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Effect of Pressure and Thermal Expansion on Diverse Substance Properties

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Abstract: *The relationship between pressure, thermal expansion, and certain properties of substances can be elucidated through a derived equation that incorporates variables T, α, β, and γ, utilizing the Maxwell Thermodynamic relation which is a fundamental principle in thermodynamics. These variables play a crucial role in understanding the behaviour of substances under different conditions. This equation allows us to quantitatively analyse and predict the behaviour of substances under different temperature and pressure conditions, providing valuable insights into their physical properties and behaviour*.

Keywords: Thermal expansion, Equation of state, Thermodynamic properties, Maxwell relations, statistical mechanics

I. INTRODUCTION

Variation of properties of substances with pressure and thermal expansion are great concern in pharmaceutical industry. Gases at ordinary temperature expand more rapidly than liquids and solids.

For liquids, the coefficient of volume expansion is relatively independent on temperature. However, for the gases, it is dependent on temperature. Generally, linear, area and volume expansions are there in substances due to thermal radiation. For linear(l), area(A) and volume(V) expansion are

$$(\Delta l)/ l = \alpha . \Delta T$$
$$(\Delta A)/ A = \beta . \Delta T$$
$$(\Delta V)/ V = \gamma . \Delta T$$

Where α, β and γ are the coefficients of linear, area and volume expansion respectively. These are in the ratio 1: 2:3.

Copper expansion coefficient is five times that of glass. i.e. why medicinal bottles are used of glass. One is more interested in volume expansion coefficient rather than linear and area expansion coefficient γ for Aluminium $7x10^{-5}K^{-1}$, Brass 6 x $10^{-5}K^{-1}$, Iron 3.55 x $10^{-5}K^{-1}$, Glass 2.5 x$10^{-5}K^{-1}$.

Thermal conductivity K for copper 385, insulating bricks 0.15 glass 0.8 wood, 0.12 air, 024 in units of $JS^{-1}m^{-1}K^{-1}$

The substance which expands on heating, melting points is raised and substance which contract on heating, melting point is lowered by increase of pressure as in the case of wax.

Melting of ice decreases with increase in pressure hence the ice melts at the temperature lower than 0° C at a pressure higher than normal temperature pressure.Ice will melt at 0° C only at a pressure of 76 cm of mercury.

With increase in pressure, the boiling point of liquid increases and vice-versa. The liquid will boil at a lower temperature under reduced pressure. Water boils at a 100° C only at 76 cm of mercury.In laboratory, pressure is less than atmospheric pressure so water boils at lower than 100° C.

From Maxwell fourth thermodynamic relation

$$(\partial S / \partial P)T = - (\partial V / \partial T)P$$

OR

$$(T\partial S / \partial P)T = - T (\partial V / \partial T)P$$
$$(\partial Q/ \partial P)T = - T (\partial V / \partial T)P \quad - (I)$$

Where,

$\partial Q=T. \partial S$ and ∂S is the change in entropy.

(1 / V) $(\partial V / \partial T)P$ represent the increased in volume per unit rise in temperature at constant temperature , but this is γ coefficient of volume expansion.

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So,

$$(1 / V) (\partial V / \partial T)_P = \gamma$$

Or

$$(\partial V / \partial T)_P = V . \gamma \qquad - (II)$$

From (I) and (II)

$$(\partial Q / \partial P)_T = - T.V. \gamma \qquad - (III)$$

From equation (III), it is clear that if γ the coefficient of volume expansion is positive i.e. substances expand on heating, then
$(\partial Q / \partial P)_T$ is negative means heat should be withdrawn from the substance in order to keep the temperature constant. Increase in pressure heats a body that expands on heating.
If γ the coefficient of the volume expansion is negative i.e. substance contracts on heating then $(\partial Q / \partial P)_T$ is positive means there is cooling so heat must be added to keep the temperature constant, when the pressure is increased.
In case of linear and area expansion according to need and utilization equation (III) becomes

$$(\partial Q / \partial P)_T = - T. l. \alpha$$

And

$$(\partial Q / \partial P)_T = - T. A. \beta$$

But, in practical purposes, coefficient of volume expansion γ is more relevant than α and β.

II. CONCLUSION

Pressure and thermal expansion have a significant impact on the characteristics of substances. Changes in pressure can alter properties such as density, viscosity, and compressibility. Thermal expansion, on the other hand, affects dimensions and volume. Understanding these effects helps us comprehend how substances behave under different conditions and enables us to predict their behaviour accurately. By studying the deduced equation involving temperature, thermal expansion coefficient, pressure coefficient, and compressibility coefficient, we can quantitatively analyse and describe these effects in a precise manner.

REFERENCES

[1]. BrijLal, Dr. N.Subramaniam. P.S. Henne, S. Chand Prakashan Heat Thermodynamics and statistic Physics by– Chapter 6.
[2]. Ekta Khare, Dr.Devendra Kishore, "Threshold size and Tablet and Capsule: Prospective study", International Journal of Advance Research in Science, Communication and Technology (IJARSCT) 2024;4(1):68-69.
[3]. Ekta Khare, Dr.Devendra Kishore, "Exploring the Science behind the Color Selection of Tablets and Drugs:A Spectrum-Based Analysis", International Journal of Research Publication and Reviews (IJRPR) 2024;5(3):7215-7217.
[4]. Swarnim Srivastava, Ekta Khare, "Biosensors Based Medical Devices for Disease Monitoring Therapy", International Journal of Advance Research in Science, Communication and Technology (IJARSCT) 2021; 4(2):263-278.