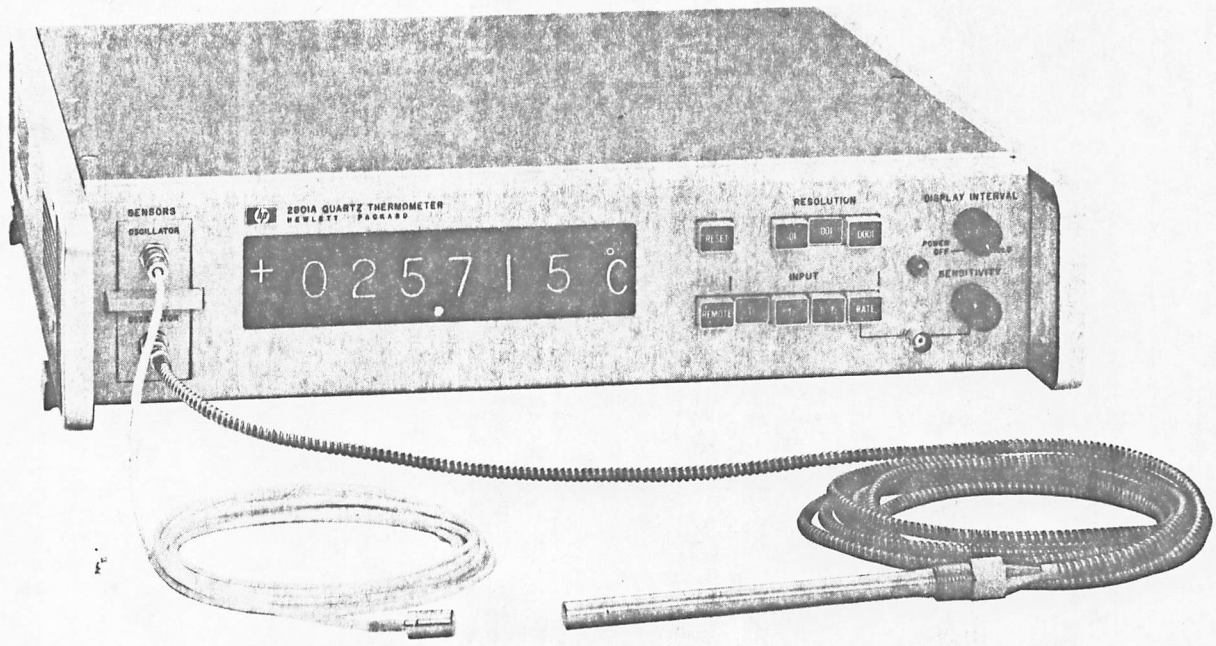
APPLICATION NOTE 78-4

A Glossary Of Terms Pertaining To Temperature Measurement



HP 2801A QUARTZ THERMOMETER

HEWLETT hp PACKARD

A

Absolute Zero: The temperature at which a system would undergo a reversible isothermal process without transfer of heat, and at which the volume of an ideal gas would become zero. Calculated to be -273.16°C.

Absorption: The process whereby some or all of the energy of electromagnetic radiations is transferred to the substance on which they are incident or which they traverse.

Accuracy: The quality of freedom from mistake or error, that is, of conformity to truth or to a rule. Accuracy is distinguished from precision as in the following example: a six-place table is more precise than a 4-place table. However, if there are errors in the 6-place table, it may be either more or less accurate than the 4-place table.

Accuracy of Measurement: The degree of correctness with which a method of measuring yields the "true" value of a quantity. Usually expressed in terms of error, as a percentage of the full scale value and/or the actual value.

Adiabatic: A process that takes place without gain or loss of heat (not completely realizable in practice).

Adsorption: Type of adhesion which takes place at the surface of a solid or liquid in contact with another medium.

Allotropy: A property of certain substances existing in two or more forms distinct in physical, and some chemical, properties.

Alumel: A nickel-aluminum alloy used in thermocouples.

B

Black Body: An ideal body which would absorb all and reflect none of the radiation falling upon it.

Boiling: Process of changing from liquid to vapor state, restricted usually to cases in which the vapor pressure of the liquid is equal to or greater than the atmospheric pressure above the liquid.

