition, critical constants, and vapor pressures).
- **ThS** Statistical mechanics and statistical thermodynamics.
- **ThSo** Properties of solutions (activities, fugacities, pH, vapor pressures, heats of solution and dilution, and colligative properties).

3. Bibliography and Author Index

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4. Subject Index

This index is divided into a number of principal and subsidiary subject headings to which are assigned appropriate letter-code symbols. The letter-number symbols following each heading refer to references in the bibliography.

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MeD (density and molar volume): C9, D8, H15, I7, L3, N19, S52.

MeDf (diffusion): A11, A12, B70, C42, J6, N15, N17, U2, U3, W5.

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Nu **Nuclear properties:** S32, S42, S43.

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NuH (hyperfine structure): E4, P33.

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NuM (masses and binding energy): D39, E14, M38, O3, O4, P5.

NuMg (magnetic moments): B8, B9, B71, B72, C21, C24, J7, P33, R7, R33.

NuQ (quadrupole moments): B9, B53, C21, D16, D35, F10, M58.

NuR (reactions): N20.

NuRe (magnetic resonances): A9, A10, B8, B9, B71, C4, C21, H9, M42, P33 R12, S36, S62.

NuS (spins, states, and wave functions): C4, C21, F10, J4, M1, M58, P6, R8, R9, S2, S36, S67.

Sd **Solid state:** A9, A10, K34, N19.

SdCr (crystal structure—including electron, neutron, and x-ray diffraction): B14, G1, L23, L24, M31, M32, M35, M43, S45, W26.

SdEl (electromagnetic properties): A14, P11, R12.

SdNu (nuclear properties): S62.

SdSp (spectra): D15, G11, H2, H11, J19, L33, P10.

SdTr (transitions—including phase transitions): B14, B59, K40, L3, M31, M32, M33, P11, S48.

Se **Isotope separation:** D7, D28, H18, H30, I3, K11, S16, S17, S50, W3, Y2.

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SeCh (chemical reaction): B10, B32, B49, B84, C7, C18, E15, K24, N19, P8, S56, W2.

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SeDs (distillation): D27, E2, M5, M6, M7, W34.

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SeEm (electromagnetic methods): B19.

SeMs (mass spectrometer and mass spectrograph): K12, L16.

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ThD (diffusion and heat conduction): A11, A12, B59, C5, G22, G27, J6, M45, P32.

ThF (thermodynamic functions for pure substances and reactions between them—E, H, S, C_v, C_p, F, K, ΔH, ΔS, ΔE, ΔC_p, ΔF, data of state, and thermal expansion): B39, B54, B59, D8, D32, F12, H35, K29, L3, L35, M3, N2, N14, O8, P18, P20, S52, Z1.

ThP (phase equilibria—melting points, triple points, boiling points, heats of transition, critical constants, and vapor pressures): A13, B59, C14, C31, C35, D13, F12, G8, J18, L18, M59, N19, Z1.

ThS (statistical mechanics and statistical thermodynamics): B39, B59, O8, S56.

ThSo (properties of solutions—activities, fugacities, pH, vapor pressures, heats of solution and dilution, and colligative properties): H36.

5. Compound Index

This index will be useful in locating references dealing with a particular deuterium or tritium compound. Tritium compounds are designated by a "-t" following the compound name. Each entry in the index contains one or more letter codes and a series of letter-number symbols indicating, respectively, the subject content and the location of the references in the bibliography. A description of the coding system may be found in the Introduction.

Cesium arsenate, dihydrogen (CsH_2AsO_4) **SdTr**:S48.

Chloramine (NH_2Cl) **SpVi**:M54; **StD**:M54.

Chloroacetamide ($CH_2ClCONH_2$) **SpVi**:K45; **St**:K45.

Chloroacetic acid ($CH_2ClCOOH$) **SpM**:A2.

Chloroacetylene (C_2HCl) **SpM**:W22.

Chlorobenzene (C_6H_5Cl) **NuRe**:M42.

Chlorobutane (C_4H_7ClO) **KiL**:P31.

Chlorodibromo methane ($CHClBr_2$) **SpVi**:M44, P20; **StD**:P20; **ThF**:P20.

