Solvent and Temperature Effect on the Dipole Moment of Dichloroethane

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Summary: Dipolemoment of dichloroethane is determined in four different solvents i.e. benzene, tetra-chloromethane, cyclohexane and 1,4-dimethylbenzene in the temperature range of 20°C to 40°C with the interval of 5°.

Introduction

A bond moment is merely a measure of the electrical asymmetry of a certain section of a molecule and is affected by the environment of this section. The use of moment found for a bond in one environment and for the same bond in a different environment may lead to incorrect conclusions.

Muller[1] was the first to show that electric moments obtained from measurement made with solution vary with the nature of the solvent used and these values differ from the moments found in gaseous state.

Two general causes for this are:-

I: Dipole association: These are the forces which dissolved molecules exert upon one another. However in a series of solutions of the same substance, the association effect would diminish as dilution proceeds.

II: The solvent effect: This is the effect of non-polar solvent on the molecules of polar solute. It is found that even if infinite dilute solution is taken this effect remains.

Electric moment depends on temperature too. According to Debye[5].

$$P = a + b/T$$

Where p is polarisation, T is for temperature a and b are constants obtained from the intercept and slope respectively when P is plotted vs 1/T.

This equation shows that polarisation does depend on the temperature and that it decreases with increase in the temperature. Solvent and temperature effect were noted in very dilute solutions using Guggenhiem[2-3] and Smith equation, obtained by plotting $\epsilon_{12} - n_{12}^2$ vs c.

$$\text{Slope} = 4/3 \frac{4/3\pi N (\epsilon_1+2)(n_1^2+2)}{3} \quad \frac{\mu^2}{3KT}$$

Results and Discussion

The final result is summarised in table II. Comparing table III with table I, it is concluded that dipole-moment of 1,2 dichloro-ethane increases with the increased dielectric constant of the solvent.

Larger values given by benzene may be due to the formation of the complexes. Hydrogen atom of dichloro ethane may interact with the electrons of the benzene ring. 1,4-dimethyl benzene has two bulky methyl groups in it, so this effect is hindered, giving smaller values as compared to benzene. Table II shows that dipolemoment values decrease when temperature is increased and this is in agreement with the Debye's equation.

Experimental

1,2 dichloro-ethane was studied in four different solvents with the mole fraction, ranging from 6.8×10^{-4} to 58.1×10^{-4}. The solvent used for this purpose were cyclohexane, tetrachloro-ethane, 1,4-dimethylbenzene and benzene, in the temperature range of 20 – 40°C with the interval of 5°. For the determination of the dipole moment of the solute, the solvent must be non-polar and neutral. These requirements are generally completely fulfilled by these solvents. The solvents, were distilled twice and then dried. The dielectric constants of the pure solvents (table I) and those of dilute solutions were determined by means of Dipole meter type $DMOI_4$ manufactured by the Wissen schaftliche – Technische Werkstatten GmbH, (Germany). The instrument was calibrated in terms of n-butyl-alcohol.

The refractive index values of the pure solvents (table II) and dilute solutions were determined with Abbe's refractometer.

Notations used are:

ϵ_{12} = dielectric constant of the solution n_{12} = refractive index of the dilute solution ϵ_1 = dielectric constant of the pure solvent n_1 = refractive index of the pure solvent, N = avogadros number K = Boltzmann constant T = Temperature c = mole fraction μ = dipole moment, of the solute.

Table I *Dielectric constant (ϵ_1) of pure solvents*

Temp.	Benzene	1,4-dimethyl-benzene	Tetrachloro-methane	Cyclohexane
20°C	2.284	2.270	2.238	2.024
25°C	2.274	2.268	2.228	2.015
30°C	2.270	2.265	2.224	2.010
35°C	2.265	2.260	2.220	2.005
40°C	2.265	2.255	2.220	2.000

Table II *Refractive indices (n_1) of pure solvents*

Temp.	Benzene	1,4-dimethyl-benzene	Tetrachloro-methane	Cyclohexane
20°C	1.5011	1.4958	1.4595	1.4265
25°C	1.4990	1.4930	1.4580	1.4250
30°C	1.4960	1.4920	1.4560	1.4235
35°C	1.4930	1.4910	1.4535	1.4220
40°C	1.4910	1.4890	1.4520	1.4190

Table III *Dipole-moment (μ), of dichloroethane in various solvents*

Temp.	Benzene	1,4-dimethyl-benzene	Tetrachloro-methane	Cyclohexane
20°C	1.835	1.633	1.457	1.409
25°C	1.831	1.629	1.455	1.403
30°C	1.829	1.624	1.449	1.399
35°C	1.828	1.621	1.445	1.386
40°C	1.824	1.616	1.437	1.383

References

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