Boiling Point: Normal boiling point of a liquid is defined as the temperature at which its maximum or "saturated" vapor pressure is equal to normal atmospheric pressure, 760 mm of mercury. Boiling point varies with atmospheric pressure. For example, water boils at ordinary room temperature if the pressure is reduced to about 17 mm.

Boiling Point of Solution: Dissolving a nonvolatile substance in a liquid raises the boiling point of the solvent. Molecular weight of the solute or purity of the solvent can be determined from the boiling point elevation.

Bridge, Mueller: A bridge for measuring four terminal resistors, particularly resistance thermometers.

British Thermal Unit: Energy required to raise the temperature of one pound of water one degree Fahrenheit.

C

Calorie: Originally defined as the amount of heat required to raise the temperature of one gram of water one degree Celsius. Now defined as 1 calorie = 4.1840 absolute joules. (1 cal. = .00396573 BTU.)

Calorimeter: An apparatus for measuring the change of heat content of a system.

Calorimeter, Bomb: A calorimeter in which a weighted sample of liquid or solid material is burned in oxygen, to determine heat evolved.

Calorimetric Coefficient: One of the following six coefficients, used to express the rate of absorption of heat during reversible changes of pressure, volume and temperature (1) heat of compression at constant volume (2) heat of expansion at constant pressure (3) specific heat at constant volume (4) specific heat at constant pressure (5) latent heat of change of pressure (6) latent heat of change of volume.

Calorimetry: The quantitative determination of heat content.

Capacity, Specific Thermal: See Specific Heat.

Carnot Cycle: An ideal cycle of four reversible changes in the physical condition of a substance; useful in thermodynamic theory.

Celsius, Centigrade: See Temperature Scale.

Change of State: Transformation from one to another of the three states of matter — gaseous, liquid or solid.

Chromel: A nickel-chromium alloy used in thermocouples.

Conductivity, Thermal: Quantity of heat transmitted per unit time per unit cross section per unit temperature gradient, usually expressed in calories/square centimeter/degree.

Consolute Temperature: Critical temperature above or below which two partially-miscible liquids are miscible in all porportions.

Convection, Thermal: The transference of heat by the bodily movement of heated particles of matter.

Critical Temperature: The maximum temperature at which a gas or vapor can be liquified.

Cryogenics: That branck of physics concerned with the production and measurement of very low temperatures, below 80° Kelvin.

Cryometer: A low-temperature thermometer.

Cryoscope: An instrument for measuring the freezing or solidification point.

Cryoscopic Constant: A quantity calculated to represent the molal depression of the freezing point of a solution.

Cryoscopy: Examination of the freezing point of solutions.

Cryostat: A low-temperature thermostat.

Crystal, AT-Cut: A quartz crystal cut characterized by a substantially-zero temperature coefficient.

Crystal, LC-Cut: A quartz crystal cut characterized by a very linear coefficient of change of resonant frequency with temperature.

D

Dewar Flask: A double-walled vessel in which the region between the walls has been evacuated, and in which the walls have been silvered.

Dew Point: The temperature at which the actual content of water vapor in the atmosphere is sufficient to saturate the air with water vapor.

E

Ebullioscope (Ebulliometer): An instrument that measures a property by a deviation from a normal known boiling point.

Ebullioscopic Constant: A quantity calculated to represent the molal elevation of the boiling point of a solution.

Ebullioscopy (Ebulliometry): Determination of molecular weight by measurement of elevation of boiling point.

Ebullition (Boiling): The vaporization of a liquid due to escape of bubbles of its vapor formed where heat is applied below the surface.

Endothermic: Characterized by the absorption of heat.

Enthalpy: Thermodynamic potential. (At constant pressure the change in enthalpy is equal to the heat flow into the system from the surroundings.)

Entropy: A quantity occurring in the mathematical treatment of thermodynamic processes. If a physical system is left to itself and allowed to distribute its energy in its own way, it alwyas does so such that the entropy increases while at the same time the available energy of the system diminishes.

Equation of State: The relationship between pressure, volume and temperature of a gas, and the gas constant. There are many variants of this equation, developed by: Keyes, Berthelot; Beattie and Bridgman; van der Waals; Dieterici Clausius.