Chloroform ($CHCl_3$) **EqG**:S18; **EqL**:H27; **IsKi**:E15; **IsSp**:G15; **Ki**:E15; **KiL**:H27; **SpEl**:G15; **SpVi**:B33; **KiG**:S18.

Chlorosilane (SiH_3Cl) **SpM**:B2, B3; **SpVi**:A6; **StD**:A6, B2, B3; **Sy**:B3.

Cholestanol ($C_{27}H_{48}O$) **InKi**:D6.

Δ^7-Cholestenol-t **BiC**:B48.

Cholesterol ($C_{27}H_{46}O$) **EqH**:F20; **Sy**:B88, F20, L6.

Cholesterol-t ($C_{27}H_{46}O$-t) **BiC**:B48; **InBi**:B47.

CH radical **KiG**:B77; **SpEl**:B77.

C_2H radical **ElGd**:S13; **SpVi**:S13.

C_2H_3 radical **ElGd**:S13; **SpVi**:S13.

Chromic oxide **AdG**:V5, V6; **EqH**:V5, V6.

Cortisone-t **Sy**:F21.

Cyanuric acid ($(HCNO)_3$) **SdCr**:W26; **SpVi**:W26.

Cyclobutane (C_4H_8) **Sy**:L32.

Cyclobutene (C_4H_6) **Sy**:L32.

Cyclohexane (C_6H_{12}) **ElRf**:D12; **KiR**:B94; **MeV**:D19; **SpVi**:D19, L9; **St**:L9; **ThP**:D13.

Cyclohexane carboxylic acid. See Hexahydrobenzoic acid.

Cyclohexanone ($C_6H_{10}O$) **InKi**:W32.

Cyclooctatetraene (C_8H_8) **Sy**:L32.

Cyclooctatriene (C_8H_{10}) **Sy**:L32.

Cytosine-t ($C_4H_5N_3O$-t) **EqL**:E8; **Sy**:E8.

Decane ($C_{10}H_{22}$) **BiC**:B28; **InBi**:B27, B28; **Sy**:B28.

Decyl alcohol ($C_{10}H_{21}OH$) **SpVi**:Q1.

Diborane. See Boron hydride.

Diborane dimethylamine ($C_2H_6NB_2H_5$) **Sy**:B89.

Dibromo chloro methane. See Chloro dibromo methane.

Dibromoethane ($C_2H_4Br_2$) **InKi**:S10; **SpVi**:B30; **Sy**:B30, L18.

Dibromoethylene. See Acetylene dibromide.

Dibromomethane. See Methylene bromide.

Dibutyl isopropyl carbinol ($C_{12}H_{26}O$) **EqL**:H29; **KiL**:H29.

Dichloroethylene. See Acetylene dichloride.

Dichloropropene. See Dichloropropylene.

Dichloropropylene ($C_3Cl_2H_4$) **Sy**:L17.

Diethyl amine ($(C_2H_5)_2NH$) **EqL**:K23.

Diethyl ketone ($(C_2H_5)_2CO$) **KiG**:W30; **KiP**:W30; **SpVi**:N11; **Sy**:L19.

Digermane (Ge_2H_6) **ThF**:Z1; **ThP**:Z1; **Sy**:Z1.

Dihydroxyanthraquinone ($C_{14}H_8O_4$) **SpVi**:H1.

Diisopropyl chromate ($C_6H_{14}CrO_4$) **KiL**:L22; **Sy**:L22.

Diphenyloxazole-t ($C_{15}H_{11}NO$-t) **AnC**:H13.

Diphosphopyridine nucleotide **InBi**:F8, L28; **KiB**:F8, L28.

Dodecane ($C_{12}H_{26}$) **BiC**:B28; **InBi**:B27, B28; **Sy**:B28.

Estrone acetate **InBi**:P5.

Ethane (C_2H_6) **EqH**:A7; **KiG**:R14, R15; **KiH**:A7, K9; **KiP**:D5; **SpVi**:R16, R17, R18, R19, R20.

Ethanolamine. See Amino ethanol.

Ethyl acetate ($C_4H_8O_2$) **Sy**:N10.

Ethylacetoacetate ($C_6H_{10}O_3$) **SpVi**:R22.

