PREDICTION OF ENTROPY OF VAPORIZATION CF INORGANIC GASES

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ABSTRACT

Generalized correlations have been developed to predict entropy of vaporization for inorganic gases based respectively on (i) molacular volume at boiling point, (ii) normal boiling point (iii) molecular weight.

1. INTRODUCTION

ARGON is non-polar, non-reactive and devoid of any quantum mechanical effect and hence it is ideally suited to be used as a reference substance for prediction of thermodynamic properties of organic and inorganic compounds. It has been shown earlier¹ that the entropy of vaporization of hydrocurbons at various reduced temperatures can be predicted accurately using ARGON as a reference substance. A similar procedure is being extended, in this work, for inorganic gases. Both non polar and highly polar gases are considered and correlations are given for both these types of gases.

Entropy of vaporization of argon (ΔS_A) and various inorganic Gases (ΔS_S) from the literature²⁻⁹ were plotted against temperatures, from which the smoothed values of $\Delta S_A \Delta S_S$ at the required reduced temperatures were obtained. The reduced temperatures for the gases considered generally varied between 1.0 and 0.60. When these values of entropy of vaporization of Argon were plotted against the entropy of vaporization of one inorganic gas at various reduced temperatures a good linear relationship was obtained. Similar good linear relationships were observed for all the 12 inorganic gases considered in this work. All these lines pass through the origion, but the slopes were found to vary with the chemical species.

To arrive at a generalised equation to predict ΔS_s for all gases and for all temperature ranges, attempts were made to correlate these slopes with some easily assessible physical properties of these substances. Following the successful correlation⁽¹⁾ obtained for the case of hydrocarbors, attempts were made to correlate slopes with either molecular weights or the normal boiling points. But both of them failed to show any general pattern with which one could base the generalised equation to predict ΔS_s . However when these values of slopes were plotted against the molecular volume at its boiling point of these substances on semi-logarithmic coordinates they showed a definite pattern. All the diatomic gases fell in a good straight line and all the polyatomic gases fell in a different straight line. Considering the degrees of freedom for mono, di, and polyatomic gases to be 3, 5 and 6 respectively and the mean energy of a molecule is proportional to $(\frac{1}{2}f)$, where f is the degree of freedom, a correction was available for the slopes. These values were divided by $(\frac{1}{2}f=k)$ and plotted against the molecular volumes when a good linear relationship was obtained for both diatomic and polyatomic gases. A generalised equation to predict the entropy of vaporization of inorganic gases at various temperatures was obtained, which is

$$\Delta S_{S} = K \left[(0.1716 \log V_{b} + 0.1651) \Delta S_{A} \right]$$
[1]

where K = 2.5 for diatomic gases and 3.0 for polyatomic gases.

Equation 1 was tested for all the 12 gases considered in this work. Table 1 gives the physical properties of these substances. Literature values of $\Delta S_A^{(2)}$ and $\Delta S_S^{(2-9)}$ and the calculated values of ΔS_S by using equation 1 for different reduced temperatures and the percentage errors are given in Table 2. Equation 1 does not give a good fit for highly polar gases like NH_3 , H_2S , H_20 and N_2H_4 . The entropy of vaporization at different temperatures can be predicted within an over all average error of 2.7% for non-polar gases, by using equation 1. In no case, for these non-polar gases, the average error exceeds 5.4%.

The boiling point correlation, although failing to predict for the non-polar gases, gave accurate prediction for the highly polar gases. The respective equations for normal boiling point correlation and molecular weight correlation from reference (1), are

$$\Delta S_4 = [1.069 - 1.029 \times 10^{-3} T_b] \Delta S_s$$
[2]

and

$$\Delta S_A = [0.926 - 2.326 \times 10^{-3} M] \Delta S_S$$
[3]

Equation [2] predicts the entropy of vaporization of highly polar gases, (Table 2) within an over-all average error of 3.1%. Equation 3 is not recommended for both polar and non polar inorganic gases.

Equation 1 is recommended for non-polar gases and Equation 2 is recommended for polar gases, to predict the entropy of vaporization of inorganic gases at different temperatures, within an average error of 3.0%.

| | Compounds | | Molecular Volume at Boiling Point | Normal Boiling Point | Molecular weight |
|-----|------------------|---|---|-------------------------|---------------------|
| | | | (V _b) | (T_b) | (<i>M</i>) |
| 1. | Nitrogen | , | 31.2 | 77.35 | 28.02 |
| 2. | Otygen | | 25.6 | 90.16 | 32.00 |
| 3. | Carbon monoxide | | 30.7 | 81 66 | 28 01 |
| 4. | Chlorine | | 45.5 | 238 6 | 70. 91 |
| 5, | Carbon dioxide | | 34.0 | 194.71 | 44.01 |
| 6. | Sulfur dioxide | | 44 8 | 263 16 | 64 07 |
| 7. | Nitrous oxide | | 36.4 | 183.66 | 44.02 |
| 8. | Phosgene | | 69.5 | 280.72 | 98.92 |
| 9, | Ammonia | | 25.8 | 239.81 | 17 03 |
| 10. | Hydrogen sulfide | | 32 9 | 213.56 | 34.08 |
| 11. | Water | | 18.9 | 373,16 | 18.02 |
| 12. | Hydrazine | | 46.0 | 386.66 | 32.05 |

TABLE I Properties of the Compounds

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| a gy rain dh' an | Tr. | ^ ^ S_A (Ref. 2) | ∆Ss Lrt. | ^ SS Cal. (Eq. I) | %Div. | ^ SS Cal. (Eq. 2) | %Div. | ^SS Cat. (Eq. 3) | %Div |
|--|------|---------------------|-------------|-------------------------|-------|-------------------------|-------------|------------------------|-------|
| Nitrogen (Ref 2) | 0 96 | 4 46 | 4.88 | 4 70 | 1.5 | 4 51 | 7.6 | 5 18 | 61 |
| | 160 | 5.23 | 592 | 5 51 | 6.9 | 5.29 | 9.01 | 6.08 | 2.7 |
| | 0 92 | 5 97 | 6.80 | 6 29 | 7.5 | 6 03 | 11.3 | 6.94 | 2,0 |
| | 0 88 | 7.41 | 8 27 | 7.81 | 56 | 7 49 | 9.4 | 8.61 | 41 |
| | U 84 | 8 74 | 9 67 | 9.19 | 50 | 883 | 8.7 | 1015 | 5.0 |
| | 080 | 10 02 | 10 95 | 10 56 | 3.6 | 10.13 | 7.5 | 11 64 | 63 |
| | 0 76 | 11.33 | 12.23 | 11.94 | 2.4 | 11.45 | 64 | 13.16 | 7.6 |
| | 0 72 | 12 63 | 13.44 | 13 31 | 1.0 | 12 77 | 5.0 | 14.67 | 9.1 |
| | 0 68 | 14 00 | 14.27 | 14.75 | 3.4 | 14.15 | 0.8 | 16.26 | 13.9 |
| | | | | Average | 4.3 | Average | 7.5 | Average | 6.3 |
| Oxygen (Ref. 3) | 96 0 | 4 46 | 4 78 | 4 54 | 5.0 | 4.57 | 4.4 | 5 24 | 9.6 |
| | 0.94 | 5.23 | 571 | 5.32 | 6.8 | 5.36 | 6.1 | 6 14 | 7.5 |
| | 0.92 | 5.97 | 6.46 | 6.07 | 6.0 | 6.12 | 53 | 7.01 | 85 |
| | 0.88 | 7.41 | 7 70 | 7.53 | 2.2 | 7.59 | 14 | 8.70 | 130 |
| | 0.84 | 8 74 | 9 04 | 8.89 | 1.6 | 8.95 | 01 | 10.26 | 13.4 |
| | 0.80 | 10 02 | 10.17 | 1019 | 0.2 | 10 26 | 0.9 | 11.77 | 15.7 |
| | 0 76 | 11.33 | 11.86 | 11.52 | 2.9 | 11.61 | 2.1 | 13.30 | 12.1 |
| | 0.72 | 12.63 | 12.81 | 12.84 | 0.2 | 12 94 | 1.0 | 14 83 | 158 |
| | 0.68 | 14.00 | 14.13 | 14.24 | 0.8 | 14.34 | 1.5 | 16.44 | 16.3 |
| | 0 64 | 15.42 | 15.63 | 15 68 | 0.3 | 15.80 | 9944 400 | 18.11 | 15.9 |
| | | | | Å VÅTG GA | 36 | Averose | u e | A verone | 9 6 1 |