Eutectic Temperature: A minimum point on a temperature-composition curve at which a liquid consisting of two or more components is in equilibrium with its components in the solid state. It represents the lowest melting point of the system.

Exothermic: Characterized by the evolution of heat. An exothermic change is a physical or chemical change which proceeds with the development of heat.

F

Fahrenheit: See Temperature Scale.

Freezing Point: The temperature at which a liquid becomes a solid (not necessarily identical with the melting point of the solid).

Freezing Point Depression: Freezing point of a solution is generally lower than that of the pure solvent, and the molecular weight of the solute may be derived from measurement of the depression.

G

Gold Point: The melting point of gold (+1063.0°C) is one of the fixed points of the International Temperature Scale.

H

Heat, Atomic: The product of the gram-atomic weight of an element and its specific heat.

Heat Capacity: The amount of heat necessary to raise the temperature of a system, entity or substance by one degree; most frequently expressed in calories per degree Celsius. (If the mass of the substance is specified, then atomic heat, molar heat and specific heat can be derived.)

Heat, Latent: Heat which is gained by a substance or system without an accompanying rise in temperature during a change of state.

Heat, Molecular (Molar): The product of the gram-molecular weight of a compound and its specific heat.

Heat of Activation: The increase of heat content accompanying the transformation of a substance from a less active to a more reactive form.

Heat of Adsorption: The increase of heat content when one mole of a given substance is adsorbed upon another specified substance.

Heat of Aggregation: The increase of heat content accompanying the formation of various aggregates of matter, such as crystals, etc.

Heat of Association: The increase of heat content when one mole of a coordination compound is formed from its constituent molecules or other particles.

Heat of Combustion: The increase in heat content when one mole of a substance undergoes oxidation, whereby the products obtained in complete combustion are produced.

Heat of Condensation: The increase in heat content when unit mass, or one mole of a vapor is converted into liquid at its boiling point under isobaric conditions without change of temperature. (This quantity is the reverse of the latent heat of vaporization.)

Heat of Cooling: An increase in the heat content of a substance or system at certain temperatures on its cooling curve, arising from an internal change.

Heat of Crystallization: The increase in heat content of one mole of a substance attributable to its transformation to the crystalline state.

Heat of Decomposition: The change of heat content when one mole of a compound is decomposed into its elements. (This quantity is equal in quantity to the heat of formation.)

Heat of Dilution, Differential: The increase in heat content of a system resulting from addition of an infinitesimal quantity of solvent to the solution.

Heat of Dilution, Integral: The increase in heat content occurring when a specified amount of the solvent is added to a solution.

Heat of Dissociation: The increase in heat content occurring as a result of the breaking apart of molecules.

Heat of Formation: The increase in heat content of the system when one mole of a substance is formed from its elements.

Heat of Fusion, Latent: The increase in heat content when unit mass, or one mole of a solid is converted into liquid at its melting point, without change of temperature. Commonly determined at constant pressure.

Heat of Hydration: The increase of heat content when one mole of a hydrate is formed from the anhydrous form of the compound, and from water.

Heat of Ionization: The increase of heat content accompanying the ionization of one mole of a substance.

Heat of Linkage: The bond energy of a particular valence linkage between atoms.

Heat of Neutralization: The increase in heat content of a system undergoing a neutralization reaction involving molar quantities of reactants.

Heat of Solidification: The increase in heat content upon the formation of one mole of a solid from a substance commonly in the liquid state.

Heat of Solution, Differential: A partial differential quantity obtained by differentiating the total heat of solution.

Heat of Solution, Integral: The difference between the heat content of a solution, and the heat contents of its components.

Heat of Sublimation, Latent: The increase of heat content when unit mass, or one mole, of a solid is converted into vapor under isobaric conditions.

Heat of Transition: The increase in heat content when one mole of a substance changes to an allotropic form, at the transition temperature.

Heat, Specific: The quantity of heat per unit mass (sometimes per unit volume) and per unit temperature rise, required to raise the temperature of a substance without change of phase. It is thus equal to the ratio of the heat capacity of a body to the mass (or volume) of the body, and may be called the *specific thermal capacity.* Measured in calories per gram degree, joules per kilogram degree, or ergs per gram mole.