Ethyl alcohol (C_2H_5OH) **EqL**:C41, F8, H28, K23, R22; **InBi**:F8; **IsKi**:R21s; **KiB**:F8, V1; **KiL**:R21s, R22; **SpVi**:Q1.

Ethyl amine (C_2H_7N) **EqL**:H29; **KiL**:H29.

Ethyl benzene (C_8H_{10}) **ElRo**:F4.

Ethyl diazoacetate ($C_4H_6N_2O_2$) **EqL**:R22.

Ethylene (C_2H_4) **AnMs**:D30; **AnSp**:D30; **BiC**:C3; **EqH**:D30, L4, M24; **KiG**:L30, R1; **KiH**:D30, L4, M24, W38; **KiP**:D5; **SpVi**:C11, C13, C34, C37, H17, M20, S66, T15; **StD**:C13, C37, T15; **Sy**:B30, L18, R2.

Ethyl naphthalene ($C_{12}H_{12}$) **SpVi**:G18; **Sy**:G18.

Ethylene oxide (C_2H_4O) **IsTh**:L18; **Sy**:L18; **ThP**:L18.

Ethyl ethoxyacetate ($C_6H_{12}O_3$) **SpVi**:R22.

Fluoroform (CHF_3) **SpVi**:P18; **Sy**:P18; **ThF**:P18.

Fluorosilane (SiH_3F) **SpM**:B1, B3, W23; **SpVi**:A6; **StD**:A6, B1, B3; **Sy**:B3.

Formaldehyde (CH_2O) **SpVi**:D9, T15; **StD**:T15; **Sy**:B6.

Formic acid ($HCOOH$) **SpVi**:S64.

Formic acid dimer ($(HCOOH)_2$) **SpVi**:S65.

Formic acid, sodium salt of (CHO_2Na) **EqL**:B60; **KiL**:B60.

Formyl radical (CHO) **KiG**:B77; **SpEl**:B77.

Fumaric acid ($C_4H_4O_4$) **AnMs**:B58.

Germane. See Germanium hydride.

Germanium hydride (GeH_4) **ThF**:Z1; **ThP**:Z1; **Sy**:Z1.

Germanium monochlorohydride (GeH_3Cl) **SpVi**:L35; **ThF**:L35.

Glutamic acid ($C_5H_9NO_4$) **AnMs**:B58; **BiC**:K33; **EqL**:G24; **Sy**:G24, K32.

Glutamic acid, N carbamyl ($C_6H_{10}N_2O_5$) **EqL**:G24; **Sy**:G24.

Glutamic acid, N carboxyethyl ($C_8H_{13}NO_6$) **BiC**:K33; **Sy**:K32.

Glutamic amide ($C_5H_{10}N_2O_3$) **SpVi**:D10.

Glutamine. See Glutamic amide.

Glutaric acid ($C_5H_8O_4$) **EqL**:G24; **SdSp**:H2; **SpVi**:H2; **Sy**:G24.

Glycine ($C_2H_5NO_2$) **EqL**:B61; **KiL**:B61.

Glycollic acid ($HOCH_2COOH$) **EqL**:B62; **KiL**:B62.

Guanine-t ($C_5H_5N_5O$-t) **EqL**:E8; **Sy**:E8.

Hafnium hydride (HfH_2) **IsCr**:S29; **StD**:S29.

Helium hydride (HeH) **NuM**:M38; **Sr**:M37, M38.

Heptadecane ($C_{17}H_{36}$) **InBi**:B27.

Heptane (C_7H_{16}) **EqH**:B96; **KiH**:B96.

Heptylamine ($C_7H_{17}N$) **EqL**:H29; **KiL**:H29.

Hexadecane ($C_{16}H_{34}$) **BiC**:B28; **InBi**:B28; **Sy**:B28.

Hexahydrobenzoic acid ($C_7H_{12}O_2$) **SdSp**:H_2; **SpVi**:H_2.

Hexane (C_6H_{14}) **KiL**:S49.

Hexestrol-t ($C_{18}H_{22}O_2$-t) **Sy**:L1.

Hexyl alcohol ($C_6H_{13}OH$) **SpVi**:Q1.

Hexyl bromide ($C_6H_{13}Br$) **KiL**:H25.

Hydrazine hydrobromide ($N_2H_4 \cdot HBr$) **SdSp**:D15; **SpVi**:D15.