Prediction of Entropy of Vaporization of Inorganic Gases

| | | | TABI | TABLE 2-(contd.) | (') | | | | |
|-------------------|------|-----------------|-------------|------------------------|-------|-----------------------|-------|------------------------|-------|
| | Tr. | °SA (Ref. 2) | A.Ss Lit | ≜Ss Cal. (Eq.]) | %Div. | ۵55 Cal (Eq. 2) | %Div. | ^SS Cal. (Eq. 3) | SDIV. |
| Carbon monoxide | 0.96 | 4.46 | 4.53 | 4.69 | 3.5 | 4,53 | 0.0 | 5.18 | 6.41 |
| (Ref. 2) | 0.94 | 5.23 | 5.67 | 5.50 | 30 | 5.31 | 6.3 | 6.08 | 7.2 |
| | 0.92 | 5 97 | 6 63 | 6.27 | 54 | 6.06 | 8.6 | 6.94 | 4.7 |
| | 0.88 | 7.41 | \$ 07 | 7.79 | 3.5 | 7.52 | 68 | 8 01 | 63 |
| | 0.84 | 8.74 | 9.24 | 9.18 | 06 | 887 | 40 | 10.15 | 9.8 |
| | 0.80 | 10 02 | 10 44 | 10 53 | 60 | 10.17 | 2.6 | 11 64 | 115 |
| | 0.76 | 11.33 | 11.82 | 11 90 | 0.7 | 11 50 | 2.7 | 13.16 | 11 3 |
| | 0.72 | 12 63 | 13.24 | 13.27 | 0.2 | 12.82 | 3 2 | 14.67 | 10.8 |
| | 0,68 | 14 00 | 14.85 | 14.71 | 0.9 | 14,21 | 43 | 16.24 | 95 |
| | | | | Average | 2.1 | Average | 4.3 | Average | 9.5 |
| Chlorine (Ref. 4) | 0.96 | 4.46 | 5.05 | 5 01 | 0.8 | 5,41 | 7.1 | 5,86 | 16.8 |
| | 0.94 | 5.23 | 6.07 | 5.88 | 31 | 6.35 | 4.6 | 6.87 | 13.2 |
| | 0 92 | 5.97 | 6.96 | 6.71 | 3.6 | 7,25 | 4.2 | 7.84 | 12.6 |
| | 0.88 | 7.41 | 8.56 | 8 33 | 2.7 | 00 6 | 5.1 | 9.74 | 13.7 |
| | 084 | 8 74 | 966 | 982 | 1.4 | 10.61 | 6.5 | 11 48 | 15.3 |
| | 080 | 10.02 | 11.28 | 11.26 | 0.2 | 12.17 | 7.9 | 13.16 | 16.7 |
| | 0 76 | 11.33 | 12.63 | 12 74 | 60 | 13.76 | 8.9 | 14.89 | 17.9 |
| | 0.72 | 12.63 | 13.97 | 14 20 | 16 | 15.34 | 9.8 | 16.59 | 18.7 |
| | 0 68 | 14 00 | 15.44 | 15.74 | 1.9 | 17 00 | 10.1 | 18 39 | 1.61 |
| | 0.64 | 15.42 | 17.13 | 17.33 | 1.2 | 18 73 | 9.3 | 20 26 | 18.3 |
| | 0.60 | 16.98 | 19.06 | 19 09 | 0.1 | 20.62 | 8,2 | 22.31 | 17.0 |
| | | | Average | 1.6 | | Average | 7.4 | Average | 16.3 |
| | | | | | | | | | |

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| | Tr. | ^∆ <i>SA</i> (Ref 2) | ۵Ss Lit. | △ <i>SS</i> Cal. (Eq. 1) | %Div. | ^ <u>^ SS</u> Cal (Eq. 2) | %Div. | ^ SS Cal. (Eq_3) | °/₀Div. |
|-----------------|------|-------------------------|-------------|--------------------------------|------------|---------------------------------|------------|------------------------|---------------------|
| Carbon dioxide | 0,96 | 4.46 | 5.73 | 5 73 | 0.0 | 5 13 | ¥ U I | 5 47 | 4 |
| (Ref. 2) | 0 94 | 5.23 | 6.86 | 671 | 5.6 | 6 U3 | 200 | 4 4 7 7 7 4 | 5 C |
| | 0.92 | 5.97 | 7.88 | 7.66 | 10 | 6.87 | 4 0 | | 4 C |
| | 0.88 | 7.41 | 9.77 | 9.51 | 0 r 1 c | 0 2 3 | 14.0 | C7.1 | |
| | 0.84 | 8.74 | 11.46 | 11 22 | 10 | 20.01 | 2.4 | 2.00 | - r v - r |
| | 080 | 10.02 | 13 07 | 12.86 | 1.6 | 11 54 | 1 1 1 | 10.01 | 4. |
| | 0 76 | 11.33 | 14.72 | 14 54 | | | 11./ | 11.21 | 5.0 |
| | 0.72 | 12.63 | 16.51 | 16.21 | 7 7 | 1.0.0 | | 0/ 01 | 0 I |
| | 0.68 | 14.00 | 01 01 | | ~ • | 14.04 | 11.9 | 15.33 | 7.1 |
| | 0010 | 00.41 | 10.40 | 1611 | 2.3 | 16.12 | 12.4 | 17 00 | 7.6 |
| | | | | Average | 1.8 | Average | 12.0 | Average | 7.1 |
| Sulphur dioxide | 0 96 | 4,46 | 5.74 | 6.00 | 4 5 | 5 50 | ч С | 20.2 | |
| (Ref. 5) | 0,94 | 5.23 | 7.02 | 7.04 | 0.3 | 6.55 | | 100 | 2 .2 |
| | 0.92 | 5.97 | 8 13 | 8.03 | 61 | 0 × C | | 072 | 1 2" 0 |
| | 0.88 | 7.41 | 10.05 | 0 07 | 0 | 04.7 |) () (| 00 / | 0.0 |
| | 0.84 | 8.74 | 11 78 | 11 76 | | 07 6 | | 70 A | 5 .1 |
| | 0.80 | 10.02 | 13 50 | 11 49 | | 10,95 22 51 | 0.1 | 62.11 | 4.9 |
| | 0.76 | | > · · · · | 101-10 | 1.0 | 12.35 | 10 | 12.90 | 4.4 |
| | 0/.0 | 11.33 | 15.20 | 15.24 | 0.1 | 14.19 | 7.0 | 14.58 | 4.4 |
| | 77.0 | 12.65 | 17.06 | 16.99 | 0.4 | 15 82 | 5.7 | 16.26 | 47 |
| | 0.68 | 14.00 | 18.98 | 1884 | 0.7 | 17.54 | 7.6 | 18.02 | 5 0 |
| | 0.64 | 15.42 | 21.05 | 20.75 | 1.4 | 19.32 | 8,2 | 19.85 | 57 |
| | | | | Average | 1.0 | Average | 6.9 | Average | 6 , 3 |
| | | | | | | | | | |