Heat Transfer: Heat can be transferred by three different methods: by *conduction,* where the heat must diffuse through solid materials or stagnant fluids; by convection, where the heat is carried from one point to another by actual movement of the hot material (common in fluids); and by *radiation,* where heat is transferred by means of electromagnetic waves.

I

Ice Point: An old fixed point for thermometry; the temperature of a mixture of melting ice and water at normal atmospheric pressure, defined as 0°C. Now replaced officially by the *triple point of water.*

Inversion Temperature: See Neutral Temperature.

Isothermal: Of constant temperature.

J

Joule: The fundamental unit of energy or work in the MKS (meter-kilogram-second) system of units.

K

Kelvin: See Temperature Scale.

M

Melting Point: The temperature at which the solid and liquid phases of a substance are in thermodynamic equilibrium (usually referred to normal pressure).

Mole: One gram-molecule of any substance, i.e., the molecular weight of the substance expressed in grams (gram-molecular weight).

Molal: (1) Pertaining to moles (gram-molecular weights); (2) pertaining to a solution, containing one mole of solute per kilogram of solvent.

Molar: (1) Pertaining to molecules or moles per unit volume; thus a molar solution contains one mole of solute per liter of solution.

N

Neutral Temperature: The temperature at which the electromotive force produced by heating one junction of a thermocouple reaches a maximum, the other junction being constant at 0°C. Above this temperature the electromotive force steadily decreases until it reaches a zero value. The latter point is called the *temperature of inversion.*

O

Oxygen Point: The boiling point of oxygen (-182.970°C) is one of the fixed points of the International Temperature Scale.

P

Peltier Effect: The evolution or absorption of heat at a junction between two dissimilar conductors, across which a current passes.

Phase: A homogeneous, physically-distinct part of a system which is separated from other parts of a system by definite bounding surfaces. (For example, a system of two insoluble or partly-soluble liquids which form layers has two phases.)

Pyrometer: Originally a device for measuring high temperatures, but pyrometers are now used also in the same ranges as thermometers. Four major types of pyrometers are: thermoelectric (thermocouple); resistance; optical; and radiation.

R

Rankine: See Temperature Scale.

S

Seebeck Effect: The production of electromotive force as a result of a circuit containing two conducting materials having two junctions between the materials at different temperatures. This effect is the basis of all thermocouples.

Silver Point: The melting point of silver (+960.8°C) is one of the fixed points of the International Temperature Scale.

Standard Conditions: For a gas, a temperature of 0°C and a pressure of 1 standard atmosphere (760 mm of mercury).

Steam Point: A standard point for temperature calibration defined as 100° on the Celsius scale. It is the temperature at which pure water boils under a pressure of 760 mm of mercury.

Sublimation: The transformation of a solid directly to the gaseous condition without passing through the liquid state.

Sulfur Point: The boiling point of sulfur (+444.600°C) is one of the fixed points of the International Temperature Scale.

Supercooling: The cooling of a liquid below its freezing point without the separation of the solid phase.

Superheating: A very pure substance may sometimes be heated to a temperature well above that at which it would ordinarily go through a change of state, without such change taking place. For example, a liquid may be heated to above its boiling point without boiling occurring.

T

Temperature: A manifestation of the average translational kinetic energy of the molecules of a substance due to heat agitation. It is measurable by any one of the many effects due to changes or differences in this energy. Thus, substances expand, their electrical resistivity changes, gases and vapors exert varying pressure, the viscosity of fluids alters, etc.

Temperature, Absolute: (1) The temperature measured on the thermodynamic scale (2) The temperature measured from absolute zero (-273.16°C).

Temperature Scale, Absolute: Any temperature scale whose zero is the absolute zero of temperature, -273.16°C or -459.7°F. Most commonly used in the Kelvin scale, but the Rankine scale is also employed.

Temperature Scale, Celsius: A temperature scale based on the mercury-in-galss thermometer, with the freezing point of water defined as 0°C and the boiling point as 100°C.

Temperature Scale, Centigrade: The older name of the Celsius scale.