Hydrazine hydrochloride ($N_2H_4 \cdot HCl$) **SdSp**:D15; **SpVi**:D15.

Hydriodic acid (HI) **ElD**:B14; **EqG**:T4; **IsEq**:B39; **IsKi**:**B39**; **KiG**:S14, T4; **KiP**:S14; **SdCr**:B14; **SdTr**:B14; **SpM**:B92, K26; **ThF**:B39; **ThS**:B39.

Hydrobromic acid (HBr) **ElD**:P26; **ElT**:P26; **EqG**:M13; **KiG**:M13, M14; **MeDf**:B70; **SpM**:G17; **SpVi**:K13; **Sy**:L18; **StD**:K13.

Hydrochloric acid (HCl) **EqG**:S18; **EcO**:B86s; **ElD**:P11; **IsSp**:P12; **KiG**:S18; **KiH**:B86s; **MeDf**:B70; **SdEl**:P11; **SdTr**:P11; **SoI**:B86s; **SpM**:A2; **SpVi**:G23, H8, P12; **Sr**:J13; **StD**:P12; **Sy**:P11.

Hydrocyanic acid (HCN) **SpM**:G16, W22; **SpVi**:D29; **StD**:D29.

Hydrogen (H_2) **AdG**:S4, S12, V5, V6; **BIB**:P16; **BiC**:E7, H39, M12, P17, S38, W13, W42; **EcP**:B57; **ElMg**:B9; **ElMr**:I2; **ElP**:R9, S46; **ElRf**:E13; **ElT**:B17; **Eq**:K5; **EqG**:B56, C23, E6, M41, P7, T4; **EqH**:A7, B64, B84, B96, D30, E6, E11, F19, F20, G28, K3, K6, K15, K16, K46, K47, L4, M23, M24, M41, M48, M52, T13, V5, V6, W1, W35, W36, W37; **EqL**:C44, D37, D38, L21; **In**:H22; **InBi**:H38, M18; **InKi**:B77, K21, K46, K47, K49, K50, S49; **InSt**:L21, P27; **Is**:P21; **IsEq**:B39; **IsKi**:B39, M15, W24; **KiB**:C44; **KiG**:B56, C23, M15, M41, S18, T4, W21, W24; **KiH**:A1, A7, B57, B64, B96, D30, E6, G28, K6, K10, K15, K16, K20, K22, L4, M23, M24, M41, M48, M52, S4, W1, W36, W37, W38; **KiL**:D37, D38; **KiP**:M15, M16, R11, W24; **KiR**:G5, P27, S37, W27; **KiS**:K8; **MeAc**:M2, S51; **MeD**:D8, S52; **MeDf**:A11, A12, N15, U2, U3; **MeV**:A11, A12, B15, B16, M46, P21; **NuM**:M38; **Sd**:K34; **SdCr**:M35; **SdEl**:R12; **SdNu**:S62; **SdTr**:B59, K40; **SeDf**:B18; **SeEl**:B90; **SeEm**:B19; **SoG**:L26; **SpEl**:L5; **SpVi**:D18, S46; **Sr**:E14, M37, M38, M55, N16, O3, O4, S5; **Th**:B59; **ThD**:A11, A12, B59, G22, G27; **ThF**:B39, B59, D8, F12, N2, O8, S52; **ThP**:B59, C14, F12; **ThS**:B39, B59, O8.

Hydrogen peroxide (H_2O_2) **ElD**:M34; **ElGd**:G9; **ElRe**:S35; **Ge**:G7; **SpM**:M34; **St**:G7, M34; **Sy**:G9; **ThP**:G8.

Hydrogen selenide (H_2Se) **IsSp**:M57; **StD**:M57.

Hydrogen sulfide (H_2S) **IsSp**:M57; **KiP**:D5; **SpEl**:R6; **SpM**:B50; **StD**:M57.

Hydronium ion (H_3O^+) **EcC**:G6.

Hydroxylamine (H_3NO) **SpVi**:N7; **St**:N7.

Hydroxyl ion (OH^-) **EcC**:G6; **EqH**:K38; **KiB**:K38; **SpEl**:S11.

Hydroxyl radical (OH) **ElGd**:B78; **KiG**:B77; **SpEl**:B77, B78; **SpVi**:B78; **ThF**:M3.