Prediction of Entropy of Vaporization of Inorganic Gases

| ^{a,SS} ^{b,VV}, ^{b,SS} ^{b,SS} ^{b,SS} ^{b,SS} ^{b,SS} ^{b,SS} ^{c,SS} < | | | | TAB | TABLE 2-(contd) | (<i>p</i>) | | | | |
|--|-------|------|-----------------|--------------|------------------------|--------------|-----------------------|-------|-----------------------|--------------|
| cide 0 96 4.46 6.06 5.80 4.3 5.07 16.3 5.41 1 0.92 5.23 7.08 5.79 4.1 5.07 16.3 5.41 5.35 1 6.15 5.41 5.35 1 6.15 5.41 5.35 1 6.15 5.41 5.35 1 5.35 1 5.35 1 5.35 1 5.35 1 5.35 1 5.35 1 5.35 1 5.35 1 5.35 1 5.35 1 5.35 1 5.35 1 5.35 1 5.35 1 5.35 1 5.35 1 5.35 1 | | Tr. | ^5A (Ref. 2) | ^ SS Lit. | ^SS Cal. (Eq. 1) | %Div. | Cal Cal (Eq. 2) | %Div. | ASS Cal (Eq. 3) | le Div. |
| 0 0.94 5.23 7.08 6.79 4.1 5.94 16.1 6.35 1 0.92 5.97 7.96 7.75 2.6 6.78 14.8 7.25 0.88 7.41 9.63 11.39 10.7 12.66 10.07 12.16 10.17 0.80 10.02 12.76 13.02 2.0 11.39 10.7 12.16 10.17 0.76 11.33 14.36 14.71 2.4 12.87 10.4 13.76 0.76 11.33 14.36 14.71 2.4 12.87 10.4 13.76 0.76 11.33 16.03 16.03 16.03 2.5 15.91 103 17.00 0.76 15.32 20.03 2.5 19.50 9.5 10.4 13.76 0.76 15.43 12.55 19.20 9.5 10.2 13.70 0.76 15.43 15.52 20.01 2.7 19.26 2.64 7.7 | oxide | 96 0 | 4.46 | 6.06 | 5.80 | 4.3 | 5.07 | 16.3 | 5 41 | 10.7 |
| $ \begin{array}{cccccccccccccccccccccccccccccccccccc$ | و) | 0 94 | 5.23 | 7.08 | 6.79 | 4.1 | 5.94 | 16.1 | 6.35 | 10.3 |
| $\begin{array}{cccccccccccccccccccccccccccccccccccc$ | | 0.92 | 5.97 | 7.96 | 7.75 | 2.6 | 678 | 14.8 | 7.25 | 80 |
| $\begin{array}{cccccccccccccccccccccccccccccccccccc$ | | 0.88 | 7.41 | 9.63 | 9.62 | 0.0 | 8.42 | 12 6 | 9.00 | - 49 - 52 |
| $\begin{array}{c ccccccccccccccccccccccccccccccccccc$ | | 0.84 | 874 | 11.21 | 11.35 | 1.2 | 9.93 | 114 | 10.61 | |
| 0.76 11.33 14.36 14.71 2.4 12.87 10.4 13.76 0.72 12.63 16.03 16.03 16.40 2.3 14.35 10.5 15.31 0.68 14.40 17.74 18.18 2.5 15.91 10.3 17.00 0.61 15.42 19.30 2.5 19.30 9.5 206.2 0.66 15.45 21.33 22.06 3.4 19.30 9.5 206.2 0.66 15.46 51.3 22.06 3.4 19.30 9.5 206.2 0.66 16.98 21.33 22.06 3.4 19.30 9.5 206.2 0.66 16.98 21.33 22.06 3.4 7.7 5.72 4.3 6.41 0.94 5.23 7.32 7.55 3.1 6.70 8.3 7.51 0.92 5.97 8.62 1.07 0.6 9.50 10.7 10.55 0.92 5.97 18.73 18.73 12.65 5.5 16.36 0.88 7.41 10.64 10.70 0.6 9.5 10.7 0.88 7.41 10.64 10.70 0.6 9.2 10.7 <td></td> <td>0.80</td> <td>10.02</td> <td>12.76</td> <td>13.02</td> <td>2.0</td> <td>11.39</td> <td>10.7</td> <td>12.16</td> <td>4 7</td> | | 0.80 | 10.02 | 12.76 | 13.02 | 2.0 | 11.39 | 10.7 | 12.16 | 4 7 |
| $ \begin{array}{c ccccccccccccccccccccccccccccccccccc$ | | 0.76 | 11.33 | 14.36 | 14.71 | 2.4 | 12.87 | 10.4 | 13.76 | 4.7 |
| 0.68 14.00 17.74 18.18 2.5 15.91 10.3 17.00 0.64 15.42 19.52 20.03 2.6 17.52 10.2 18.72 0.60 16.98 21.33 22.06 3.4 19.30 9.5 20.63 0.64 15.42 19.52 20.03 2.5 Average 12.1 Average 0.64 15.42 19.52 20.03 2.5 Average 12.1 Average 0.94 5.23 7.32 7.55 3.1 6.70 8.5 7.51 0.94 5.23 7.32 7.55 3.1 6.70 8.5 7.51 0.94 5.23 7.32 7.55 3.1 6.70 8.5 7.51 0.94 5.23 7.55 10.7 8.5 7.51 9.5 0.92 5.97 8.53 8.62 1.0 7.65 10.3 8.58 0.84 8.74 12.33 12.62 2.3 12.56 10.3 10.55 0.88 7.41 10.64 16.19 4.0 10.55 10.5 10.55 0.88 7.41 10.65 5.2 12.84 6.6 14.40 </td <td></td> <td>0 72</td> <td>12.63</td> <td>16.03</td> <td>16 40</td> <td>2.3</td> <td>14.35</td> <td>10.5</td> <td>15.33</td> <td>1</td> | | 0 72 | 12.63 | 16.03 | 16 40 | 2.3 | 14.35 | 10.5 | 15.33 | 1 |
| 0.64 15.42 19.52 20.01 2.6 17.52 10.2 18.72 0.60 16.98 21.33 22.06 3.4 19.30 9.5 20.62 Average 2.5 Average 12.1 Average 2.5 Average 12.1 Average 2.6 0.96 4.46 5.98 6.44 7.7 5.72 4.3 6.41 0.94 5.23 7.32 755 3.1 6.70 8.5 7.51 0.94 5.23 7.32 755 3.1 6.70 8.5 7.51 0.92 5.97 8.53 3.62 1.0 7.65 10.3 8.58 0.94 5.23 12.60 1.0 7.65 10.3 8.58 7.51 0.92 5.97 8.53 10.70 0.6 9.50 10.77 10.55 0.88 7.41 10.76 10.70 0.6 9.50 10.71 10.55 0.88 7.41 10.77 12.31 12.66 14.40 10.55 16.28 16.28 0.76 11.33 </td <td></td> <td>0.68</td> <td>14.00</td> <td>17.74</td> <td>18.18</td> <td>2.5</td> <td>15.91</td> <td>10.3</td> <td>17.00</td> <td>4 2</td> | | 0.68 | 14.00 | 17.74 | 18.18 | 2.5 | 15.91 | 10.3 | 17.00 | 4 2 |
| 0 660 16.98 21.33 22.06 3.4 19.30 9.5 20.62 Average 2.5 Average 2.5 Average 12.1 Average 0 96 4.46 5 98 6.44 7.7 5.72 4.3 6.41 0 94 5.23 7.32 7.55 3.1 6.70 8.5 7.51 0 94 5.23 7.32 7.55 3.1 6.70 8.5 7.51 0 94 5.23 7.32 7.55 3.1 6.70 8.5 7.51 0 94 5.23 7.32 7.55 3.1 6.70 8.5 7.51 0.92 5 97 8.53 8.62 1.07 0.6 9.50 10.7 10.54 0.88 7.41 10.64 12.65 2.3 12.20 9.7 10.54 0.80 10.02 13.75 14.46 5.2 12.84 6.6 14.95 0.76 11.33 15.36 16.35 6.4 14.52 5.5 16.28 0.76 11.33 15.36 16.37 8.1 16.19 4.0 18.15 0.76 11.33 15.36 16.37 9.6 17.94 | | 0.64 | 15.42 | 19.52 | 20.03 | 2.6 | 17.52 | 10.2 | 18.72 | 4 |
