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HIGH TEMPERATURE PROPERTIES OF SODIUM AND POTASSIUM

ELEVENTH PROGRESS REPORT FOR PERIOD 1 APRIL TO 30 JUNE 1963

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ABSTRACT

A program is in progress at this Laboratory to measure various thermophysical properties of sodium, potassium, and their vapors at elevated temperatures. Preliminary results are presented for the saturated vapor pressure of potassium from 0.34 to 27.3 atm and the specific heat of the saturated liquid from 1300° to 2100°F. Pressure-volume-temperature data for the vapor states of potassium (temperature range from 1573° to 2520°F and pressure range from 2.3 to 24.3 atm) have been obtained, and a thermodynamic treatment of the data is underway.

PROBLEM STATUS

This is an interim report on this problem; work is continuing.

AUTHORIZATION

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INTRODUCTION

In the development of compact turboelectric systems, the National Aeronautics and Space Administration is sponsoring a property measurement program for the evaluation of several liquid metals as possible working fluids. As an integral part of this program, the Naval Research Laboratory is engaged in the measurement of various thermophysical properties of sodium to 2500°F and potassium to 2100°F.

SUMMARY OF EXPERIMENTAL PROGRAM

The properties of the saturated liquid metals which are being determined experimentally include density, vapor pressure, specific heat, and surface tension (potassium only). Saturated and superheated vapor properties, including specific volume, specific heat, enthalpy, entropy, and free energy, are being derived from experimental PVT studies.

Eight PVT experiments with potassium to temperatures of 2520°F and seven with sodium to temperatures of 2600°F have been made. This completes the programmed experimental work for both metals; however, three additional experiments with sodium will be made to more adequately cover the required superheat range. Vapor pressures for potassium ranged from 0.34 atm at 1206°F to 27.3 atm at 2393°F, and a preliminary curve is presented.

Specific heat values for liquid potassium from 1300° to 2100°F have been obtained with the copper block calorimeter, and preliminary values are tabulated in this report. Specific heat values for sodium from 212° to 2135°F were previously reported (1).

Densities of liquid potassium and sodium at higher temperatures have been previously reported (2,3). Additional measurements to be made at lower temperatures have been delayed in favor of the PVT studies.

The surface tension measurements of liquid potassium have also been delayed in favor of the PVT studies; however, apparatus and furnace modifications are being readied for this work at the completion of the few remaining PVT experiments.

INDIVIDUAL PROPERTY TESTS

Pressure-Volume-Temperature

The Cb-1% Zr apparatus and the method being used to determine the vapor properties of sodium and potassium have been described in previous reports (1,4). The experimental program has been accelerated during the past quarter by careful planning and scheduling of the various filling, welding, degassing, and testing operations (1) required to complete each experiment.

Eight null-point experiments with potassium and seven with sodium have been completed. The potassium experiments cover superheat states in the temperature range from 1573° to 2520°F and in the pressure range from 2.3 to 24.3 atm. The sodium experiments cover superheat states in the temperature range from 1755° to 2588°F and in the pressure range from 1.9 to 25.0 atm. As previously pointed out, this completes the anticipated experimental work for both metals; however, three additional experiments with sodium will be required to satisfactorily cover the superheat range.

Since graphical presentations of sample PVT experiments have been made in previous reports (1,5), additional reporting of individual experiments will not be made at the present time. The raw data for each experiment are being reduced to true quantities, and a thermodynamic treatment of the composite data for each metal is underway.

Saturated Vapor Pressure

Preliminary vapor pressures of potassium (from 0.34 atm at 120°F to 27.3 atm at 2393°F) as observed in eight null-point experiments are shown in Fig. 1, where $\log p$ versus $1/T$ is plotted. Only a cursory examination of the vapor pressure data has been made, and an analysis of the data with a comparison to the work of other investigators will be made in a later report.

Saturation vapor pressures were obtained with each PVT experiment over a temperature range determined by the weight of alkali metal and its superheat temperature. It was found that saturation pressures for a given experiment near the intersection of the saturation and superheat curves were always below those on the true saturation curve. This lowering of the vapor pressure appears to be associated with some adsorption phenomenon, and observed pressures in these ranges have not been included in Fig. 1. The experimental points at the highest temperatures and pressures were determined by a special PVT experiment using a large excess of potassium.

Specific Heat

Specific heats of saturated liquid potassium have been determined from 1300° to 2100°F. An Inconel bucket containing the alkali metal is thermally equilibrated at a known temperature in a specially designed furnace and dropped into the calorimeter, permitting a measurement of the heat evolved in cooling the sample to 30°C (the standard operating temperature of the calorimeter). This procedure is repeated at a number of equilibrium temperatures for both filled and empty buckets, and the heat capacities of the sample are derived by standard calorimetric procedures.

The observed specific heats of potassium are presented in Table 1. These higher temperature results were obtained using a thick walled container which was required to withstand the pressure of the potassium vapor. This resulted in an unfavorable sample-to-container heat content ratio of 1 to 17. Measurements at lower temperatures are now in progress using a thin walled container with a more favorable heat-content ratio. All specific heat results will be analyzed and compared with existing measurements at the conclusion of the lower temperature work.

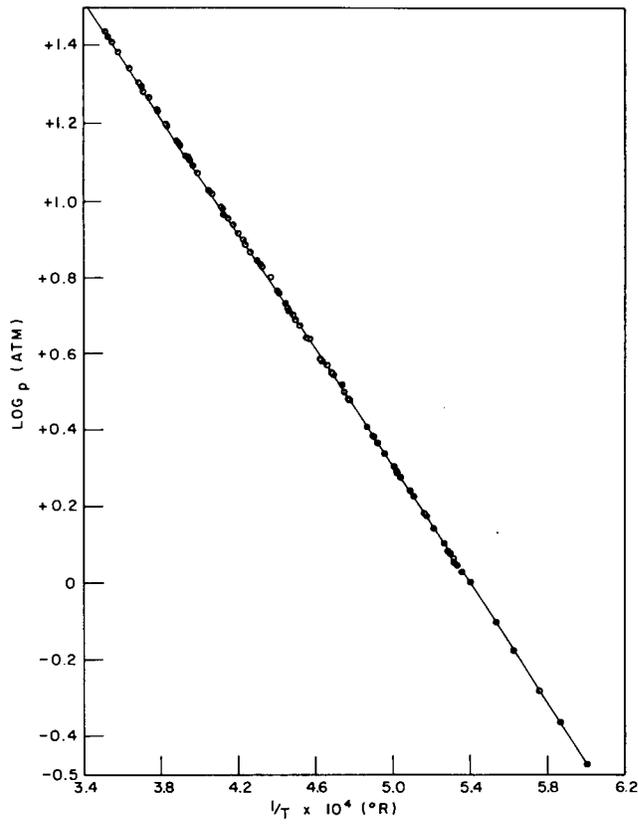


Fig. 1 - Vapor pressure of potassium

Table 1
Specific Heat of Potassium

Temperature (°F)	Specific Heat (BTU/lb-°F)
1412.64	0.188
1677.49	0.189
1933.34	0.204

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