Hypophosphorous acid (H_3PO_2) **EqL**:M27; **KiL**:M27.

Imidogen (NH) **ElGd**:L13; **SpEl**:F9, L13.

Indium hydroxide (InO_3H_3) **SdSp**:G11; **SpVi**:G11.

Isobutane (C_4H_{10}) **EqH**:K16; **KiH**:K16.

Isothiocyanic acid (HNCS) **SpM**:D31; **StD**:D31.

Ketoglutaric acid. See Acetone dicarboxylic acid.

Lauric acid ($C_{12}H_{24}O_2$) **SdSp**:H2; **SpVi**:H2.

Lithium aluminum hydride ($LiAlH_4$) **Ge**:M36.

Lithium aluminum hydride-t ($LiAlH_4$-t) **Ge**:M36; **IsKi**:K4; **KiL**:K4.

Lithium borohydride ($LiBH_4$) **EqH**:B84.

Lithium borohydride-t ($LiBH_4$-t) **IsKi**:K4; **KiL**:K4.

Lithium hydride (LiH) **IsCr**:N14; **SdCr**:S45; **StD**:N14; **ThF**:N14.

Lithium hydride–t (LiH-t) **IsCr**:N14; **StD**:N14; **ThF**:N14.

Lithium hydroxide monohydrate ($LiOH \cdot H_2O$) **SpVi**:J14.

Magnesium hydroxide ($Mg(OH)_2$) **SdSp**:H11; **SpVi**:H11.

Maleic acid ($C_4H_4O_4$) **InSt**:C2; **SpVi**:C2.

Maleic acid, postassium salt of ($C_4H_3O_4K$) **InSt**:C2; **SpVi**:C2.

Malonic acid ($C_3H_4O_2$) **SdSp**:H2; **SpVi**:H2.

Manganese hydride (MnH) **SpEl**:N3; **SpVi**:N3.

Mercapto radical (HS) **SpEl**:L12, R6; **StD**:L12.

Methane (CH_4) **AnMs**:D21; **EqG**:C23; **EqH**:K15, M23; **Is**:P21; **KiG**:C23, W31; **KiH**:K15, M23; **KiP**:R11; **KiR**:W27; **MeV**:P21; **SpVi**:B7, B67, B68, B69, W28; **Sr**:L38; **StD**:B67; **ThP**:A13.

Methane-t (CH_4-t) **MeDf**:J6; **ThD**:C5, J6.

Methionine ($C_5H_{11}NO_2S$) **InBi**:D17.

Methyl acetate. See Acetic acid, methyl ester of.

Methyl acetylene. See Allylene.

Methyl alcohol (CH_3OH) **BiC**:R3, V2; **EqL**:J12; **InBi**:V2; **InSt**:J12, S15, T1; **IsSp**:S60; **KiR**:C30, P30; **SpVi**:B11, Q1, S15s, S30, S60, S61, T1; **StA**:T1; **StD**:S30.

Methyl alcohol-t (CH_3OH-t) **BiC**:R3, V2; **InBi**:V2.

Methyl aldehyde (CH_3CHO) **KiG**:R15.

Methyl bromide (CH_3Br) **Is**:M49; **IsSp**:G15; **SpEl**:G15; **SpM**:M49; **SpVi**:C33, W29; **StD**:M49; **Sy**:N13.

2-Methyl butyl alcohol ($C_5H_{12}O$) **InKi**:D20.

2-Methyl butyric acid ($C_5H_{10}O$) **InKi**:D20.

2-Methyl butyric acid, methyl ester of ($C_6H_{12}O_2$) **InKi**:D20.

Methyl chloride (CH_3Cl) **Is**:M49; **NuQ**:D35; **SpM**:M49; **StD**:M49.

Methylene chloride (CH_2Cl_2) **ElD**:M60; **SpM**:M60; **StD**:M60.

Methyl fluoride (CH_3F) **SpM**:G16.

Methyl formamide (C_2H_5NO) **IsSp**:K17.

Methyl iodide (CH_3I) **Is**:M49; **SpM**:M49; **StD**:M49.

Methyl naphthalene ($C_{11}H_{10}$) **SpVi**:G18; **Sy**:G18.