| Average 2.5 Average 12.1 Average 096 4.46 5.98 6.44 7.7 5.72 4.3 6.41 094 5.23 7.32 755 3.1 6.70 8.5 7.51 094 5.23 7.32 8.53 3.1 6.70 8.5 7.51 092 5.97 8.53 8.62 1.0 7.65 103 858 0.88 7.41 10.64 10.70 0.6 9.50 10.7 10.55 0.88 7.41 10.64 10.70 0.6 9.50 10.7 10.55 0.84 8.74 12.33 12.62 2.3 12.84 6.6 14.40 0.76 11.33 15.36 16.35 6.4 14.52 5.5 16.28 0.76 11.33 15.36 16.37 9.6 17.94 2.0 20 20 0.78 13.75 18.73 8.1 16.19 4.0 1815 0.76 11.33 15.36 10.3 20.71 20.12 0.64 15.47 20.17 22.26 10.4 9.76 20 0.64 15.47 20.17 22.26 </td <td></td> <td>0 60</td> <td>16.98</td> <td>21.33</td> <td>22.06</td> <td>3.4</td> <td>19.30</td> <td>9.5</td> <td>20 62</td> <td>3.3</td> | | 0 60 | 16.98 | 21.33 | 22.06 | 3.4 | 19.30 | 9.5 | 20 62 | 3.3 |
| 096 4.46 598 6.44 7.7 5.72 4.3 6.41 094 5.23 7.32 755 3.1 6.70 8.5 7.51 094 5.23 7.32 755 3.1 6.70 8.5 7.51 0.92 5.97 8.53 8.62 1.0 7.65 10.3 8.58 0.88 7.41 10.64 1070 0.6 9.50 107 10.55 0.88 7.41 10.64 1070 0.6 9.50 107 10.55 0.84 8.74 12.33 12.62 2.3 12.20 9.2 12.56 0.80 10.02 13.75 14.46 5.2 12.84 6.6 14.40 0.76 11.33 15.36 16.35 6.4 14.52 5.5 16.28 0.76 11.33 15.36 16.37 8.41 16.19 4.0 18.15 0.78 12.63 16.37 8.71 16.19 4.0 18.15 0.71 12.41 20.21 9.6 17794 2.7 20.12 0.64 15.42 20.17 22.256 10.4 19.76 2.0 2.0 | | | | | Average | 2.5 | Average | 12.1 | Average | 6.1 |
| 094 5.23 7.32 7.55 3.1 6.70 8.5 7.51 0.92 5.97 8.53 8.62 1.0 7.65 103 8.58 0.92 5.97 8.53 8.62 1.0 7.65 103 8.58 0.88 7.41 10.64 10.70 0.6 9.50 107 10.55 0.84 8.74 12.33 12.65 2.3 12.20 9.2 12.56 0.80 10.02 13.75 14.45 5.2 11.34 6.6 9.60 10.55 0.76 11.33 15.36 16.35 6.4 14.52 5.5 16.28 0.76 11.33 15.36 16.35 6.4 14.52 5.5 16.28 0.76 11.33 15.54 18.73 8.4 16.19 4.0 18.15 0.76 11.34 20.21 20.221 9.6 17.94 27.7 20.12 0.64 15.42 20.17 22.26 10.4 19.76 2.0 22.16 0.64 15.42 20.17 22.26 10.4 19.76 2.0 22.16 | | 0 96 | 4.46 | 5 98 | 6.44 | 7.7 | 5.72 | 4.3 | 6 41 | ۲ ک ا |
| 5 97 8.53 8.62 1.0 7.65 103 8.58 7.41 10.64 1070 0.6 9.50 107 10.55 8.74 12.33 12.62 2.3 12.20 9.2 12.56 10.02 13.75 14.46 5.2 12.84 6.6 14.40 11.33 15 36 16.35 6.4 14.52 5.5 16.28 11.33 15 36 16.35 6.4 14.52 5.5 16.28 12.63 16.57 18.73 8.1 16.19 4.0 18.15 14.00 18.44 20.21 9.6 17.94 2.7 20.12 15.42 20.17 22.26 10.4 19.76 2.0 22.16 15.42 20.17 22.26 10.4 19.76 2.0 22.16 | () | 0 94 | 5.23 | 7.32 | 7 55 | 3.1 | 6.70 | 8.5 | 7.51 | a . c |
| 7.41 10.64 10.70 0.6 9.50 10.7 10.55 8.74 12.33 12.62 2.3 12.20 9.2 12.56 10.02 13.75 14.45 5.2 12.84 6.6 14.40 11.33 15.36 16.35 6.4 14.52 5.5 16.28 11.33 15.36 16.35 6.4 14.52 5.5 16.28 12.63 16.57 18.73 8.1 16.19 4.0 18.15 14.00 18.44 20.21 9.6 17.94 2.7 20.12 15.42 20.17 22.26 10.4 19.76 2.0 22.16 15.42 20.17 22.26 10.4 19.76 2.0 22.16 | | 0.92 | 597 | 8.53 | 8.62 | 1.0 | 7 65 | 10.3 | 8.58 | 90 |
| 8.74 12.33 12.62 2.3 12.20 9.2 12.56 10.02 13.75 14.46 5.2 12.84 6.6 14.40 11.33 15.36 16.35 6.4 14.52 5.5 16.28 12.63 16.87 18.73 8.4 14.52 5.5 16.28 12.64 20.21 9.6 17.94 2.7 20.12 15.42 20.17 22.26 10.4 19.76 2.0 22.16 Average 5.4 Average 6.4 Average | | 0.88 | 7.41 | 10.64 | 10 7U | 06 | 056 | 107 | 10.55 | 0.0 |
| 10.02 13.75 14.46 5.2 12.84 6.6 14.40 11.33 15.36 16.35 6.4 14.52 5.5 16.28 12.63 16.57 18.73 8.4 14.52 5.5 16.28 14.00 18.44 20.21 9.6 17.94 2.7 2012 15.42 20.17 22.26 10.4 19.76 2.0 22.16 Average 5.4 Average 6.4 Average | | 0.84 | 8.74 | 12 33 | 12.62 | 2.3 | 12 20 | 9.2 | 12.56 | 6.1 |
| 11.33 15 36 16 35 64 14 52 5.5 16.28 12.63 16.87 18.73 8.1 16.19 4.0 18.15 14.00 18.44 20.21 96 17 94 2.7 20.12 15.42 20.17 22.26 10.4 19.76 2.0 22.16 Average 5.4 Average 6.4 Average | | 0.80 | 10.02 | 13.75 | 14.46 | 5.2 | 12.84 | 6.6 | 14.40 | 4.7 |
| 12.63 16.87 18.73 8.1 16.19 4.0 18.15 14.00 18.44 20.21 9.6 17.94 2.7 20.12 15.42 20.17 22.26 10.4 19.76 2.0 22.16 Average 5.4 Average 6.4 Average | | 0.76 | 11.33 | 15 36 | 16 35 | 64 | 14 52 | 5.5 | 16.28 | 60 |
| 14 00 18.44 20.21 9 6 17 94 2.7 20 12 15 42 20.17 22.26 10.4 19.76 2.0 22.16 Average 5.4 Average 6.4 Average | | 0 72 | 12.63 | 16.87 | 18,73 | 8.1 | 16.19 | 4.0 | 18 15 | 16 |
| 15.42 20.17 22.26 10.4 19.76 2.0 22.16 Average 5.4 Average 6.4 Average | | 0 68 | 14 00 | 18.44 | 20.21 | 96 | 17 94 | 2.7 | 2012 | 1.6 |
| 5.4 Average 6.4 Average | | 0.64 | 15 42 | 20.17 | 22.26 | 10.4 | 19.76 | 20 | 22.16 | 9.9 |
| | | | | | Average | 5.4 | Average | 6.4 | Average | 5.0 |