Temperature Scale, Fahrenheit: A temperature scale based on the mercury-in-glass thermometer, with the freezing point of water defined as 32°F and the boiling point as 212°F.

Temperature Scale, International (Practical): A scale of temperature fixed by international agreement. Between -19°C and +660°C, it is based on the resistance of a standard platinum resistance thermometer (in accordance with certain formulas). From +660°C to the gold point, it is based upon the platinum-platinum rhodium thermocouple, and beyond this upon the optical pyrometer.

Temperature Scale, Kelvin: A temperature scale based on the second law of thermodynamics; it is independent of the properties of any particular substance. Its zero is the lower limit of temperature, which can be approached but never reached, and the size of a degree is taken such that the difference between the boiling and freezing points of water is 100°K. Careful measurements have indicated that the zero of the Celsius scale is at 273.16°K. The International Union of Pure and Applied Physics in 1955 recommended that the *triple point of water* be defined as 273.16°K. This would make the Kelvin scale fundamental, rather than the Celsius scale.

Temperature Scale, Rankine: An absolute temperature scale on which the difference between the boiling and freezing points of water is 212° and the zero of which is the absolute zero of temperature. (Freezing point of water is 491.7°R; 1°R = 1°F)

Temperature, Standard: In general, a temperature established by some unvarying process, such as a melting or boiling point, or the pressure or volume of a substance, under defined conditions.

Thermel: Any thermoelectric thermometer utilizing the Seebeck effect. The simplest form of this is the thermocouple.

Thermistor: A resistance element made of semi-conductor material which exhibits a high negative temperature coefficient of resistivity. It is utilized as a thermometer.

Thermocouple: A device consisting of two metals, one of whose junctions is kept at a fixed temperature. The electromotive force generated in the circuit is measured to give the temperature of the other junction, making a convenient and simple thermometer.

Thermograph: An instrument used to make a continuous record of temperature.

Thermometer: An instrument used to measure the temperature of a body. Instruments for measuring high temperatures are termed pyrometers, and are based upon the measurement of radiation emitted by the hot body (or by measurement of the change in resistance of a wire, or by use of a thermocouple.)

Thermometer, Bourdon: A flat hollow tube filled with an organic liquid; as the temperature of the liquid increases, its expansion causes the tube to straighten. This movement is used to drive a pointer.

Thermometer, Constant-Pressure: An instrument for measuring temperatures based on the expansion of a gas with increasing temperature, the pressure remaining constant.

Thermometer, Constant Volume: An instrument for measuring temperatures based on the increase in pressure of a gas with temperature, the volume remaining constant.

Thermometer, Hydrogen: A gas thermometer using hydrogen.

Thermometer, Liquid Expansion: A device using the relative expansion of a liquid and its transparent container. The mercury-in-glass thermometer may be used between its boiling point (+357°C) and its freezing point (-39°C). In some mercury thermometers an inert gas is introduced above the mercury, the pressure of which raises the boiling point. Alcohol is often used because of its lower freezing point (-114°C) and because its expansion coefficient is more than six times that of mercury. The boiling point, however, is very low (78°C).

Thermometer, Solid Expansion: Characterized by low expansion coefficient, but durability. Most commonly implemented by the differential expansion of two solid strips fastened (e.g. welded) together. The warping that takes place with temperature change is communicated through gears to a pointer shaft.

Thermometric Coefficient: There are two: the coefficient of change of pressure at constant volume, and the coefficient of expansion at constant pressure.

Thermometry: The measurement of temperature and of changes in temperature.

Thermopile: A device for measuring temperature (difference), consisting of a number of thermocouples in series, all junctions of type A-B being at the unknown temperature and all junctions of type B-A at the reference temperature.

Thermostat: An apparatus designed to maintain a constant temperature within a system.

Thomson Effect: A thermoelectric effect; when a electric current passes between two points of a homogeneous wire at different temperatures, an amount of heat is emitted or absorbed in addition to the Joule (ohmic) heat.

Transistion Point: A point at which a system changes phase. Examples are melting, vaporization, etc.

Triple Point: The temperature at which the three phases (solid, liquid and vapor) of a pure substance co-exist in equilibrium. Triple point of water is the primary defining point of the Kelvin scale, defined as 273.16°K.