Methyl nitrite (CH_3NO_2) **KiR**:D23; **Sr**:D23.

Methyl radical (CH_3) **IsKi**:M15, W24; **KiG**:M10, M15, T20, W24, W31; **KiP**:K25, M11, M15, M16, T20, W24; **Sr**:L38.

Methyl silane (CH_3SiH_3) **SpM**:D2; **St**:D2.

Methylene bromide (CH_2Br_2) **SpVi**:D32; **ThF**:D32.

Naphthalene ($C_{10}H_8$) **IsMs**:M51; **SdSp**:P10; **SpEl**:C27; **SpVi**:G18, O6, P10; **Sr**:M51; **Sy**:G18.

NH radical. See Imidogen.

Nicotinamide, dihydromethyl ($C_7H_{10}N_2O$) **InKi**:R4.

Nitric acid (HNO_3) **SpVi**:C22.

Nitric acid, methyl ester of (CH_3NO_2) **SpVi**:T2; **St**:T2.

Nitrobenzene ($C_6H_5NO_2$) **KiL**:B66.

Nitrous acid (HNO_2) **SpEl**:D24; **SpVi**:D24.

Octadecane ($C_{18}H_{38}$) **BiC**:B28; **InBi**:B27, B28; **Sy**:B28.

Octadecene. See Octadecylene.

Octadecylene ($C_{18}H_{36}$) **KiH**:K20; **Sy**:K20.

Octane (C_8H_{18}) **BiC**:B28; **EqH**:B96; **InBi**:B27, B28; **KiH**:B96; **Sy**:B28.

Octyl alcohol ($C_8H_{17}OH$) **SpVi**:Q1.

Octyl bromide ($C_8H_{17}Br$) **KiL**:H25.

Octyl chloride ($C_8H_{17}Cl$) **KiL**:H25.

Oleic acid ($C_{18}H_{34}O_2$) **InBi**:F3; **KiH**:K20; **Sy**:K20.

Oleic acid, methyl ester of ($C_{19}H_{36}O_2$) **InKi**:K21; **KiH**:K20; **Sy**:K20.

Organic compounds-t **AnC**:V3, W39, W40; **AnDn**:C32.

Oxalic acid ($H_2C_2O_4$) **SdSp**:H2; **SpVi**:H2.

Pentaborane (B_5H_9) **ElD**:H34; **EqG**:M41; **EqH**:M41; **KiG**:M41; **KiH**:M41; **SpM**:H34; **SpVi**:H35; **StD**:H34; **Sy**:H35; **ThF**:H35.

Pentachlorophenol (C_6Cl_5OH) **SpVi**:K44.

Pentane (C_5H_{12}) **KiL**:S49; **SpVi**:S28.

2-Pentylchlorosulfite ($C_5H_{11}ClSO_2$) **IsKi**:L25; **KiL**:L25; **Sy**:L25.

Phenol (C_6H_5OH) **EqG**:B75; **KiG**:B75; **Sr**:M53.

Phosphine (PH_3) **ElD**:S33; **EqG**:W17; **EqH**:W17, W18, W19; **KiH**:W18; **SpM**:B93, S33, S57, S59; **SpVi**:W17; **StD**:S33.

Phosphoric acid (H_3PO_4) **EcP**:H36s; **InKi**:K50, N1; **ThSo**:H36.

Phosphoric acid-t (H_3PO_4-t) **EqH**:T23; **KiH**:T23.

Phyllanthol **InSt**:B13.

Picolene (C_6H_7N) **SoH**:C35; **ThP**:C35.

Polythene ($(C_2H_2)_n$) **Sy**:R27.

Potassium amide (KNH_2) **EqL**:D37, D38, S24; **KiL**:D37, D38, S24.

Potassium arsenate, dihydrogen (KH_2AsO_4) **SdTr**:S48.

Potassium fluoride (HF_2K) **SpVi**:J15.

Potassium hydroxide (KOH) **EcO**:B86s; **KiH**:B86s; **SoI**:B86s.

Potassium phosphate, dihydrogen (KH_2PO_4) **IsSp**:L33; **SdSp**:L33; **SdTr**:S48; **SpVi**:L33; **StA**:L33.

Propane (C_3H_8) **EqH**:A7, K6, K16; **KiH**:A7, K6, K16; **KiP**:D5.