T. R. DAS, S. H. IBRAHIM AND N. R. KULOOR

| Tr. $\binom{6.5}{(Re1, 2)}$ $\binom{6.5}{Lit}$ $\binom{6.5}{Cal}$ $\binom{6.5}{Cal}$ $\binom{6.5}{Cal}$ $\binom{6.5}{Cal}$ $\binom{6.5}{Cal}$ $\binom{6.6}{Cal}$ | | the second s | | | (| | | | | |
|--|------------------|--|--------------------------------|------------|-------------------------|---------|-------------------------|---------|------------------------|----------|
| 0.96 446 5.44 5.45 0.2 5.42 0.4 5.03 0.94 5.23 6.69 6.39 4.5 5.90 5.70 5.79 5.74 11.30 11.46 10.68 6.8 10.63 7.2 9.86 11.33 11.45 5.72 6.75 $5.14.25$ $11.2.79$ $11.2.5$ | | Tr. | ^ 5 S _A (Ref. 2) | د. Lit. | ^ 55 Cal. (Eq. 1) | % Div. | ^.SS Cal. (Eq. 2) | %Div. | ^SS Cal. (Eq. 3) | °/, Div. |
| $\begin{array}{cccccccccccccccccccccccccccccccccccc$ | Ammonia (Ref. 2) | 0.96 | 4 46 | 5.44 | 5.45 | 0.2 | 5 42 | 40 | 5.03 | 4 6 |
| 092 597 7.78 7.30 6.5 7.46 6.77 6.74 11 0.88 7.41 9.68 9.05 6.5 9.01 6.9 8.36 11.30 0.84 8.74 11.46 10.68 6.6 13.12 12.19 7.1 11.30 0.86 10.02 13.12 13.85 6.6 13.78 7.1 12.78 11.30 0.76 11.33 14.83 13.85 6.6 13.78 7.1 12.78 14.25 0.71 12.60 15.42 17.01 13.67 7.5 14.25 13.78 0.72 12.60 15.41 7.5 13.78 7.1 12.78 14.20 0.76 14.00 18.50 17.11 7.5 13.70 15.49 15.79 0.64 15.42 20.53 18.84 8.2 18.75 8.7 17.40 1 0.64 15.42 20.53 18.84 8.2 18.75 8.7 17.40 1 1 0.64 4.46 5.05 | | +6.0 | 5.23 | 6,69 | 6.39 | 4 5 | 636 | 4 0 | 20.2 | ., i |
| 0.88 7.41 9.68 9.05 6.5 901 6.9 8.36 10.8 7.41 9.68 9.05 6.8 10.63 7.2 9.86 10.8 0.80 10.02 13.12 12.38 6.6 13.78 7.1 12.78 11.30 17.6 11.30 17.6 11.30 17.6 11.30 17.6 11.30 17.6 11.30 17.6 11.30 17.6 11.30 17.6 11.30 17.6 11.30 17.6 11.2.78 11.0 18.5 11.1 7.5 117.01 7 7 9 15.79 15.79 0.64 15.42 20.53 18.84 82 18.75 8.7 17.40 15.79 15.79 0.94 5.50 75.69 12.7 5.5 4.0 5.27 0.94 5.23 6.20 70.6 11.2 7.6 6.16 0.6 6.18 0.92 5.97 7.113 7.6 5.6 11.2 7.6 11.6 9 9 10.22 1.4 705 0.88 7.4 10.15 11.16 9 9 10.22 1.4 10.32 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.34 2.6 13.38 7.4 10.32 0.64 15.42 17.87 10.9 16.4 12.79 16.7 11.8 2.1 10.32 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 7.4 10.12 11.6 9 9 10.22 1.4 10.32 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 14.95 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 10.00 14.87 2.3 16.53 10.55 10.54 10.0 14.87 2.3 16.53 10.56 18.21 10.0 14.87 2.3 16.53 10.56 18.21 10.0 14.87 2.3 16.53 10.56 18.21 10.0 14.87 2.3 16.53 10.56 18.21 10.0 14.87 2.3 16.53 10.56 18.21 10.55 10.54 10.55 10. | | 0 92 | 5 97 | 7.78 | 7.30 | 6.2 | 7.26 | 6.7 | 5.74 | 13.2 |
| 0.84 8.74 11.46 10.68 6.8 10.63 7.2 9.86 10.8 0.80 1002 13.12 12.24 6.7 12.19 7.1 11.30 10.72 13.63 14.25 6.6 13.78 7.1 12.78 17.00 16.8 14.00 18.54 17.0 15.36 7.1 12.78 17.00 16.8 14.00 18.54 17.5 17.00 75 14.25 15.79 15.50 12.79 5.56 12.79 16.57 7.56 5.16 0.56 5.16 0.56 5.18 0.92 5.97 7.113 7.50 12.79 10.05 11.487 2.4 10.12 11.16 9.9 10.29 11.48 705 0.88 7.41 00.12 11.56 11.2 6.9 10.29 11.20 14.45 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 16.11 17.87 10.9 16.48 2.3 16.53 0.66 18.21 0.66 11.3 11.787 10.9 16.48 2.3 16.53 0.66 11.3 11.787 10.9 16.48 12.3 16.53 0.66 11.3 11.787 10.9 16.48 12.3 16.53 0.66 11.3 11.787 10.9 16.48 10.1 18.16 16 18.21 10.55 0.66 11.2 11.2 17.87 10.9 16.48 10.1 18.16 16 16.18 11.6 15.5 0.65 15.5 0.66 10.0 Avenage 1.9 Avenage 10.0 | | 0.88 | 7.41 | 9.68 | 9 05 | 6.5 | 10.6 | 69 | 8 36 | 13.6 |
| 0.80 10.02 13.12 12.24 6.7 12.19 7.1 11.30 1 0.75 11.33 14.83 13.85 6.6 13.78 7.1 12.78 1 0.72 12.63 16.60 15.43 7.0 15.36 7.5 14.25 1 0.72 15.63 15.61 15.43 7.0 15.36 7.1 12.78 1 0.64 15.42 20.53 18.84 8.2 18.70 7.9 15.79 1 0.64 15.42 20.53 18.84 8.2 18.76 7.9 15.79 1 0.64 15.42 20.53 18.84 8.2 18.75 8.7 17.40 1 0.64 15.42 20.53 18.84 8.2 18.75 8.7 17.40 1 0.96 4.46 5.05 5.69 12.7 5.25 4.0 5.27 0.94 5.23 6.20 16.67 7.6 6.16 0.6 6.18 0.93 7.41 10.15 11.16 92 8.77 10.35 0.88 7.41 10.15 11.16 92 1.4 705 0.83 <t< td=""><td></td><td>0.84</td><td>8.74</td><td>11.46</td><td>10.68</td><td>68</td><td>10.63</td><td>7.2</td><td>986</td><td>14.0</td></t<> | | 0.84 | 8.74 | 11.46 | 10.68 | 68 | 10.63 | 7.2 | 986 | 14.0 |
| 0.76 11.33 14.83 13.85 6.6 13.78 7.1 12.78 1 0.72 12.63 16.60 15.43 7.0 15 36 7.5 14.25 1 0.72 12.63 16.60 15.43 7.0 15 36 7.5 14.25 1 0.64 15.42 20.53 18.84 8.2 18.75 8.7 17.40 1 0.64 15.42 20.53 18.84 8.2 18.75 8.7 17.40 1 0.64 15.42 20.53 18.84 8.2 18.75 8.7 17.40 1 0.64 15.42 5.05 15.69 12.77 5.25 4.0 5.27 0.95 5.97 7.13 7.65 12.77 5.25 4.0 5.27 0.94 5.27 7.13 7.65 9.2 872 0.1 8.75 0.88 7.41 8.66 9.46 9.2 872 0.3 8.75 0.88 7.41 8.74 10.15 11.16 9.9 <td></td> <td>0.80</td> <td>1002</td> <td>13.12</td> <td>12.24</td> <td>67</td> <td>12,19</td> <td>7 1</td> <td>11.30</td> <td>011</td> | | 0.80 | 1002 | 13.12 | 12.24 | 67 | 12,19 | 7 1 | 11.30 | 011 |
| 0.72 12.63 16.60 15.43 7.0 15.36 7.5 14.25 1 0.64 15.42 18.50 1711 7.5 17.03 7.9 15.79 1 0.64 15.42 20.53 18.84 8.2 18.75 8.7 17.40 1 0.64 15.42 20.53 18.84 8.2 18.75 8.7 17.40 1 0.96 4.46 5.05 5.69 12.7 5.25 4.0 5.79 1 0.96 4.46 5.05 5.69 12.7 5.25 4.0 5.27 0.94 5.23 6.20 16.67 7.6 6.16 0.4 703 0.92 5.77 7.13 7.65 6.9 7.03 1.4 703 0.88 7.41 8.66 9.46 9.2 873 1.4 703 0.88 7.41 8.74 10.15 11.16 9.9 10.29 1.4 703 0.88 7.41 10.15 11.16 9.9 10.29 <t< td=""><td></td><td>0.76</td><td>11.33</td><td>14 83</td><td>13.85</td><td>6.6</td><td>13.78</td><td>7.1</td><td>12.78</td><td>13.8</td></t<> | | 0.76 | 11.33 | 14 83 | 13.85 | 6.6 | 13.78 | 7.1 | 12.78 | 13.8 |
| 0 68 14.00 18 50 1711 7.5 17.03 7.9 15.79 1 0.64 15.42 20 53 18.84 8.2 18.75 8.7 17.40 1 0.64 15.42 20 53 18.84 8.2 18.75 8.7 17.40 1 0.96 4.46 5.05 5.69 12.7 5.25 4.0 5.27 0.94 5.23 6.50 12.7 5.25 4.0 5.27 0.94 5.23 6.67 7.6 6.16 0.6 6.18 0.92 5.97 7.13 7.62 6.9 7.03 1.4 7.05 0.92 5.97 7.13 7.62 6.9 7.03 1.4 7.05 0.88 7.41 8.76 9.2 872 0.7 1.1.85 7.05 0.84 8.74 10.15 11.16 9.9 10.22 1.1.87 7.05 0.88 7.41 8.75 10.6 11.80 2.4 10.55 0.88 10.02 11.56 | | 0.72 | 12.63 | 16.60 | 15.43 | 7.0 | 15 36 | 75 | 14.25 | 141 |
| 0.64 15.42 20.53 18.84 8.2 18.75 8.7 17.40 1 0.96 4.46 5.05 5.69 12.7 5.25 4.0 5.27 0.94 5.23 6.50 12.7 5.25 4.0 5.27 0.94 5.23 6.60 12.7 5.25 4.0 5.27 0.94 5.23 6.60 12.7 5.6 6.16 6.18 0.92 5.97 7.13 7.62 6.9 7.03 1.4 705 0.92 5.97 7.13 7.62 6.9 7.03 1.4 705 0.88 7.41 8.74 10.15 11.16 9.9 10.22 1.4 705 0.84 8.74 10.15 11.16 9.9 10.22 1.133 13.00 14.46 11.2 10.32 0.76 11.33 13.00 14.46 11.2 11.0 14.87 2.4 14.92 0.76 11.33 13.00 14.46 11.2 10.9 14.87 2.4 14.92 0.76 11.33 13.00 14.46 11.2 10.9 14.87 2.4 14.92 0.64 15.42 | | 0 68 | 14.00 | 18 50 | 17 11 | 7.5 | 17.03 | 6.1 | 15 79 | 146 |
| Average 6.0 Average 6.4 Average 1.4 0.96 4.46 5.05 5.69 12.7 5.25 4.0 5.27 0.94 5.23 6.67 7.6 6.16 0.6 5.27 5.27 0.94 5.23 6.67 7.6 6.16 0.6 5.27 5.27 0.92 5.97 7.13 7.62 6.9 7.03 1.4 7.05 0.92 5.97 7.13 7.62 6.9 7.03 1.4 7.05 0.88 7.41 8.69 9.46 9.2 8.72 0.7 8.75 0.84 8.74 10.15 11.16 9.9 10.22 11.80 2.1 11.83 0.80 10.02 11.56 11.277 10.0 14.87 2.4 10.35 0.76 11.33 13.00 14.46 11.2 11.80 2.1 11.83 0.76 11.33 13.00 14.46 11.2 2.4 13.28 0.76 11.33 13.00 14.46 11.80 2.3 <t< td=""><td></td><td>0.64</td><td>15.42</td><td>20 53</td><td>18.84</td><td>8 2</td><td>18.75</td><td>8.7</td><td>17.40</td><td>15.2</td></t<> | | 0.64 | 15.42 | 20 53 | 18.84 | 8 2 | 18.75 | 8.7 | 17.40 | 15.2 |