Propene. See Propylene.

Propionic acid ($C_3H_6O_2$) **SdSp**:H2; **SpVi**:H2.

Propyl alcohol (C_3H_7OH) **KiL**:C20, L22s; **SpVi**:Q1.

Propyl bromide (C_3H_7Br) **KiL**:S26; **Sy**:S26.

Propylene (C_3H_6) **EqH**:B64; **KiH**:B64; **KiP**:D5; **SpVi**:L37; **Sy**:R2.

Propyne. See Allylene.

Pyridine (C_5H_5N) **SpVi**:C29.

Pyridine hydrochloride (C_5H_5N·HCl) **IsSp**:L33; **SdSp**:L33; **SpVi**:L33; **StA**:L33.

Pyrone ($C_5H_4O_2$) **EqL**:L34; **Sy**:L34.

Pyrrole (C_4H_5N) **SpVi**:T22.

Rubidium arsenate, dihydrogen (RbH_2AsO_4) **SdTr**:S48.

Rubidium phosphate, dihydrogen (RbH_2PO_4) **IsCr**:M39; **SdTr**:S48.

Serine ($C_3H_7O_3N$) **BiC**:E9, E10, T3; **InBi**:E9, S44; **KiB**:E10.

Sodium borohydride ($NaBH_4$) **EqH**:B84.

Sodium formate (HCOONa) **EqL**:B62; **KiL**:B62.

Sodium hydroxide (NaOH) **EqL**:H27; **KiL**:H27.

Sorbic acid ($CH_3(CHCH)_2CO_2H$) **InSt**:C36; **SpEl**:C36; **SpVi**:C36; **Sy**:C36.

Stearic acid ($C_{18}H_{36}O_2$) **AnC**:B21, R31; **SdSp**:H2; **SpVi**:H2; **InBi**:F3.

Steroids **EqH**:F19; **IsSp**:J16; **SpVi**:J16; **St**:J16; **Sy**:F19, N12.

Stibine (SbH_3) **SpVi**:G3, H14; **StD**:G3, H14.

Stilbene-t ($C_{14}H_{12}$-t) **SpFl**:B34; **Sy**:B34.

Styrene-t (C_8H_8) **Sy**:B31.

Succinic acid ($C_4H_6O_4$) **SdSp**:H2; **SpVi**:H2.

Sulfuric acid (H_2SO_4) **EcO**:B86s; **EqL**:S19, S49; **KiH**:B86s; **KiL**:S19; **SoI**B86s.

Testosterone ($C_{19}H_{28}O_2$) **InBi**:F17, F18.

Tetrachloropropane ($C_3Cl_4H_4$) **Sy**:L17.

Tetradecane ($C_{14}H_{30}$) **BiC**:B28; **InBi**:B27, B28; **Sy**:B28.

Toluene (C_7H_8) **EqG**:K42; **EqL**:D37, K42; **InKi**:K41; **KiL**:B83, D37; **KiP**:K41; **Sy**:B83, K42.

Toluene-t (C_7H_8-t) **EqL**:O5; **KiL**:O5.

p-Tolyldiazonium chloride ($C_7H_7N_2Cl$) **EqL**:M47; **KiL**:M47.

Trichloroacetic acid ($C_2HCl_3O_2$) **SdSp:**H2; **SpVi:**F22, H2, K43.

Triethoxy silane ($(C_2H_5O)_3SiH$) **EqL:**K23.

Triethylamine hydrochloride ($C_6H_{15}N{\cdot}HCl$) **IsSp:**L33; **SdSp:**L33; **SpVi:**L33; **StA:**L33.

Triethyl silane ($(C_2H_5)_3SiH$) **EqL:**K23.

Trifluoroacetic acid (CF_3COOH) **SpVi:**F22, F23.

Trifluoroacetic acid, trimer ($(CF_3COOH)_3$) **SpVi:**K29; **ThF:**K29.

Trigermane (Ge_3H_8) **ThF:**Z1; **ThP:**Z1; **Sy:**Z1.

Trimethyl acetic acid ($C_5H_{10}O_2$) **SdSp:**H2; **SpVi:**H2.

Trinitrobenzene ($C_6H_3N_3O_6$) **EqL:**K18.