| 0.96 4.46 5.05 5.69 12.7 5.25 4.0 5.27 0.94 5.23 5.20 16.67 7.6 5.16 6.16 6.18 0.92 5.97 7.13 7.65 6.9 7.03 1.4 7.05 0.88 7.41 8.66 9.46 9.2 872 1.4 7.05 0.88 7.41 8.66 9.46 9.2 872 0.7 8.75 0.84 8.74 10.15 11.16 9.9 10.29 1.4 10.32 0.84 8.74 10.15 11.16 9.9 10.29 1.4 10.32 0.80 10.02 11.56 12.79 10.6 11.80 2.1 11.83 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 11.2 13.34 2.6 14.92 0.76 11.33 13.00 14.46 11.2 13.38 16.53 0.76 11.33 13.66 10.0 14.87 2.4 14.92 0.64 15.42 17.87 10.9 16.48 2.3 16.53 <t< td=""><td></td><td></td><td></td><td></td><td>Avêr</td><td>age 6.0</td><td>Aver</td><td>1ge 6.4</td><td>Avcrag</td><td>ie 13.2</td></t<> | | | | | Avêr | age 6.0 | Aver | 1ge 6.4 | Avcrag | ie 13.2 |
| 094 5.23 6.20 16.67 7.6 6.16 0.6 6.18 0.92 5.97 7.13 7.62 6.9 7.03 1.4 7.05 0.88 7.41 8.66 9.46 9.2 8.72 0.7 8.75 0.84 8.74 10.15 11.16 9.9 10.29 1.4 7.05 0.84 8.74 10.15 11.16 9.9 10.29 1.4 10.32 0.80 10.02 11.56 12.79 10.6 11.83 2.6 13.34 0.76 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.72 11.33 13.00 14.46 11.2 13.34 2.6 13.38 0.76 11.33 13.00 14.46 10.9 16.48 2.3 16.53 0.72 11.33 13.00 14.46 10.9 16.48 2.3 16.53 0.64 15.42 17.87 19.68 10.1 18.16 16 16.53 0.64 15.42 17.87 19.68 10.1 18.16 16 16.53 0.64 15.42 17.87 19.68 10.1 18.16 | [ydrogen Sulfide | 0.96 | 4.46 | 5.05 | 5.69 | 12.7 | 5.25 | 4.0 | 263 | 5 8 |
| 597 7.13 7.62 6.9 7.03 1.4 7.05 7.41 8.66 9.46 9.2 8.72 0.7 8.75 8.74 10.15 11.16 9.9 10.29 1.4 7.05 10.02 11.56 12.79 10.6 11.80 2.1 11.83 11.13 13.00 14.46 11.2 13.34 2.6 13.8 11.13 13.00 14.46 11.2 13.34 2.4 14.92 11.33 13.00 14.46 11.2 13.34 2.4 14.92 11.33 13.00 14.46 11.2 13.34 2.6 14.92 11.33 13.00 14.46 11.2 13.34 2.6 14.92 14.00 16.11 17.87 10.9 16.48 2.3 16.53 15.42 17.87 19.68 10.1 18.16 16 18.21 | (Ref. 6) | 0.94 | 5.23 | 6.20 | 6.67 | 7.6 | 6.16 | 0.6 | 618 | 0 Y C |
| 7.41 8 66 9 46 9.2 8 72 0.7 8.75 8.74 10.15 11.16 9 9 10.29 1.4 10.32 10.02 11.56 11.279 10.6 1180 2.1 1183 11.33 13.00 14.46 11.2 13.34 2.6 13.38 11.33 13.00 14.46 11.2 13.34 2.6 14.92 11.33 13.00 14.46 11.2 13.34 2.6 14.92 12.63 14.52 110 14.87 2.3 16.53 12.60 16.11 17.87 10.9 16.48 2.3 16.53 15.42 17.87 10.9 16.48 2.3 16.53 15.42 17.87 10.9 18.16 16 18.21 | | 0.92 | 5 97 | 7.13 | 7.62 | 6'9 | 7 03 | 1.4 | 20.6 | |
| 8.74 10.15 11.16 9.9 10.29 1.4 10.32 10.02 11.56 12.79 10.6 11.80 2.1 11.83 11.33 13.00 14.46 11.2 13.34 2.6 13.38 12.63 14.52 16.12 11.0 14.87 2.4 14.92 14.00 16.11 17.87 10.9 16.48 2.3 16.53 15.42 17.87 19.68 10.1 18.16 1.6 18.21 Åverage 10.0 Åverage 1.9 Åverage | | 0.88 | 7.41 | 8 66 | 946 | . 9.2 | 8 72 | 0.7 | 8.75 | 101 |
| 10.02 11.56 / 12.79 10.6 11 80 2.1 11 83 11.33 13.00 14.46 11.2 13.34 2.6 13.38 12.63 14.52 16.12 11.0 14.87 2.4 14.92 14.00 16.11 17.87 10.9 16.48 2.3 16.53 15.42 17.87 19.68 10.1 18.16 1.6 18.21 Åverage 10.0 Åverage 1.9 Åverage | | 084 | 8.74 | 10.15 | 11.16 | 66 | 10.29 | 1.4 | 10.32 | 61 |
| 11.33 13.00 14.46 11.2 13.34 2.6 13.38 12.63 14.52 16.12 110 14.87 2.4 14.92 14.00 16.11 17.87 10.9 16.48 2.3 16.53 15.42 17.87 -19.68 10.1 18.16 1 1 18.21 | | 080 | 10.02 | 11.56 | 12.79 | 10.6 | 11 80 | 2.1 | 11 83 | 23 |
| 12.63 14.52 16.12 11 0 14.87 2.4 14.92 14.00 16.11 17.87 10.9 16.48 2.3 16.53 15.42 17.87 19.68 10.1 18.16 1.6 18.21 Åverage 10.0 Average 1.9 Average | | 0 76 | 11.33 | 13.00 | 14.46 | 11.2 | 13.34 | 2.6 | 13.28 | 2.9 |
| 14.00 16.11 17.87 10.9 16.48 2.3 16.53 15.42 17.8719.68 10.1 18.16 1.6 18.21 Average 10.0 Average 1.9 Average | | 0.72 | 12.63 | 14.52 | 16.12 | 11 0 | 14.87 | 2.4 | 14 92 | 2.7 |
| 15.42 17.8719.68 10.1 18.16 1.6 18.21 Average 10.0 Average 1.9 Average | | 0 68 | 14.00 | 16.11 | 17.87 | 10.9 | 16.48 | 2.3 | 16.53 | 2.6 |
| 10.0 Average 1.9 Average | | 0.64 | 15.42 | 17.87 | | 10.1 | 18,16 | 16 | 18 21 | 6,1 |
| | | | | 1 | Avera | | Aver | 1ge 1.9 | Avera | |

Prediction of Entropy of Vaporization of Inorganic Gases

| and a second | | | TAR | A \$5 | | <u>⊳ Ss</u> | | D \$5 | ······································ |
|---|------|-------------------------|--------------|----------------|----------|-----------------|---------|-----------------|--|
| 1979-1980-1991 - 1991 - 1992 - 1992 - 1993 - 1993 - 1993 - 1993 - 1993 - 1993 - 1993 - 1993 - 1993 - 1993 - 199 | Tr. | △ <i>SA</i> (Ref. 2) | e Ss Lit. | Cal. (Eq 1) | %Div. | Cal. (Eq. 2) | %Div. | Cal. (Eq. 3) | °/₀Div. |
| Water (Ref. 8) | 0.96 | 4 46 | 6.36 | 5.14 | 19.2 | 6.51 | 2.3 | 5.04 | 20.7 |
| | 0.94 | 5.23 | 7.64 | 6 02 | 21.2 | 7.63 | 0.1 | 5 91 | 22.6 |
| | 0 92 | 5 97 | 8.76 | 6.88 | 21 5 | 8.72 | 0.5 | 6 75 | 22.9 |
| | 0 88 | 7.41 | 10.80 | 8 54 | 20.9 | 10 82 | 0.2 | 8.38 | 22 4 |
| | 0 84 | 8.74 | 12 66 | 10.07 | 20.4 | 12.76 | 0.8 | 988 | 21,9 |
| | 0 80 | 10 02 | 14.47 | 11 54 | 20.2 | 14 63 | 1.1 | 11.33 | 217 |
| | 0.76 | 11.33 | 16.28 | 13 06 | 19.8 | 16.54 | 1.6 | 12 81 | 21 3 |
| | 0.72 | 12.63 | 18 16 | 14.56 | 198 | 18 44 | 1.5 | 14 28 | 21.4 |
| | 0 68 | 14.00 | 20 13 | 16.14 | 198 | 20.44 | 1.5 | 15 83 | 21.4 |
| | 0.64 | 15 42 | 22 23 | 17 77 | 20.1 | 22 51 | 1.2 | 17 44 | 21.5 |
| | 0,60 | 16.98 | 24.56 | 19.57 | 20.3 | 24.79 | 0.9 | 19.21 | 21.8 |
| | | | | Avera | age 20.3 | Avera | ige 1.1 | Avera | ge 21.8 |
| Iydrozine (Ref. 9) | 0 96 | 4.46 | 7.04 | 6.03 | 14.3 | 6 64 | 5.7 | 5 24 | 25.5 |
| | 0.94 | 5 23 | 8.42 | 7 07 | 16.0 | 7 79 | 7.5 | 614 | 27.0 |
| | 0 92 | 5.97 | 9.61 | 8.07 | 16.0 | 8.89 | 7.5 | 7.01 | 27 0 |
| | 0 88 | 7.41 | 11.60 | 10 01 | 13.7 | 11.04 | 4.8 | 8.70 | 25 0 |
| | 0.84 | 8.74 | 13.47 | 11 81 | 12.3 | 13.62 | 3.3 | 10.∠6 | 238 |
| | 0.80 | 10.02 | 15.18 | 13,54 | 108 | 14 93 | 1.6 | 11.77 | 22.5 |
| | 0.76 | 11 33 | 17.02 | 15.31 | 10.0 | 16.88 | 0.8 | 13.31 | 21.8 |
| | 0.72 | 12 63 | 18 87 | 17.07 | 9.5 | 18.82 | 03 | 14.83 | 21.4 |
| | 0,68 | 14.00 | 20 93 | 18.92 | 9.6 | 20.86 | 03 | 16.44 | 214 |
| | 0.64 | 15.42 | 23 06 | 20,84 | 9.6 | 22.98 | 0,3 | 18.11 | 21.5 |
| | 0.60 | 16.98 | 25.26 | 22,94 | 9.2 | 25.30 | 0.1 | 19.94 | 21.1 |
| | | | | Avera | ge 11.9 | Avera | ige 2.9 | Avera | ge 23.5 |

TABLE 2-(contd.)

Nomenclature

 $\Delta S_{\rm S} - \text{Entropy of vaporization of the substances (Cal/mole <math>^{\circ}K$) $\Delta S_{A} - \text{Entropy of vaporization of Argon (Ca!/mole <math>^{\circ}K$) $V_{b} - \text{Molecular volume at its boiling point (cc/g mole)}$ $T_{b} - \text{Normal boiling point}^{\circ}K$ M - Molecular weight $k = \frac{1}{2} f (f = 5 \text{ for diatomic gases and } f = 6 \text{ for polyatomic gases})$ f = Degrees of freedom

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