Triphenylsilane ($(C_6H_5)_3SiH$) **EqL:**K23.

Triphenylsilane-t ($C_{18}H_{16}Si$-t) **IsKi:**K4; **KiL:**K4.

Tritium **BiB:**C19, W12; **BiC:**C19, E7, S39, S40, W13; **BiZ:**T11; **EqG:**D26, E6; **EqH:**E6, T13; **EqL:**O5; **Ge:**T9; **In:**S9; **InA:**U1; **InBi:**B5, T9; **Is:**W12; **KiG:** D26, M26; **KiH:**E6; **KiL:**O5; **KiR:**H4; **Sp:**C22; **SpVi:**D18.

Tryptophane ($C_{11}H_{12}N_2O_2$) **InBi:**S6.

Uracil-t ($C_4H_4N_2O_2$-t) **EqL:**E8; **Sy:**E8.

Uranium hydride (UH_3) **ElMg:**T21; **ElMm:**T21; **IsTh:** N19; **MeD:**N19; **Sd:**N19; **ThP:**N19.

Valeric acid ($C_5H_{10}O_2$) **SdSp:**H2; **SpVi:**H2.

Vinyl bromide (C_2H_3Br) **SpVi:**C12, M21; **StD:**M21.

Water (H_2O) **Ad:**B73; **AdG:**S3; **BiB:**H33, K39, P19; **BiC:**F11, H33, K39, M29, P9, W13; **BiZ:**C16, G4, H37, K31, L29, P29, T10, T11; **EcC:**G6; **ElD:**A14, H10; **ElGd:**B78, R5; **ElMm:**J7; **ElP:**D1; **ElRe:**S35; **Eq:**B74; **EqG:**W17; **EqH:**B10, K37, K38, P13, T13, W17, W18, W19; **EqL:**A4, B60, B61, B62, B76, F8, H27, H28, K18, K23, K42, K48, R22, W10; **In:**B73, N17, P13, W5; **InBi:**C16, F8, K35, M17, W15; **InKi:** B81, C1, C25, W10; **InSt:**B76; **Is:**P21, R34; **IsCr:**R36; **IsKi:**E15; **IsSp:**M57; **IsTh:**B54; **Ki:**B74, E15; **KiB:** C6, F8, J11, K37, K38, K39, M17, P14, S37; **KiH:**D22, W18; **KiL:**A4, B60, B61, B62, H27, H28; **KiR:**F5, K14; **MeAc:**L3, P2, S22; **MeD:**C9, H15, I7, L3; **MeDf:**N17, W5; **MeSt:**H15; **MeV:**H15, P21, R34; **SdEl:**A14; **SdTr:**L3; **SeCr:**R26; **SeCh:**B10, C7, E15; **SeDf:**C7; **SpEl:**B24, B78; **SpM:**B20, B91, C38, C39, J7, J8, P24, P25, R24; **SpVi:**B22, B23, G25, J17, L14, P13, P25; **StD:**M57; **ThD:**M45, P32; **ThF:**B54, L3; **ThP:**C35, G8, J18, M59.

Water-t (H_2O-t) **BiB:**B37, C10, C19, P23; **BiC:**B4, C19, P9, W13; **BiZ:**C16, L29, P22, T10, T11, T12; **In:**G20, W5, **InBi:**B4, C16, P28, T7, T8; **InSp:**M57; **MeDf:**C42, W5; **SdSp:**J19; **SpFl:**J19; **StD:**M57; **ThP:**J18.

WASHINGTON, January 4, 1957.

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The National Bureau of Standards

The scope of activities of the National Bureau of Standards at its headquarters in Washington, D. C., and its major field laboratories in Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D. C.

Electricity and Electronics. Resistance and Reactance. Electron Devices. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

Heat and Power. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Engine Fuels. Free Radicals Research.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Nuclear Physics. Radioactivity. X-rays. Betatron. Nucleonic Instrumentation. Radiological Equipment. AEC Radiation Instruments.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Gas Chemistry. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Specifications. Heat Transfer.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuity. Digital Systems. Analog Systems. Application Engineering.

- Office of Basic Instrumentation
- Office of Weights and Measures

BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships.

Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Systems. Navigation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering.

Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Calibration Center. Microwave Physics. Microwave Circuit Standards.